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Forest certification and green building standards: overview and use in the U.S. hardwood industry

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ABSTRACT

The environmental movement has emerged as a response to society's concerns about the sustainability of Earth's natural resources and the effects of human activity on the environment and on society's well-being. Effects such as deforestation, air and water pollution, and resource depletion have shown to cause a decline in the quality of life of humans. In response, concerned citizens, non-governmental organizations, and governments have started initiatives to ensure the responsible utilization of our natural resources. Two of these initiatives in particular are relevant for U.S. hardwood products manufacturers: forest certification systems and green building standards. The former are standards created with the purpose of ensuring the sustainable utilization of the forest resource. Most forest certification systems also offer a chain-of-custody certification, to assure customers that label-carrying products indeed originate from certified forests. Green building standards were created to reduce the environmental impact caused by building construction and use.

This paper presents the results from a survey of U.S. hardwood lumber manufacturers, with the objective of learning about the industry's awareness and perceptions about forest certification and green building systems and the impact of the environmental movement on the industry. Questions asked ranged from familiarity with different systems for forest certification and green building standards to these systems' financial and market impact on hardwood lumber industry participants. Responses show that industry participants are more familiar with forest certification systems than with green building standards. Among forest certification systems, the Sustainable Forest Initiative (SFI) is the most recognized, followed by the Forest Stewardship Council (FSC). Almost 30 percent of respondents reported holding some type of chain of custody (COC) certification and 26 percent stated that obtaining certification was in their plans. Out of the respondents who participated in COC certification at the time of the study, only 25 percent reported having benefited financially from it. Awareness with green building standards among respondents is low in general, but the Leadership in Energy and Environmental Design (LEED) and the National Green Building Standard were the most recognized. When asked what the industry should do to obtain the maximum benefits from the environmental movement, most respondents, 36 percent, suggested that the industry should do more to educate the public on the environmentally-friendly nature of hardwood products.

1. Introduction

The environmental, or "green," movement is one of the most important developments in modern society. The environmental movement started in the 1960s out of concerns about environmental sustainability (Friedman, 2007; Kibert, 2005; United Nations, 1987). These concerns have encouraged governments and other policy-setting bodies from around the world to issue strategies aimed at ensuring the sustainable use of the planet's natural resources and the prevention of waste. For this purpose, international organizations such as, for example, the World Wildlife Fund (WWF), Greenpeace (Greenpeace, 2011), or the United Nations Environment Programme (UNEP), have been created to promote the responsible utilization of our resources (UNEP, 2011; WWF, 2011c). Also, businesses are making efforts to include environmental issues in their corporate culture, motivated

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not only by regulation but also by consumer demand (Bowyer, 2008).

As have all industries, the U.S. hardwood industry has the potential to be affected by the environmental movement. Apart from federal and state government regulations, two developments in particular affect how companies in the U.S. hardwood industry sector do business: the growing demand for hardwood products with forest certification (Vlosky et al., 2009) and the increasing adoption of green building standards in the construction industry (U.S. Green Building Council, 2009). In the first part of this manuscript, details are provided about the evolving forest certification and green building construction systems. Then, a presentation and discussion follows about the results from a survey of the U.S. hardwood industry regarding the benefits and challenges of forest certification and green building standards for the industry. The last portion of this paper presents a discussion of the research findings and potential scenarios of future development of forest certification systems and green building construction standards in respect to the U.S. hardwood industry.

1.1. Forest area, type of forests, geographical distribution, and ownership

Forests cover about 4 billion hectares (Table 1), a third of the total global land area. More than half of that area is concentrated in five countries: the Russian Federation, Brazil, Canada, United States, and China (FAO, 2010). Primary forests, defined as forests not significantly disturbed by human activity (FAO, 2010), constitute 36 percent of the total forest area and 57 percent are classified as regenerated forests (where humans have intervened, chiefly with selective logging); and 7 percent is planted forests (e.g., plantations). More than a quarter of the total forest area is designated primarily for production (Table 1).

Ownership of world's forests is largely public (80% according to FAO, 2010). However, communities, individuals, and private enterprises have been playing an increasingly important role in forest ownership and management. Examples are the increasing private ownership of forests in Russia and Africa, or more community involvement in forest management in South America and Southeast Asia (FAO, 2010).

1.2. Benefits from forests

Forests, in addition to representing a major resource for human sustenance, provide carbon sequestration, temperature regulation, protection against erosion and flood control, water storage, and habitat to half of all known plant and animal species (Böswald, 1996; Chlebek and Jarabac, 1996; Lenz, 1967; WWF, 2011b). A quarter of the world's population directly relies on forests for its subsistence, while all humans are in one way or another dependent on products from our forests (FAO, 2011a). Forests offer shelter for most of our terrestrial biological diversity, and play a vital role in conserving water and providing wood and non-wood products for communities around the world. Also, recently, the importance of forests for climate change has been recognized more prominently. While forests are major carbon sinks, global forest degradation or clearing also contributes a sixth to global carbon emissions. However, if forests were managed sustainably on a global scale, they would have the potential to absorb one tenth of the projected carbon emissions by 2050 (FAO, 2011a).

The trunk of the trees is an extremely environmentally-friendly material. In fact, wood is considered the most environmentally-friendly material of all materials used by humans in large quantities as long as timber harvesting is done in a sustainable way. The utilization of wood is carbon neutral at worst, and carbon absorbing at best. Trees harvest carbon dioxide from the atmosphere when growing and release it again when burnt. However, if trees harvested are turned into durable goods, like, for example, the construction of houses, wood's carbon is sequestered and wood serves as a valuable carbon sink. Typical wood substitutes lack this quality. Also, the energy input for processing wood is much smaller than for concrete, brick, or steel (Sutton, 1999). For example, net energy requirement for the extraction, manufacturing, and transportation of softwood lumber is 2.9 million Btu per oven-dry ton, whereas equivalent volumes of steel studs requires almost ten times that amount (26.7 million Btu; Koch, 1992). Also, biofuels from forest biomass are widely acknowledged to be an environmentally-friendly alternative to fossil fuels as the net output of carbon dioxide, heavy metals, ash, and sulfur are small compared to other fuels (FAO, 2011a; Bergman and Zerbe, 2004).

