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For centuries wood has served as a primary structural building material in small dwelling, large communal structures, bridges, and temporary structures. Even today wood is the dominant material in residential construction. Despite this long standing use of wood, non-residential multi-story construction in light of the green building revolution has yet to fully incorporate wood as a main structural material. Research has shown wood to be an environmentally friendly material due to its sequestration of carbon during growth, low embodied energy, and effects on building efficiency. For a look into why wood has yet to find it's way into mainstream sustainable non-residential design, an investigation of two leading green building rating systems, LEED and Green Globes, was performed to identify how these rating systems evaluate wood. It is evident that Green Globes is currently doing a better job at rewarding designers for using wood products through the use of Life Cycle Assessment (LCA) tools and for recognizing all main sustainable forestry certification programs. In contrast, the current version of LEED does not reward the use of LCA when performing material selection, and only recognizes one of the main forestry certification programs, alienating the majority of sustainably grown wood in North America.

Key Words: Wood, Sustainability, LEED, Green Globes

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Finding a Place for Wood in Non-Residential Design: LEED vs. Green Globes Certification

by

Jordan M. Henderson

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

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PREFACE

Most modern development, until the late 20th century, has placed society's built environment at odds with the natural environment it has come to exist within. Rapid growth, intense urbanization and industrialization, and a growing need for energy have left our surroundings trying to recover while the number of large-scale factories, office buildings, schools, and shopping centers, among other facilities, continue to grow, necessary for accommodating increasing populations. Until recently, the design and construction of these facilities has fostered an adversarial relationship with the natural surroundings, forcing native environments to accommodate to the built environment. For centuries, environmental systems have reacted to these rapid changes without a broad societal understanding of the long-term ramifications. However, recent concern regarding society's development patterns have led to a re-evaluation of the way human development impacts natural systems. In the context of human development, "green", or environmentally responsible infrastructure, is a relatively new idea. Although techniques such as passive heating and cooling have been around for centuries, widespread interest in environmentally responsible infrastructure did not gain traction until the late 20th century.

In 1970, a small cadre of architects, environmentalists, and ecologists began to question the massive scale development and transformation of urban landscapes in America. These man-made environments enabled modern society's profound dependence on cheap fossil fuels starting in the 1930s (Cassidy 4). The advent of air conditioning, fluorescent lighting, structural steel, and reflective glass, as well as the affordability of fossil fuels during the post-war era, drove architects and engineers to phase out passive environmental control in favor of large mechanical heating and cooling systems (Gissan 12). Public demonstrations opposing this fossil fuel dependence culminated in the celebration of the first Earth Day in April 1970. Apart from localized demonstrations, however, the movement as a whole did not catch public attention until the Organization of Petroleum Exporting Countries (OPEC) oil embargo of 1973, which drastically spiked fuel prices across the country and around the world. A widespread energy crisis and far-reaching concern regarding America's heavy reliance on fossil fuels arose as a result (Cassidy 4).

The next decade saw efforts from sources around the world in energy conservation giving the green building movement momentum. In 1987, the United Nation's World Commission on Environment and Development offered a report titled *Our Common Future* under leadership from Norwegian Prime Minister Gro Harlem Bruntland. In the report, the commission offered the first definition of "sustainable development":

> *"Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities." ("Our Common Future")*

This first definition of sustainable development formed a framework from which modernized nations could pattern their development, and offered a global challenge to re-think traditional development strategies in the interest of future generations.

From increased public awareness and governmental efforts in the field of sustainable development, the ’80s and early ‘90s saw the green building movement develop even further. On Earth Day, April 21, 1993, the newly elected President of the United States, Bill Clinton, announced that the White House would undergo a complete energy and environmental audit, resulting in a “greening” of the Presidential residence. Three years later, the improvements to the building resulted in $300,000 in annual energy and water savings as well as a reduction in atmospheric emissions by 845 tons of carbon per year (Cassidy 5). In response to the success of the White House experiment, numerous federal buildings were remodeled with similar responses. Simultaneously in 1993, the American Institute of Architects (AIA) held a meeting aimed at identifying the interest in developing a standard for improving the environmental performance of buildings. It was from these meetings that the modern green building revolution began, stemming from the movement started nearly 20 years prior. As a result of these meetings an initial set of green building criteria were compiled within a few years (Bland 56). The green building revolution would shift attention from the “greening” of federal buildings exclusively to an evaluation of building techniques employed for a much wider array of building types.