1.3. Deforestation and responses to deforestation

As discussed above, forests are of critical importance for the future of humanity and the survival of species (Böswald, 1996; Chlebek and Jarabac, 1996; FAO, 2011a; Lenz, 1967; WWF, 2011b). However, forests have been and continue to be subject to intensive utilization and logging activities. As a result, large areas of forest lands have been lost mostly to agricultural use but also to urbanization. The world lost 13 million hectares forestland per year during the last decade as compared to 16 million hectares per year during 1990–2000 (FAO, 2010). While most boreal and temperate forest areas have been stabilized lately, the annual loss of 13 million hectares per year during the last decade occurred entirely in tropical forests, one of the most valuable areas in respect to biodiversity and natural regeneration. In fact, the deforestation of tropical forests is estimated to contribute about 15 percent of global total carbon dioxide emissions, a greenhouse gas (Achard et al., 2010). However, there are vast regional differences in respect to deforestation. South America and Africa account for most of the deforestation (7.4 million hectares of net change per year), while Asia's net change in forest area was positive with more than 2.2 million hectares added per year. In fact, China alone added a net 2.0 million hectares annually (FAO, 2010), as China has increased planted forests more than all other countries combined during the last two decades (FAO, 2010). These additional forest areas are needed. To maintain the current level of global wood consumption per capita (0.6 m^3 per person per year), 2.5 billion m^3 wood harvest will have to be added to the current 3.5 m^3 over the next decade to account for population growth and increasing standards of living (Sutton, 1999).

As one response to these challenges, governmental regulation and non-governmental certification systems of forests have been established. The former include laws, restrictions, and taxes, among

Table 1
Forest area distribution by world region, area designated for production, and change in forest area for 2000–2010 (FAO, 2011b).

Region	Forest area (1000 ha) in 2010	Area designated for production (1000 ha) in 2010	Change in forest area 2000–2010 (%)
Africa	674,419	186,027	−0.49
Asia and the Pacific	740,383	230,519	0.19
Europe	1,005,001	524,620	0.07
Latin America and the Caribbean	890,782	83,378	−0.46
The Near East	122,327	46,348	0.07
North America	678,958	97,138	0.03
World	**4,032,905**	**1,131,210**	**−0.13**

others; while private initiatives include, prominently, forest certification (McGinley and Cubbage, 2011).

1.4. Forest certification

Forest certification systems are initiatives with the purpose of promoting the sustainable utilization of forests from an environmental, economic, and social point of view (Bowyer, 2008; Hansen et al., 2006). Differently from regulatory approaches to forest sustainability, the stated driving force for the adoption for forest certification standards was market demand (McGinley and Cubbage, 2011). One main driver for the creation of forest certification systems was to address the need of communicating the environmental quality and sustainability of forest products to consumers. The underlying assumption for the establishment of forest certification systems is that consumers prefer products manufactured by companies responsible with the environment. The hope is that such consumer preference creates a "pull" effect by which companies are incentivized to adopt environmentally-friendly practices (Vidal et al., 2005).

The first forest certification system with a global scope was the system developed by the Forest Stewardship Council (FSC, 2010). The FSC system, formed in 1992 by several major environmental non-government organizations (NGOs) and global retailers (Nussbaum and Simula, 2005; Van Kooten et al., 2005; WWF, 2011a), today maintains an important place in shaping forest certification globally as it is responsible for the certification of the largest forest area of any stand-alone certification system. Other certification systems include the Sustainable Forest Initiative in the United States, launched in 1994 (SFI, 2010), the American Tree Farm System incepted in 1941 (ATFS, 2010), or Canada's Standards Association system, founded in 1996 (CSA, 2011). In 1999, European small forest owners founded the Program for the Endorsement of Forest Certification systems (PFEC, 2011). The PFEC is an umbrella organization that endorses 29 national forest certification systems in 28 countries, including SFI, ATFS, and the CSA system (PFEC, 2011). Other certification systems are the Indonesian Ecolabelling Institute (LEI, 2011), the Brazilian Programa Brasileiro de Certificação Florestal (CERTFOR, 2011), the Malaysian Timber Certification Council (MTCC, 2006), and Chile's Sistema Chileno de Certificación de Manejo Forestal Sustentable (CERTFOR, 2011). These national systems were developed based on other standards and guidelines; for example the Malaysian MTCC is based on the International Tropical Timber Organization (ITTO, 2011) criteria, as is the Brazilian CERFLOR, while the Indonesian LEI system incorporates criteria from the ITTO and FSC (Perera and Vlosky, 2006).

1.4.1. Basics of certification

A forest certification system has three major components: (1) a standard describing the criteria, (2) a certification process to verify whether the standard is met, and (3) accreditation, the awarding of the certificate to organizations who have met the standards. Furthermore, a process has to be in place to review certificates over time to make sure that standards continue to be met. Also, organizations actually carrying out the certification process have to be accredited and monitored, to assure that they are competent and unbiased (Nussbaum and Simula, 2005; Perera and Vlosky, 2006). Typically, the forest certification process involves an independent third party, which is responsible to verify whether the applicant is in compliance with the standard (Baker, 2009). When certification is intended to identify products made from certified material, a labeling and a tracing system are also used. Such labeling systems provide producers with an instrument to communicate the environmental performance of their products and thus influence the buying behavior of consumers. Consumers benefit by having an easily accessible assessment of the environmental attributes of a product or service (Bratt et al., 2011). This labeling and tracing system for products is known as chain of custody (COC) certification and is explained later in this section.

Forest certification standards can be of three types: they can be based on performance, where the forest resource itself is evaluated and compared against performance standards for different components of forest management (FSC is a performance-based system; Visseren-Hamakers and Glasbergen, 2006). The second category of certification systems is based on process (also known as system-based standards), which focus on the adoption of predefined proper procedures by the certificate holder, without establishing performance standards (ISO 14001 is a system-based standard system; Baker, 2009; Perera and Vlosky, 2006). The first is output oriented (e.g., specific performance levels for forest management practices), and the second is input oriented (e.g., prescribe development, implementation, and monitoring of practices; Baker, 2009). The third, such as for example PEFC and SFI systems, use a combination of both performance- and process-focused standards (Visseren-Hamakers and Glasbergen, 2006).

Although forest certification systems may share a common goal to sustainably utilize forest resources, practices used vary widely. For example, Fernholz et al. (2011) compared FSC and SFI standards applied in the United States. This comparison discovered differences in standard structure, with the FSC having three levels: principles, criteria, and indicators, in increasing order of specificity; and the FSI having four: principles, objectives, performance measures, and indicators. Also, FSC contains a larger number of "indicators" than does the SFI (192 and 115, respectively); with indicators providing the most specific language for the auditing process (Fernholz et al., 2011). From a prescriptive viewpoint, these two standards differ in clear-cutting allowances. While SFI has a requirement of 120 acres, valid for all applications, the FSC has varying clear-cutting allowances depending on the region in question. Other differences between these two standards (FSC and SFI) exist in "green-up" requirements (limiting harvest in areas adjacent to clear-cut areas), old-growth forests conservation, genetically modified organisms restrictions, and protection of indigenous peoples' rights (Fernholz et al., 2011; Hansen et al., 2006).

Differences also exist on the main constituents of certification standards. For example, ATFS, PEFC, and SFI are perceived as more supportive of industry and landowners while FSC is seen as more aligned with international non-governmental organizations (Hansen et al., 2006). In any case, all certification systems carry the promise to improve a company's image in respect to managing their forest resources sustainably, facilitating access to markets, and allowing price premiums for certified products.

1.4.2. Chain of custody certification

Assuring the sustainable use of a forest resource is the first step in assuring the quality of use of our forest resources. In the forest products value chain, the original wood resource is subjected to a series of processing steps, starting with trees in the forest and ending with final wood products, such as furniture, kitchen cabinets, or floors in use by end customers. The tree and the resulting semi-finished and finished products typically change ownership several times before reaching the end customer. To be able to capture the benefits from sustainable management of our forest resources through, among other things, higher demand for such products, higher prices, or a better corporate image, the source of the material needs to be certified to allow customers to have verifiable information about the origin of the material. Thus, a system is needed to ensure that claims made about the origin of a particular piece of wooden material harvested from sustainable

utilized forests is valid when this product reaches its end customer. For this purpose, chain of custody certification (COC) has been introduced (Howe et al., 2005). Chain of custody, according to Vidal et al. (2005 p. 346), "… Is the custodial sequence that occurs as ownership or control of the wood supply chain is transferred from one custodian to another along the value stream," while Nussbaum and Simula (2005 p. 64) define COC as "…*All the changes of custodianship of forest products*, during the harvesting, transportation, processing and distribution chain from the forest to the end use…"Thus, a COC system includes all the technology, processes, and documentation used to monitor the origin, current location, and destination of wooden materials (Dykstra et al., 2002). To make sure that the chain of custody standards are met, a combination of segregation (maintaining materials physically separate), identification (certified material clearly labeled), and documentation ensuring that there is no mixing of certified and non-certified material are used (Nussbaum and Simula, 2005).

Two basic systems are used for COC certification: the physical separation approach and the percentage-based approach (Anderson and Hansen, 2003; Howe et al., 2005). In the physical separation system, COC standards require physical separation of certified and non-certified material during the entire transformation process. Thus, personnel, accounting practices; material storage and handling, material processing, and shipping practices have to handle and segregate certified material at all times. In the percentage-based system, COC systems only need to account for the total material flow to ensure that the percentage of certified material going into a process equals the percentage of certified material in the final products (Anderson and Hansen, 2003; Howe et al., 2005). The PEFC standard offers both physical separation and percentage-based methods (PEFC, 2010), as does the FSC (FSC, 2010). As with forest certification, COC certification includes the use of a label that conveys the message that the material is sourced from certified forests. Assessment and verification of COC systems are usually made by a third party (Anderson and Hansen, 2003; Hansen et al., 2006).

1.4.3. Forest certification in the United States

In the U.S., the four forest certification systems used are the Sustainable Forest Initiative (SFI, 2010), the Forest Stewardship Council (FSC, 2010), American Tree Farm System (ATFS, 2010), and the Program for the Endorsement of Forest Certification (PEFC, 2011b). The area of certified forests in the United States has increased over the last decade, although there are signs that this growth is slowing. Large parts of the FSC-certified forests in the U.S. are located in the upper Midwest and the Northeast, and are publicly-owned and handled by a few certificate holders (Fernholz et al., 2010). SFI-certified forests are more evenly distributed (36% in the South, 24% in the West, 41% in the Central and Northeast regions), a large part is publicly-owned, and roughly 85% of the area is managed by only a third of all certificate holders (Fernholz et al., 2010; SFI, 2011). The U.S. federal government has been active on the international stage in regards to forest certification through some of its agencies like the State Department, the Forest Service, and the U.S. Agency for International Development, or USAID (U.S. Forest Service, 2008a,b) to support the sustainable use of the forest resource. USAID, for example, has played an important role in incentivizing forest certification in Bolivia, which resulted in one of the success stories of forest certification (USAID, 2004). In the U.S., the Federal government owns a third of all forest lands; however the Forest Service has not endorsed any certification system and there is limited participation of federal forests in certification (U.S. Forest Service, 2008a,b; Fernholz et al., 2010; U.S. Forest Service, 2011). Table 2 shows the latest figures of forest area certified and the number of COC certifications awarded by each system (SFI, FSC, PEFC, ATFS) in the U.S. Fiber from ATFS-certified forest areas are recognized as a source for PEFC and SFI chain-of-custody programs, and thus it does not have its own COC system (ATFS, 2010).

Table 2
Forest certification systems in the world and the United States. Includes both hardwood and softwood forests.

System	World-wide		United States	
	Certified forest area in million ha [% of global total[b]]	COC certifications (units)	Certified forest area in million ha [% of U.S. total[b]]	COC certifications (units)
FSC[c]	134.8 [3.3%]	19,670	13.7 [4.5%]	3742
SFI[e]	78.0 [2.6%]	996	23.9 [7.7%]	885
ATFS[f]	10.5 [0.3%]	–	10.5 [3.4%]	–
PEFC[d,a]	234.6 [5.8%]	8248	34.0 [11.1%]	355

[a] PEFC is an umbrella organization that includes SFI, CSA, and ATFS.
[b] Calculated based on totals in FAO's Global Forest Resources Assessment 2010 (FAO, 2010): 4033 million ha globally and 304 million ha for the U.S.
[c] Forest Stewardship Council (FSC, 2011).
[d] Programme for the Endorsement of Forest Certification (PEFC, 2011a).
[e] Sustainable Forest Initiative (SFI, 2011).
[f] American Tree Farm System (ATFS, 2010).