Two participants of the AIA meetings, David Gottfried and Michael Italiano, formed the U.S. Green Building Council (USGBC) with the goal of creating a sustainability rating system (Cassidy 6). In 1998 the pilot for the USGBCs Leadership in Environmental and Energy Design (LEED) for New Construction rating system was approved, with the final release of LEED Version 1 in 2000. The green building movement in America was now in full force, driven by a new set of standards and practices identified by LEED. These prescribed criteria for green buildings have driven sustainable, environmentally conscious design to the forefront of modern development in America and beyond.

Further attention on green buildings in recent years has asked the question of whether rating systems such as LEED are appropriately encouraging the types of green designs that truly maximize efficiency, and minimize the environmental footprint of a building and all its components. Additional research and advances in technology have offered more tools than ever to determine which building practices should be encouraged throughout green building certification systems, which, themselves, have continued to advance.

INTRODUCTION

The green building movement, for many, is characterized by new technologies, innovative designs, and stunning symbols of man-made excellence seamlessly coupled with the natural surroundings. However, for others, the future of green buildings lies in a slight departure from the man-made, and a return to the natural. The study of natural systems in order to inspire the next generation of manmade technologies has become increasingly popular among researchers. Perhaps instead of designing buildings that aim just to minimize impacts to the natural surroundings, what if buildings at the core of their composition actually *were* natural?

As building materials, wood products mesh a unique combination of natural strength, beauty, and economy of resources that have made it a popular building material throughout history. Despite this fact, modern development often overlooks this proven material. For centuries wood has served as a primary building material for single residence dwellings, large communal structures, bridges, and temporary structures alike. Even today wood remains, convincingly, as the main building material for the majority of residential construction in the United States. The wide array of engineered wood products, uses, and aesthetic and structural capabilities of wood provide modern architects and engineers a full range of design capabilities for buildings of all sizes. More importantly, in the context of the green building revolution, wood provides a considerable amount of environmental benefit as a primary structural building material. Wood is a naturally produced material and provides benefits to the environment beyond its life as a building component. Despite wood's dominance for years in the residential construction industry, steel and concrete remain the dominant materials used in mainstream non-residential multi-story construction.

This raises the question of why wood has taken such a small role in non-residential construction throughout the green building revolution of the last few decades? Despite research that has continually identified wood as a leading renewable and environmentally conscious material, the majority of large, non-residential buildings touting green technologies and national certifications still feature the oft-used structural systems composed of steel and concrete. Often, wood appears in new green buildings in the form of interior finishes, yet wood's structural capabilities make it a more than capable choice for structural applications as well. Wood industries have called for a re-evaluation, and education of the stewards of the built environment to consider wood as a sustainable material for use in structural applications as well as aesthetic capacities in the next generation of green buildings.

For a look into why wood has yet to become a common structural material in non-residential, multi-story construction, one must look at the building requirements driving sustainable accreditation and rating. The two main green building rating systems in America today are the U.S. Green Building Council's LEED system and the Green Building Initiative's Green Globes program. Far and away, LEED has been the dominant rating system in mainstream development and modern legislation. Despite this popularity, it is evident to proponents of wood building products that the systematic rating of green building by LEED does not sufficiently encourage the use of wood as a structural material. Green building certification programs should encourage the use of wood using a holistic evaluation of wood’s environmental and socio-economic benefits over the entire life cycle of the resource. Green Globes accomplishes this much better than LEED does, currently.

METHODOLOGY

To evaluate the extent to which LEED and Green Globes recognize the environmental benefits of wood, one must understand what makes wood such an environmentally favorable material. To accomplish this, a discussion of the major benefits of wood is presented with results from objective research and professional studies. This presentation of wood's environmental benefits is stated at the beginning, in order to provide the necessary background for evaluating green rating system's methods for recognizing sustainable building materials. Following this section, a presentation of the points awarded (or not awarded) for using wood as a main structural material are examined for both the LEED and Green Globes rating systems. First, however, a brief exploration of the current LEED and Green Globes rating systems outlines the basic structure of these two systems.