1.4.4. Benefits and challenges of forest certification

One of the major incentives for companies to certify their operations is the belief that consumers will be willing to pay a premium for environmentally-certified products. However, in addition to price premiums, companies are believed to benefit from certification by improving their reputation as being long term-focused and sensible to external events, thus potentially protecting market share and financial position (Vidal et al., 2005). While there has been considerable growth in participation in forest certification and COC certification, a number of studies (Perera et al., 2008; Sustainable Forest Initiative, 2009; Vlosky et al., 2009) suggest that, although there is a growing awareness of forest certification initiatives by both consumers and suppliers, the U.S. market for forest products has not yet embraced forest certification.

A survey among primary wood products manufacturers (e.g., sawmills) in Wisconsin (Hubbard and Bowe, 2005) found that only a small percentage held COC certification (5.4 percent, e.g., 13 of 239 firms). Also, the study found that the level of awareness for certification was low. In fact, only 16 percent of all primary wood products manufacturers in Wisconsin surveyed reported being very familiar with certification while 54 percent were not familiar with certification at all (Hubbard and Bowe, 2005). Even respondents participating in COC were not able to name the advertised advantages of certification (such as, financial benefits from price premiums and increased market share; Vidal et al., 2005). Only 13 respondents (6.5 percent of COC-certified primary wood products manufacturers surveyed) agreed when asked whether certification would allow them to charge a premium for their products (Hubbard and Bowe, 2005).

In a different study by Ozanne and Vlosky (2003), a comparison of perceptions about environmentally-certified wood products among homeowners in 1995 and 2000 found little or no progress in regards to increased purchases of certified products and willingness to pay premiums for certified products. In yet another study by Perera et al. (2008), home-center retailers were surveyed in 2005 and 2006 regarding attitudes toward environmental certification of wood products. Retailers ranked the importance of certification last in a list of 21 criteria for purchasing decisions. A telephone survey conducted in 2008 (Anonymous, 2008) produced similar results as respondents ranked "environmental friendliness" last after price and quality as purchase decision criteria for wood furniture.

However, the same study also found that 19 and 12 percent of respondents, respectively, were familiar or very familiar with FSC and SFI and close to 40 percent of respondents stated a willingness to pay a 15 percent price premium for environmentally-friendly wood furniture.

Thus, while progress has been made in the certification of the sustainable use of forests, challenges remain. Demand for certified products has yet to gain a substantial share of the total market and has to result in the sellers' ability to charge price premiums to cover the additional expenses incurred from certification. Research seems to demonstrate that most customers do not yet differentiate certified from non-certified products, let alone between certification systems (Fernholz et al., 2010). Moreover, it seems that participants in forest certification systems have not yet achieved the expected financial benefits from certification. However, the emergence of green building standards has the potential to enable significant growth in the demand of certified products.

1.5. Green building

Buildings are major contributors to the environmental effects of human activity; they consume about 30 percent of all raw materials, 42 percent of all energy, and 25 percent of all water claimed by human society (Ofori et al., 2000). Buildings also are responsible for 40 percent of all pollution emissions (Ofori et al., 2000). In the U.S., buildings are the largest consumers of energy (39 percent) and the residential, commercial, and industrial buildings cause 38 percent of the nation's total carbon dioxide emissions while consuming 12 percent of all water claimed by society (Brown et al., 2005; EPA, 2009). Factors that contribute to the environmental performance of buildings are design, orientation, location, building materials, user behavior, energy and water inputs during use, and demolition (Reijnders and van-Roekel, 1999). Buildings also are responsible for the "sick building syndrome" (The Economist, 2004, p. 2), a term that describes "…Health and comfort effects associated with time spent inside a building, but with no specific illness or cause identified" (EPA, 2010b).

The numbers discussed above, among other things, have motivated the emergence of the green building movement (Retzlaff, 2008; The Economist, 2004). According to the U.S. Environmental Protection Agency's (EPA) definition, green building is "…The practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle…" (EPA, 2011). To enable the creation of environmentally responsible and resource-efficient buildings, standards have been developed and put into practice in numerous countries worldwide to assess the environmental performance of buildings. These standards are commonly referred to as green building rating systems (Ozolins, 2010). The majority of these green building rating systems contain guidelines for energy-efficient products, sustainable materials, and environmentally-friendly construction practices. These systems also promote the use of materials with recycled content and indoor air quality (Bowyer, 2008). The Food and Agriculture Organization (FAO) of the United Nations has identified green building practices and life cycle analysis as suitable strategies to improve the sustainability of human activity and to strengthen the profitability of the forest industry (FAO, 2011b).

The first green building standards system was the Building Research Establishment Environmental Assessment Method (BREEAM) established in Great Britain in 1990 (BREEAM, 2011). In North America, the Leadership in Energy and Environmental Design (LEED) system, launched in March 2000 by the United States Green Building Council (USGBC, 2011) had a pioneering role. The World Green Building Council, a union of 20 green building councils from five continents (WGBC, 2010), defines a green building council as "…Organizations that partner with industry and government to transform their building industries toward sustainability by the adoption of green building practices." Some of these organizations have established their own set of green rating systems, however, all pursue the underlying purpose of creating environmentally responsible and resource-efficient buildings (EPA, 2011). Table 3 shows a selection of important green building rating systems worldwide (USGBC, 2011; BREEAM, 2011; JSBC, 2006; Green Building Council of Australia, 2011; European Commission, 2011; New Zealand Green Building Council, 2008; The Green Building Council of South Africa, 2011; HKBEAM, 2003).