RATING SYSTEMS

LEED

The LEED Green Building Rating System began in 1998 with the release of a pilot version of LEED 1.0 by the U.S. Green Building Council. Recommendations regarding the distribution of credits quickly led to the release of a revised system, LEED 2.0 in March of 2000 (Cassidy 7). LEED has continued to refine and improve the rating system with the release of versions 2.1 in 2002, 2.2 in 2005, and with the most current version, LEED 3.0, released in 2009 (LEED 2009).

The LEED program initially focused on new construction, with LEED-NC. Subsequent rating systems for commercial interiors, cores and shells, existing buildings, and homes have been added to expand the reach of green building certification across different markets. Under LEED, projects can become certified when a number of credits from a list of requirements have been met and verified by a third-party (Bowyer 7). According to the USGBC, LEED rating systems “evaluate environmental performance from a whole building perspective over a building’s life cycle, providing a definitive standard for what constitutes a green building in design, construction, and operation” (LEED 2009). LEED rating systems are organized into five environmental categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. Two additional categories – Innovation in Design and Regional Priority – are provided to reward sustainable building expertise and to identify the importance of examining local conditions in determining design and construction practices (LEED 2009). Among the five environmental categories, there are a total of 100 possible points, with the opportunity for ten extra bonus points between the two additional categories (LEED 2009). LEED certifications are designated according to the number of points achieved. To provide a context for the weighting of points among LEED categories, the point breakdown for LEED - New Construction is provided in Table 1.

Table 1: LEED 2009 Point Distribution

Category	Points
Sustainable Sites	26
Water Efficiency	10
Energy and Atmosphere	35
Materials and Resources	14
Indoor Environmental Quality	15
Innovation in Design – *Bonus Category*	6
Regional Priority – *Bonus Category*	4
Total Points	110

Source: LEED 2009 for New Construction and Major Renovations

LEED has a list of Minimum Program Requirements (MPRs) that buildings must comply with in order to become eligible for LEED certification. The MPRs for LEED 2009: New Construction and Major Renovations indicate that eligible buildings must:

- *Comply with environmental laws*
- *Be a complete, permanent building*
- *Use a reasonable site boundary*
- *Include a minimum of 1,000 square feet of gross floor area*
- *Comply with minimum occupancy rates (Must serve an annual average of at least one full time equivalent)*

- *Commit to sharing whole-building energy and water use data for at least five years*
- *Comply with a minimum building area to site area ratio of no less than 2% of gross land area (LEED 2009)*

GREEN GLOBES

The Green Globes environmental assessment and green building rating system stems from the Building Research Establishment's Environmental Assessment Method (BREEAM) which was brought to Canada in 1996. Green Globes for New Construction is a web-based application that aids design professionals in "evaluating, quantifying, and improving the environmental friendliness and sustainability of new building projects as well as major renovations" (Green Building Initiative). Unlike LEED, Green Globes assesses projects on a 1,000-point scale in a total of seven categories: Energy, Water, Resources, Emissions, Indoor Environment, Project Management, and Site. Weighted distributions of points quantify overall building performance based on a comprehensive approach to energy performance, and an objective method of life cycle assessment analysis (Green Building Initiative). The point breakdown of Green Globes – New Construction is shown in Table 2. While Green Globes' categories do not match LEED's completely, the fundamental elements of LEED are contained within Green Globes, providing a good basis for comparison between the two.

Table 2: Green Globes Point Distribution

Environmental Assessment Area	Points
Energy – *Performance, efficiency, reduced energy demand, use of renewable energy, transportation, etc.*	380
Water – *Performance, conservation, and treatment*	85
Resources – *Low impact materials (LCA), re-use, recycling, demolition, durability*	100
Emissions – *Air emissions, ozone depletion, water and sewer protection, controls on pollution*	70
Indoor Environment – *Ventilation, lighting, thermal and acoustical comfort*	200
Project Management – *Design process, environmental purchasing, commissioning*	50
Site – *Ecological impact, development area, watershed features, enhancement*	115
Total Points	**1,000**

Source: Green Building Initiative – Green Globes NC

Green Globes has no prerequisites within the seven categories. Instead, a small set of preliminary requirements must be met to make buildings eligible for Green Globes Certification. Eligible buildings must:

> - *"Score a minimum of 35% of the total applicable points through a preliminary self-evaluation.*
> - *Have no more than 18 months of occupancy at the time of assessment.*
> - *Be at least 400 gross square feet in size." (Green Building Initiative)*

Green Globes aims to be more inclusive than competing rating systems, allowing buildings of all types to become certified. To accomplish this Green Globes features a weighted point system in which the amount of points awarded for specific criteria reflects its environmental impact or benefit. This system is in place to prevent "point chasing" and focus on true green design. Unlike LEED, Green Globes awards partial credit for criteria, and recognizes when specific criteria are non-applicable to specific buildings. For this reason, Green Globes determines levels of certification based on the percentage of applicable points obtained for a specific project, rather than raw point total. With these features, Green Globes strives to be an all-inclusive, performance-based system.

ENVIRONMENTAL BENEFITS OF WOOD

The environmental impacts of building components span the entire life of the material, from extraction or harvest through manufacturing and construction, operation, and disposal or end-of-life use. Additionally, the environmental footprint of a building reaches far beyond the life of the building itself, accumulating the individual life cycle impacts of the building materials, in addition to the on-going effects of the building in operation. The planning and design phase of a development project greatly determines the overall environmental impact of a building through the selection of materials, and the sources from with they originated. Wood has been shown to reduce the environmental footprint of a building in a myriad of ways; carbon sequestration before harvest, low embodied energy, and the operational efficiency of wood make it an ideal building material for environmentally conscious development over the entire life of a project ("Wood and Carbon Footprint").

CARBON SEQUESTERING

Long before the harvest and manufacturing of wood products for building construction, the natural growth of trees in sustainably managed forests can reduce net global emissions ("Using Wood to Fight Climate Change"). Humans contribute carbon dioxide (CO_2) to the atmosphere on a large scale from the consumption of energy produced by fossil fuels. From an elementary understanding of the biological processes in trees, it's known that trees absorb CO_2 from the atmosphere and release clean oxygen (O_2) back into the air while using the carbon to produce sugars and fiber for growth (“Wood and Carbon Footprint”).

Studies have shown that young, growing forests absorb CO_2 at a faster rate than more mature forests, which experience decreases in absorption rates after anywhere between 50 to 300 years depending on the type of species and surrounding conditions (“Wood and Green Building”). For every ton of wood, young forests absorb 1.4 tons of CO_2 and produce one ton of O_2 (“Wood: Sustainable Building Solutions”). As these forests mature, the rate of growth declines, as does the absorption rate. Sustainably managed forests keep CO_2 absorption rates high by harvesting mature forests, and replanting young forests with much more rapid rates of CO_2 absorption. Actively maintaining forests can reduce the occurrence and intensity of wildfires, which emit significant quantities of CO_2, as well (“Using Wood to Fight Climate Change”).

LOWER EMBODIED ENERGY OVER THE LIFE OF THE PRODUCT

The harvest, extraction, and manufacturing of building materials for construction has many implications on the environmental impacts of a building, considering the number of materials and assemblies that make up our structures. Traditional building materials for non-residential construction, such as steel and concrete, have been shown to have higher levels of embodied energy, a measure of the energy required to extract, process, manufacture, transport, construct, and maintain a product (“US Wood Products”).

Wood products, overall, require less energy to harvest, produce, and implement than traditional modern building materials, while providing comparable structural performance. Past arguments against wood as a structural material have come from the inherent inconsistency in a naturally occurring material as opposed to the monitored consistency of a manufactured material. However, improving technology has made the production of wood products more efficient, and consistent, ensuring all products leave the production line with the expected level of strength and durability to meet design needs (“Wood: Sustainable Building Solutions”). Wood consumes less energy, and produces fewer emissions during the production process than the traditional construction materials associated with non-residential construction. These benefits of wood require an evaluation of a material’s environmental benefits and impacts considering the life cycle of the building material. This life cycle approach has only recently entered the green building arena.

Life cycle assessment (LCA) has emerged as the accepted way to evaluate the true environmental impacts of a variety of products. In years past, green building materials have largely been identified as “sustainable” by a number of qualitative rather than quantitative characteristics. Local materials or products with recycled content, for example, have typically been regarded as better for the environment, regardless of their impacts across the entire life span of the material. Numerous LCA analyses evaluating the performance of building materials across the life cycle of the product have identified that wood consistently outperforms other building materials when considered over its lifetime.