The LEED and BREEAM systems are probably the most successful ones, not only on a national level in the U.S. and the UK, but internationally. The LEED program, for example, has certified over 10,200 projects in more than 50 countries, totaling an area of 1.8 billion square feet (U.S. Green Building Council, 2011b). The two systems have been used as models for other countries' green building standards, such as Russia that has adapted LEED, BREEAM, and the German DGNB into their green building initiative (RuGBC, 2011). Canada, Brazil, and Mexico have adopted LEED as their major green building rating system (CaGBC, 2011; CMES, 2010; Green Building Council Brasil, 2008) while BREAAM has two geographical systems for Europe and the Gulf states (Qatar, Abu Dhabi, and Dubai) (BREEAM, 2011). In Japan, the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) covered 4000 projects and a population of 30 million as of March of 2009 (Yoshida, 2009). The German green building certification system (DGNB) was launched in 2009, and has certified more than 200 projects in Germany and abroad so far (DGNB, 2011). The DGNB and the LEED systems have also made inroads in China, probably the most promising construction market in the planet at the present time, where the World Bank predicts that by 2015, half of the world's construction will take place (Boardman, n.d.).

The typical green building rating system awards points in several categories for better compliance with either a prescriptive path (e.g., complying with specific guidelines issued by a given

Table 3
Green building rating systems, worldwide.

System	Scope	Reference
Leadership in Energy and Environmental Design (LEED)	United States and International	(USGBC, 2011)
Building Research Establishment Environmental Assessment Method (BREEAM)	UK and International	(BREEAM, 2011)
GreenBuilding Programme (GBP)	European Union	(European Commission, 2011)
German Sustainable Building Council (DGNB)	Germany and International	(DGNB, 2011)
Comprehensive Assessment System for Built Environment Efficiency (CASBEE)	Japan	(JSBC, 2006)
Green Star	Australia	(Green Building Council of Australia, 2011)
Green Building Council Russia (RuGBC)	Russia	(RuGBC, 2011)
Green Star New Zealand and Homestar	New Zealand	(New Zealand Green Building Council, 2008)
Green Star South Africa	South Africa	(The Green Building Council of South Africa, 2011)
Hong Kong's Building Environmental Assessment Method (BEAM)	Hong Kong	(HKBEAM, 2003)
National Green Building Standard	United States	(National Association of Home Builders, 2011)

green building council) or a performance path (e.g., proving to a given green building council that a building solution chosen complies with goals set). Points are cumulative and result in a building obtaining a certain level of certification. For example, in the LEED standard (U.S. Green Building Council, 2010), a building that earns 60–79 points total is granted a "gold" certification. Similarly, the BREEAM system uses a rating system that grants specific certification levels (e.g., "good," "very good," or "excellent") to projects according to the number of credits accumulated (BREEAM, 2011).

There is growing evidence that these voluntary systems can result in environmental performance gains and also make economic sense (Koehler, 2007; The Economist, 2004). Using green building strategies typically increase the initial cost of a building compared with conventional construction practices, but these higher initial costs are in part offset by the energy and water savings achieved over the lifetime of the building (Chang et al., 2011). For example, Yudelson (2008) showed that green-buildings can be up to 30 percent more energy-efficient, can save 30–50 percent in water consumption, and may result in 50–90 percent less solid waste from construction. Research also supports that green building standards adoption for non-residential construction can have beneficial impacts on organizations, mainly by improving the quality of work life and customer relationships (Heerwagen, 2000). Less obvious and even more challenging to quantify are benefits such as higher sales when stores use skylights, or students performing better in classrooms with natural light (The Economist, 2004).

Green building systems, due to a desire of mostly local building interests, have multiplied over the past decade. In the U.S., a number of green building systems and labels have been created, resulting in more than 40 regional and national green building systems (Bowyer, 2008). Arguably, the four most recognized green building systems in the U.S. are the Leadership in Energy Environmental Design, or LEED (CaGBC, 2011; USGBC, 2011), the Green Globes (The Green Building Initiative, 2010), the National Association of Home Builders' (NAHB) National Green Building Standard (National Association of Home Builders, 2011), and the EPA's Energy Star system (EPA, 2011). However, examples of notable State and regional systems, such as, for example, the Austin Green Builder System (Austin Energy, 2010), the EarthCraft system (EarthCraft, 2011), or the Built Green Colorado System (Built Green, 2010) exist. Table 4 lists the five major green building systems in the U.S., as well as the number of certified projects (until 2011). Recent developments show that building codes start to incorporate green building requirements into their provisions. For example, the state of California enacted in 2010 its Green Building Standards Code (California Building Standards Commission, 2010), and the International Code Council, which is the reference source for most building standards in the U.S., is in the final phases of development of its 2012 International Green Construction Code (ICC, 2011).

Table 4
Major green building standards in the United States.

System	Registered/certified projects	Source
LEED[a]	9658 certified projects 38,115 registered projects	(U.S. Green Building Council, 2011a)
Green Globes[a]	84 certified new constructions 94 certified existing buildings	(The Green Building Initiative, 2011)
NAHB Green Building[a]	5744 certified projects	(National Association of Home Builders, 2011)
Energy Star[a]	15,170 certified commercial buildings 106 certified industrial plants Over one million qualified homes	(EPA, 2011)
EarthCraft[a]	Over 13,000 projects	(EarthCraft, 2011)

[a] Updated to September of 2011.

All green building standards share a similar objective: to reduce the environmental impact of new and existing construction throughout the life cycle of the building (EPA, 2011). As such, a wide variety of stakeholders see benefits in green building standards. Policy makers favor green building initiatives because they reduce the environmental impact of the construction, operation, and removal of buildings while also facilitating the achievement of energy independence (Office of Energy Efficiency and Renewable Energy, 2011). Homeowners achieve significant savings from reduced energy usage of a residence built with green building standards while getting satisfaction from the knowledge that their footprint on the environment is lowered (EPA, 2010a). Occupants of office and industrial buildings are interested because certified buildings have lower negative effects on their health (The Economist, 2004), although some systems have yet to include the reduction of chemicals of concern into their standard systems (Atlee, 2011). Green building-owning companies benefit from reduced operational costs and differentiation from being recognized as taking care of the environment (EPA, 2010a). Lastly, there is evidence that construction companies see a benefit from the reputation gain, a reduction in construction and operation costs, and more favorable land and financing options (Zhang et al., 2011).