> *"LCA is an internationally recognized method for measuring the environmental impacts of materials, assemblies or whole building over their entire lives – from extraction or harvest of raw materials through manufacturing, transportation, installation, use, maintenance and disposal or recycling" ("Life Cycle Assessment & Green Building")*

Some of the most significant environmental impacts of building materials occurs during extraction and production. As of 2005, wood made up 47 percent of all industrial raw materials manufactured in the United States, yet consumed only 4 percent of the total energy used in industrial raw material manufacture. Direct comparisons show that it takes five times more energy to produce one ton of cement, and 24 times more energy to produce one ton of steel than it does to produce one ton of wood ("Wood: Sustainable Building Solutions"). Considering that steel generally has greater structural capacity than wood for the same quantity of material, and that cement only accounts for approximately one-tenth of concrete by volume, these direct energy comparisons may skew actual energy savings. However, the take away from these figures is that the comparative energy used to derive usable building materials from raw resources is consistently less for wood than for other materials. Furthermore, manufacturers of wood products have made concerted efforts to use wood-based waste such as sawdust, bark, and other renewable biomass to produce their own electrical and thermal energy. In 2008, over 73 percent of the energy used to manufacture wood products in the U.S. was from renewable energy sources ("Sustainable Forestry"). This minimization of waste, and low levels of fossil fuel usage for the manufacture of wood products makes it an ideal choice for decreasing the embodied energy of materials used in construction.

In the context of building efficiency, and overall impact to the environment, wood buildings are shown to have the least environmental impacts when compared to building made primarily of steel or concrete. In a study by the Canadian Wood Council, three 2,400 square foot homes designed primarily in wood, steel, and concrete were evaluated for their environmental impacts over the first 20 years of the lifespans. The results found that, relative to the wood house, the steel and concrete designs, respectively:

- *Released 24% and 47% more air pollution*
- *Produced 8% and 23% more solid wastes*
- *Used 11% and 81% more resources*
- *Required 26% and 57% more energy*
- *Emitted 34% and 81% more greenhouse gases*
- *Discharged 4 and 3.5 times more water pollution (Wood and Green Building, the role of LCA)*

In a similar experiment, the Consortium for Research on Renewable Industrial Materials (CORRIM) released the findings of an experiment in 2004 that used LCA to evaluate differences in the environmental performance of houses made with varying materials. As part of the study, two homes framed in wood or steel were compared in the cold climate of Minneapolis, Minnesota, and homes framed in wood or concrete were compared in the warm climate of Atlanta, Georgia. The homes were evaluated with respect to separate indices for embodied energy, global warming potential (GWP), air emissions, water emissions, and solid waste. The GWP is given in CO_2 equivalent of greenhouse gas emissions of CO_2, methane and nitrous oxide, all greenhouse gases. The results from these studies are presented in Table 3.

Table 3: Environmental Performance Findings of CORRIM Investigation

Minneapolis Design	*Wood*	*Steel*	*Difference*	*Other Design vs. Wood (% change)*
Embodied Energy (GJ)	651	764	113	17%
Global Warming Potential from processing (CO_2 kg)	37,047	46,826	9,779	26%
Global Warming Potential net of carbon stored in products (CO_2 kg)	16,561	36,428	19,867	120%
Atlanta Design	*Wood*	*Concrete*	*Difference*	*Other Design vs. Wood (% change)*
Embodied Energy (GJ)	398	461	63	16%
Global Warming Potential from processing (CO_2 kg)	21,367	28,004	6,637	31%
Global Warming Potential net of carbon stored in products (CO_2 kg)	5,898	15,090	9,192	156%

Source: CORRIM Phase II Research Report - Life Cycle Environmental Performance of Renewable Building Materials in the Context of Residential Construction

Without considering the carbon stored in wood throughout the life of the building, the steel-framed and concrete-framed houses had GWP of 26% and 31% greater than the wood-framed houses, respectively. When including the effect of wood's ability to store carbon throughout the life of a building, the GWP of the steel- and concrete-framed houses was 120% and 156% greater than that of the wood-framed house, respectively (Lippke et al. viii).

In addition to the differences in GWP, the wood-framed houses consistently posed less environmental risk to the surroundings than their steel and concrete counterparts, requiring less energy from material extraction through operation.

BUILDING EFFICIENCY

The operational efficiency of buildings affects the environmental footprint for the service life of a structure. Energy use, efficiency, emissions, and waste make up the operational footprint of the buildings that make up our built environment. The global building sector currently contributes up to 30 percent of annual greenhouse gas emissions and consumes up to 40 percent of all energy, mostly going towards heating, cooling, lighting, and operating appliances (“Building and Climate Change” 3). Due to these facts, the fundamental goal of most sustainable design aims to reduce operational energy consumption through efficiency measures in design and operation.

Wood is a natural insulator, with a cellular structure that contains air pockets, which limit the material’s ability to conduct heat. Wood is a better insulator than steel and concrete by 400 times and 15 times, respectively (“Wood and Green Building”). Steel and concrete are more conductive than wood, requiring more insulation to meet similar levels of energy efficiency than wood. Increased costs for insulation can inhibit satisfaction of energy code requirements, in some cases, further highlighting wood’s superior insulating potential.

From the repeated studies, it is evident that wood buildings have a smaller environmental footprint than structures built primarily with steel and concrete, yet many of these environmental advantages of wood building materials are not revealed without an evaluation of materials across the life of the product using appropriate life-cycle analysis. For these benefits of wood to be rewarded, green building rating systems must adapt material selection criteria to reflect the growing evidence in favor of material selection based on life-cycle considerations.

LEED AND GREEN GLOBES EVALUATION OF WOOD

From the data presented in favor of wood's sustainable merit, it is clear that wood is more environmentally friendly across the lifetime of the product when compared with steel and concrete. With these results it is hard to understand why wood has yet to find a niche in non-residential construction throughout the green building movement. From here, one must look to the motivating factors driving most green development: green building rating systems.

As introduced earlier, it is evident that green building rating systems are not sufficiently encouraging the use of wood products. Having said this, however, the Green Globes rating system has taken more progressive steps towards creating a rating system that appropriately rewards the use of wood by encouraging the use of LCA, and recognizing sources of sustainably grown wood products on a larger scale than LEED.

For both the LEED and Green Globes rating systems, material selection and resource categories comprise a subset of the overall point scales. In LEED, materials and resources comprise approximately 19 percent of the total points within LEED-NC. In Green Globes, ten percent of the possible points relate to the environmental attributes of building materials (Bowyer 11). Although LEED presents a higher percentage of points available for material selection, the way in which those points are awarded dictates the degree to which each program encourages the use of wood. Within LEED and Green Globes, credits for wood can be obtained in the following areas: certified wood, recycled/reused/salvaged materials, local sourcing of materials, waste minimization, and indoor air quality. Specific inhibitors inherent in these rating systems, such as the traditional evaluations of building materials, often do not give wood credit for the benefit it actually provides.

CERTIFIED WOOD

Both LEED and Green Globes require all wood used to come from sustainably managed forests, with third-party certification credentials. In North America the four main forest certification systems are: the American Tree Farm System (ATFS), Canadian Standards Association's Sustainable Forest Management System (CSA), Forest Stewardship Council (FSC), and the Sustainable Forestry Initiative (SFI). Each third party certification system has been shown to evaluate forestry practices beyond regulatory requirements, considering economic, environmental, and social values. As of 2008, the total area of forestland certified by each certification program is shown in Figure 1.