However, green building systems have been criticized by the forest products industry and some researchers because most of them require proof of responsible practices (i.e., environmental certification) only for wood and no other materials (Bowyer, 2007). Also, some of these green building systems encourage the use of materials such as, bamboo or recycled steel over wood, despite evidence that these materials are less beneficial for the environment (Bowyer, 2007). Additionally, decisions about awards for certain materials or practices are often made without considering insights gained from life cycle analysis. Another critique to green building standards is that they do not require from other materials (e.g., steel and concrete) what is required from wood: to demonstrate that they have been responsibly produced, i.e., ensuring protection of flora, fauna, water and soil; and respecting workers and communities well-being (Mitchell, 2009).

Nevertheless, while vast differences in the incorporation of certified wood into green building codes exist among these different systems, green building systems are becoming an important driver for demand of certified wood. For example, the LEED system only recognizes FSC-certified material (U.S. Green Building Council, 2010), whereas the Green Globes system recognizes all major North American forest certification systems (FSC, SFI, ATFS, PEFC, and the CSA; Smith et al., 2006). Some forest products specialists argue that green building standards need to use globally recognized life cycle analysis standards to rate the actual environmental impact of construction materials (Anonymous, 2007; Bowyer, 2007). Life-cycle analysis incorporates attributes such as embodied energy and carbon impact into a given material's impact assessment (Falk, 2009). To this end, in an effort of the forest products industry to be proactive, the Consortium for Research on Renewable Industrial Materials (CORRIM) has been developing a "*scientifically sound database of the environmental and economic impact*" of wooden building materials, from planting to demolition (CORRIM, 2010).

Given the growing importance of forest products certification and green building standards systems, questions regarding the impact that the green movement has on U.S. hardwood lumber manufacturers have been raised. The U.S. hardwood lumber industry is a major supplier to the U.S. construction market, providing lumber valued at more than $5 billion for the manufacture of products ranging from flooring, running trim, stairs, doors,

and windows, to kitchen cabinets and furniture (U.S. Census Bureau, 2006). For U.S. hardwood lumber producers, the construction and the building furnishing market together make up an estimated 36.1 percent of their business (Espinoza et al., 2011), and thus, answers to questions as to how U.S. hardwood lumber manufacturers are impacted by forest certification and green building systems are critical. Also, other questions like, for example, how the industry adapts, what opportunities might evolve and are being pursued, or if the industry is benefiting from these trends, are of considerable interest. Thus, the objective of this research was to assess the level of awareness of forest certification and green building systems among U.S. hardwood lumber producers. In particular, focus was given on familiarity with forest certification systems and green building standards, level of adoption, benefits of chain of custody certification and green building standards, and industry members' opinions about the green movement.

2. Materials and methods

U.S. hardwood lumber producers (NAICS code 3211131), commonly referred to as hardwood sawmills, were surveyed using Dillman's Total Design method (Dillman, 2009). A total of 1216 U.S. hardwood lumber manufacturers were mailed a two-section questionnaire, the first of which requested information about changes in the hardwood lumber supply chain, and the second section containing nine questions asking about the impact of the environmental movement on the hardwood industry. Questions in this second section of the survey conducted in 2009, which provided the material discussed in this manuscript, ranged from awareness of forest certification and green building systems to financial benefits from participating in such systems. Two sets of questionnaires and reminder postcards were mailed with a two-week separation between mailings. At the closing of the survey, 137 usable questionnaires were returned. After accounting for closed mills, undeliverable addresses, duplicates, and companies not in the lumber manufacturing business, the adjusted response rate was 13.9 percent.

Non-response bias, e.g., the existence of statistical differences between respondents and non-respondents (Armstrong and Overton, 1977), was assessed by comparing early and late respondents. This practice assumes that there is a continuum between fast respondents and late respondents, and that late respondents can be used as a proxy for non-respondents (Dalecki et al., 1993; Etter and Perneger, 1997; Lahaut et al., 2003). Respondents were categorized in four "waves," corresponding with each mailing (two questionnaires and two postcards), and compared on lumber sales in 2008 (a proxy for firm size). No significant differences ($\alpha = 0.05$) were found among the waves (Kruskal–Wallis $p = 0.06$).

About three quarters of respondents (76 percent) were employed with companies having a facility only in one location. On average of all respondents, hardwood lumber manufacturing made up 80 percent of respondents' total sales. The geographic distribution of respondents consisted of companies in the South (43 percent), followed by the Midwest (30 percent), the Northeast (22 percent), and the West (1 percent). Companies with facilities in more than one region made up 4 percent of all respondents.

This study shares the typical limitations of conducting a survey (Alderman and Salem, 2010; Alreck, 2004; Krosnick, 1999). Most notably, answers come most likely only from one person of each company's management team, and responses might not necessarily reflect the views of other members of the organization or organizational policy (Alderman and Salem, 2010). Also, the survey was conducted in the second half of 2009, thus responses may have been influenced by the crisis in the housing market and the economic recession.

3. Results and discussion

The survey asked U.S. hardwood lumber manufacturers questions about the following topics: "*Familiarity with forest certification and green building standards*," followed by "*Extent of chain of custody certification*," "*Financial benefits of chain of custody certification and green building standards*," "*Demand for environmentally-certified products*," and "*Perceptions about the environmental movement*." Results from the 137 answers as well as a discussion of the findings are shown below.

3.1. Familiarity with forest certification and green building standards

The first question in the section about the impact of the environmental movement on the hardwood industry was aimed at discovering the level of awareness of hardwood lumber manufacturers in respect of forest certification and green building systems. Responses (Fig. 1) revealed that there is a higher degree of familiarity with forest certification systems than with green building

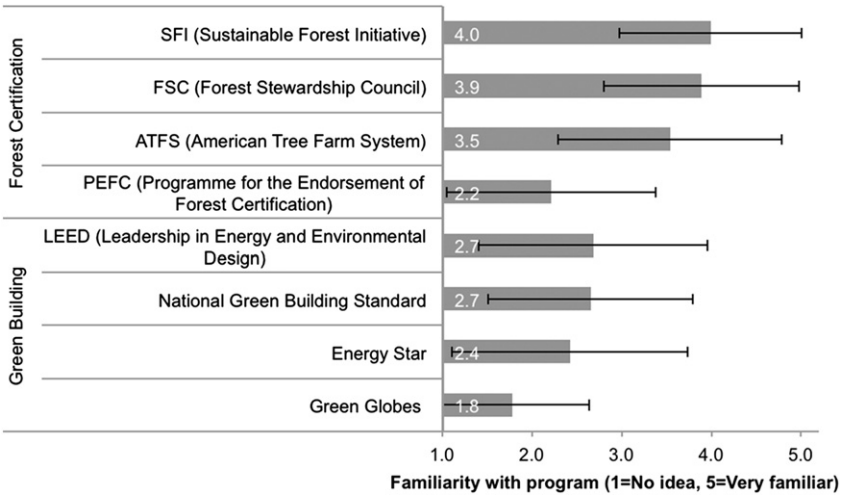

Fig. 1. Survey respondents' familiarity with forest certification and green building systems. Likert scale from 1 to 5, 1 = No idea, 2 = Not familiar, 3 = Heard about it, 4 = Familiar, and 5 = Very familiar. Error bars show one standard deviation above and below the mean.

Table 5
Extent of chain of custody certification among hardwood lumber producers.

Certification system	COC-Certified	Planning to certify
	% of respondents	
SFI (Sustainable Forest Initiative)	17.5	15.1
FSC (Forest Stewardship Council)	16.7	15.9
ATFS (American Tree Farm System)	3.2	6.3

systems. On a scale ranging from 1 ("No idea") to 5 ("Very familiar"), the respondents' average familiarity with forest certification was 3.4, as compared to an average familiarity rating of 2.4 for green building standards (significantly different, Kruskal Wallis test, $p < 0.001$). A potential explanation for this difference in familiarity is that hardwood lumber manufacturers are closer to the source of raw material (forest resources and forest certification systems) than to the final customer (residential and commercial buildings and green building systems). Also, green building is a relatively newer concept than forest certification and thus may not have reached the same level of awareness with all industry participants, yet.

Among forest certification systems, respondents had the highest degree of familiarity with SFI (average response 4.0), followed by FSC (3.9), then ATFS (3.5) and PEFC (2.2). This familiarity ranking is consistent with what is reported by the different certification systems (SFI, FSC, PEFC, and ATFS) as to the total certified area in North America (over 73 million hectares for SFI (SFI, 2010), 52.4 million for FSC (FSC, 2011), and 23 million for ATFS (ATFS, 2010)). PEFC is a special case in that it is an "umbrella" organization that endorses other forest certification systems (PEFC, 2011b), and is relatively new in North America.

Among green building standards, the NHAB National Green Building Standard and the Leadership in Energy and Environmental Design (LEED) systems were the most recognized (average response of 2.7 for both), while EPA's Energy star (average response 2.4) and the Green Globes system (average response 1.8) were less widely known by the U.S. hardwood lumber manufacturers surveyed.

3.2. Extent of chain of custody certification

The survey also strived to learn about the extent of respondents firms' participation in chain of custody (COC) certification. Specifically, companies were asked if they were COC-certified, or were planning to obtain certification (Table 5). Overall, 29 percent of respondents reported to have chain of custody certification in at least one of the existing forest certification systems at the time of the survey. Twenty-six percent were planning to certify their operations in the future. Percentages in Table 5 do not add up to 29 and 26 percent because several companies reported being certified or planning to certify with more than one system.

As shown in Table 5, nearly the same percentage of hardwood lumber manufacturers was SFI- and FSC-certified (17.5 and 16.7 percent, respectively). Interestingly, these results do not reflect the distribution of current COC certifications in United States by systems, as the ratio between FSC and SFI certifications surpasses 4 to 1 (Table 2). Possibly, these results indicate that FSC is more prevalent among secondary manufacturers (such as kitchen cabinet or furniture manufacturers), distributors, and retailers, but not among sawmills. Among respondents, only 3.2 percent had ATFS certification. ATFS was designed specifically for non-industrial landowners, and does not have a COC certification process; however, fiber from ATFS-certified forests is eligible for SFI, PEFC, or CSA certification (Anderson and Hansen, 2003; ATFS, 2010). Therefore the small percentage reported might reflect the number of hardwood sawmill operating with SFI or PEFC certification that uses ATFS-originated material. As displayed in Table 5, of all the respondents planning to certify, 15.1 percent were planning to adopt the SFI standard and 15.9 the FSC system, while 6.3 percent planned to use the ATFS certification system to certify their operations.

3.3. Financial benefits of chain of custody certification and green building standards

Forest certification or building standard systems are not legislated by the government or other organizations and they are, thus, voluntary. Therefore, their success depends on the promise of economic advantages to encourage adoption by industry participants. Such economic advantages can originate from growing market demand for certified products, the ability of producers to charge price premiums on certified or standard-conforming products, or benefits from creating access to attractive markets at home or abroad, among other things. Thus, companies that are certified by at least one of the systems were asked whether they derive financial benefits from certification. Surprisingly, three quarters of survey respondents (74.1 percent) that reported having some kind of chain of custody certification answered that they were not obtaining any financial benefits from certification, a result consistent with findings by Vidal et al. (2005). Vidal et al. (2005) reported in their study of COC certification among Canadian and U.S. lumber manufacturers that a majority of COC-certified respondents disagreed with the statements that "increased profits" and "increased market share" were benefits from certification.

Green building standard systems are based on a point system, where points are assigned to a project for specific verified practices or materials used. Thus, builders participating in green building systems need to know how a given product is rated in a specific green building standard system. Only 11.4 percent (Fig. 2) of

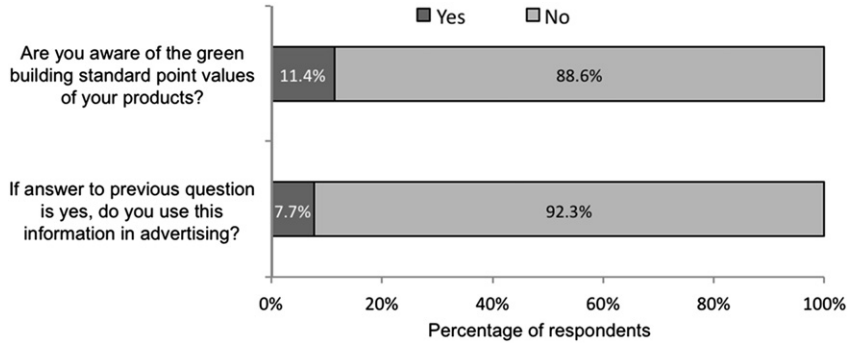

Fig. 2. Survey respondents' familiarity with green building standard point values for their product and its use in advertising.