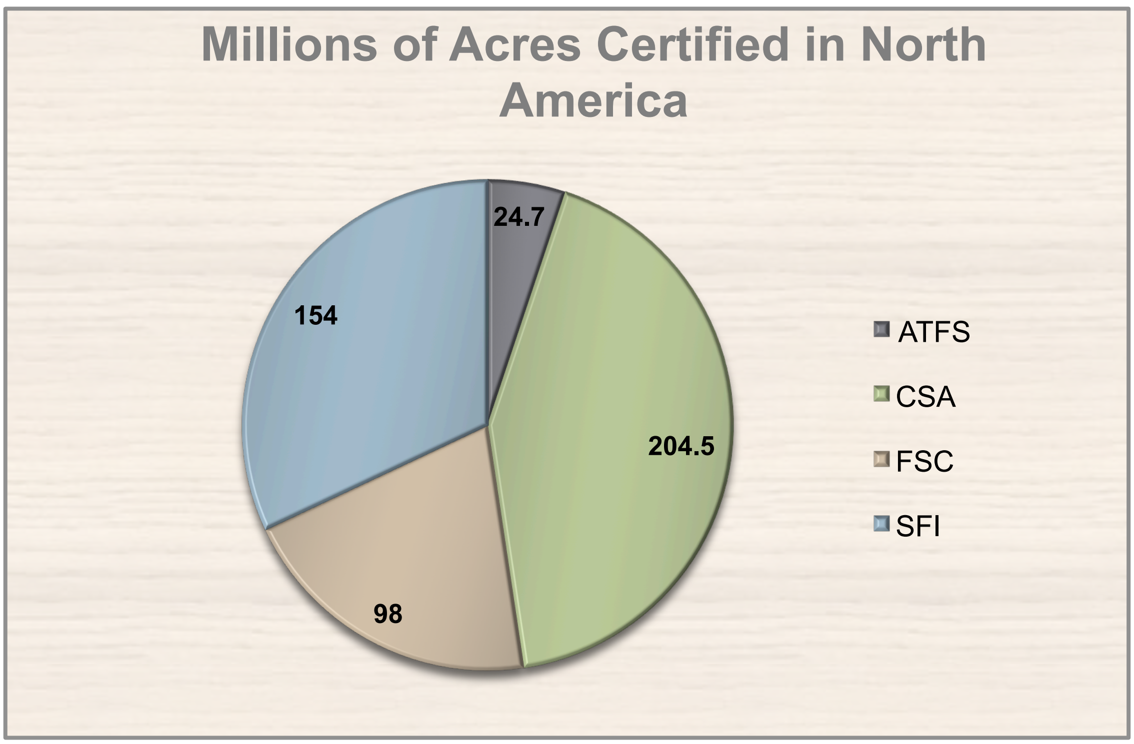

Figure 1: Acres Certified Forests in North America
Source: Woodworks - Wood Design & Green Building Series

Although these four certification programs are accepted as effective measures of sustainable forestry practices, LEED rating systems only provide credit for wood products obtained from FSC certified forests. Under Materials & Resources Credit 7: Certified Wood, LEED 2009 specifies, “use a minimum of 50% (based on cost) of wood-based materials and products that are certified in accordance with the Forest Stewardship Council’s principles and criteria, for wood building components” (LEED 2009). LEED’s failure to recognize additional third part certification alienates a large portion of wood products from around North America. Considering that the area of North American forestland certified by FSC makes up less than one quarter of land certified by ATFS, CSA, FSC, and SFI combined, the amount of wood eligible for LEED credit is substantially limited. In 2008, only 22 million acres of American forestland was FSC certified, while SFI and ATFS accounted for over 83 millions acres of certified forestland (“US Forest Products Industry Concerns”). In contrast with LEEDs recognition of certified wood, Green Globes provides credit for wood certified through all four major third party certification systems.

Aside from the fact that LEED only recognizes a small portion of certified wood, a larger issue at hand is that wood is the only building material held to such stringent standards. Third party certification verifying the sources and production practices of the steel and concrete industries do not currently exist. Wood is the only major building material to have to prove its sustainable sources through third party certification. All certification systems must be recognized to encourage use of wood from a wider base of sources throughout LEED and

Green Globes rating systems. Green Globes has been ahead of LEED on this issue from the beginning, recognizing wood from a variety of sources.

LIFE CYCLE ASSESSMENT OF BUILDING MATERIALS

From the discussion of wood's environmental benefits across the life of the product, life cycle assessment of building materials and components is the way of the future for material selection. Despite this shift in evaluations, LEED still prescribes more traditional measures of sustainability instead of rewarding credits for material selections based on LCA analyses. In part, this is because LCA has historically been very difficult to perform and hard to evaluate. Within the last several years, however, user-friendly online tools have been launched to make LCA more accessible for design professionals. These tools have been used with great success and are incorporated into Green Globes Resources category.

Green Globes, unlike LEED, rewards points for including LCA for a variety of building components such as foundation and floor assembly materials, structural systems and walls, roof assemblies, and other envelope assembly materials such as windows and cladding. Since LCA has been recognized as time consuming and laborious for building designers to complete for individual materials, the GBI commissioned the Athena Institute, in combination with the University of Minnesota and the firm of Morrison-Hershfield, to create an online LCA tool that would evaluate building materials as assemblies rather than individual parts. The Athena EcoCalculator was the result of these efforts, and is the online tool that Green Globes encourages designers to use by rating material assemblies against each other when viewed across their life cycle impacts (Green Building Initiative). This approach does not fully recognize the life cycle impacts of each individual material, but it is generally accepted that this inclusion in Green Globes' criteria for material selection addresses LCA much better than LEED. Within Green Globes, a total of 35 points out of 1000 are rewarded for completing LCA analysis of these materials. Additionally, points are awarded for using renewable or locally available materials that have undergone separate LCA evaluations (Green Building Initiative).

LEED places wood at a distinct disadvantage when compared to environmentally inferior materials by not requiring any type of LCA evaluation. Without an evaluation of a product's impact over the life of the product, other less environmentally friendly materials are selected due to the satisfaction of the prescribed criteria traditionally associated with green materials. With LEED, the evaluation of this impact is taken as a static view of the product's life cycle, without a larger view of the wider-spread risks posed to the environment from extraction through operation and disposal. For example, credits encouraging the use of regional materials, as in LEED Materials & Resources Credit 5: Regional Materials, reward the use of materials sourced and manufactured within 500 miles of the project. Traditional thought says that using local materials would reduce emissions from transportation, yet it is becoming clear that using locally sourced materials with higher embodied energy and impact over the life of the product may not, in fact, be the most sustainable choice due to higher environmental costs during material production, or from a building's operational efficiency later in the life-cycle.

Although LCA is still hard to implement in green building rating systems, the inclusion of this tool must be considered to encourage the use of materials and assemblies made of resources such as wood, which pose significantly less environmental risk over the life of the product. Current versions of LEED and Green Globes do not fully address the potential of LCA assessment due to the complexity of the assessment, yet Green Globes make an effort to acknowledge the importance of LCA by awarding points for material selection based on LCA of building assemblies. Current versions of LEED do not require the same analysis, placing wood at a significant disadvantage when to compared to alternative materials.

WHAT WOULD NON-RESIDENTIAL WOOD DESIGN LOOK LIKE?

While the environmental benefits of wood are clear, it's easy to see that green buildings do not currently utilize wood products on a large scale. What isn't as obvious for most is the way in which wood could be used to develop multi-story, sustainable, and state-of-the art structures with a warm, natural aesthetic that only wood can achieve. Attached at the end of this thesis is a digital portfolio of an architectural case study exploring the possibilities of a wood based design of a local public structure.

The Salem Public Library in Salem, Oregon is a large public structure in the middle of Salem's city center. The structure is designed entirely of concrete. As presented in the architectural portfolio, a wood-inclusive redesign of this public library could yield a sustainable, visually pleasing structure that utilizes local resources to create a central public space that embodies the natural beauty of the Pacific Northwest.

To encourage the type of green designs presented in the portfolio, green building rating systems such as LEED and Green Globes will have to lead the charge by adapting the ways in which the material selection criteria currently treat wood products.

CONCLUSIONS

Wood has repeatedly been shown to be one of the most environmentally friendly building materials available. Wood is naturally grown, renewable, readily available, requires little energy to harvest and manufacture, and is the only major building material to have third party certification verifying its source. Despite these facts, wood is not largely used as a primary structural material in green, multi-story, non-residential construction. A shift in green building systems and how they evaluate and reward material selection could go a long way towards increasing the use of wood in these types of construction. An emphasis on including more forest certification programs, and a larger emphasis on the use of LCA tools to evaluate the environmental impacts of building materials and assemblies over the entire life-cycle must be included to ensure the next generation of green buildings employ the greenest technologies and materials available.

Green Globes has taken steps towards these improvements; however, a more in-depth LCA process should be developed. LEED on the other hand, must become more inclusive when recognizing third party forest certification programs as to not limit the sources of wood designers can use. Additionally, LEED must include LCA in their credit system in some form or another. No process is currently in place within LEED to require the use of LCA for material selection. Future pilot credits for LEED have been said to address the issue of LCA, but nothing exists within the current LEED 2009 program.

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