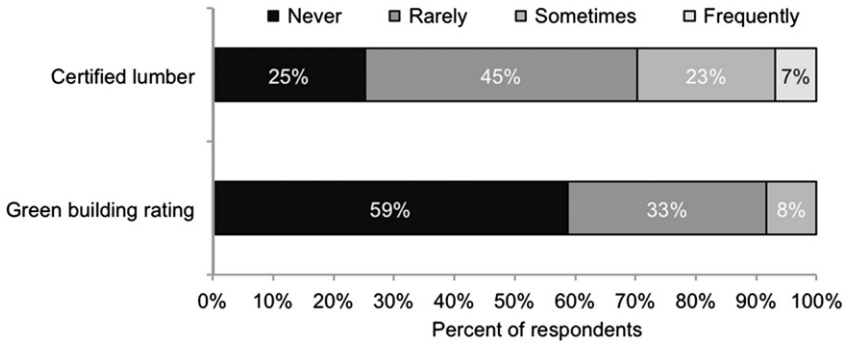

Fig. 3. Customer frequency asking for certified lumber or green building rating of products sold by U.S. hardwood lumber manufacturers.

responding U.S. hardwood lumber manufacturers reported being aware of this information when asked if they knew the standard point values of their product assigned by the different green building systems. Of these 11.4 percent, only about half (7.7 percent) reported using the standard point value in their advertising efforts (Fig. 2).

3.4. Demand for environmentally-certified products

Since participation in forest certification and green building standard systems is voluntary driven by market demand, (end-) consumer awareness is critical as is their willingness to purchase certified material or products, possibly at a premium. Ultimately, this awareness and willingness to purchase certified material or products at a price premium determines the viability and the participation rate for those systems. Therefore, the survey aimed at learning about the frequency at which customers of U.S. hardwood lumber manufacturers ask for certified lumber and/or the green building ratings of the products sold (Fig. 3). Thirty percent of responding companies reported being asked for certified lumber by their customer "frequently" or "sometimes." However, 25 percent of respondents indicated that they have "never" been asked about certified lumber and 45 percent said that they are "rarely" asked about certified lumber (Fig. 3). Respondents also indicate that they face much fewer inquiries about green building standard ratings than they do about forest certification (Fig. 3). None of the responding hardwood lumber manufacturers indicated that they are "frequently" asked about green building standard ratings of their product. Only 8 percent indicated that they are "sometimes" asked for this information. Thirty-three percent indicated that they are "rarely," and 59 percent of respondents reported that they have never been asked about the green building rating of their products.

3.5. Perceptions about the environmental movement

The U.S. hardwood industry is not known for progressive talk or actions. Therefore, discussions about the relatively young, emerging environmental movement are frequent, especially as the industry's raw material supply from the nation's forests is at the forefront of the discussion. Not surprisingly, some industry participants refer to the environmental movement as an unneeded distraction. Others see it as a golden opportunity for the industry's renewable products. To obtain a better understanding about the sentiments within the industry in respect to the environmental movement, U.S. hardwood lumber producers were asked about their level of agreement with several statements listed in Fig. 4. Using a Likert scale, answers could range from 1 (strongly disagree) to 7 (strongly agree).

Most respondents agree that demand for certified lumber for green-buildings (e.g., buildings built according to one of the green building standards) will increase (44 percent of respondents indicate a level of agreement of 5 or higher, compared to 23 percent with agreement of 3 or lower, Fig. 4). A similar percentage of respondents (43 percent) also concur that customers are increasingly concerned about the environment. Furthermore, a third of

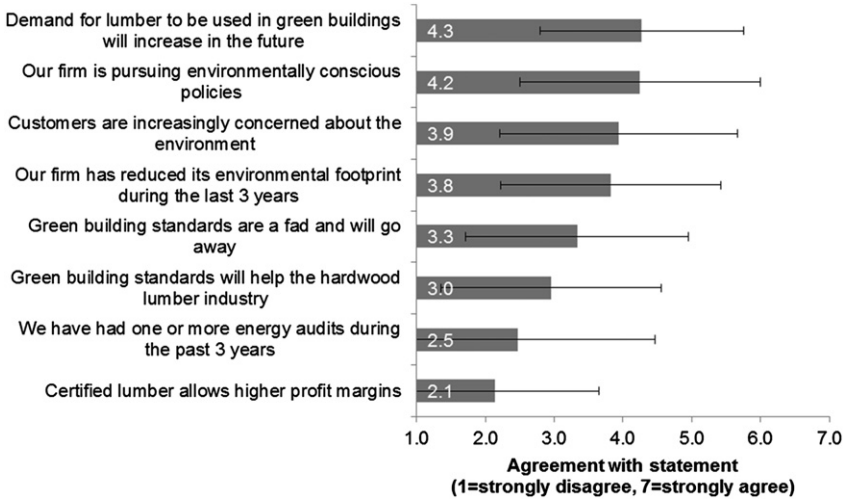

Fig. 4. Survey respondents' agreement with statements about the green movement, lumber certification, and green building standards using a Likert scale from 1 to 7. Error bars show one standard deviation above and below the mean.

respondents stated that their companies have reduced their environmental footprint during the last 3 years (32 percent) and that they are pursuing environmentally-conscious policies (39 percent). However, most respondents do not think that selling certified lumber allows higher profit margins (81 percent of respondents indicating a level of agreement of 3 or lower), or that green building standards will help their industry (62 percent with level of agreement of 3 or lower).

Lastly, the questionnaire included an open-ended question about what the industry should do to benefit from the green movement. A majority of respondents (36 percent) stated that efforts should focus on educating the public and promoting hardwood as a "green" material. Twenty-seven percent of respondents thought that standards should be changed, streamlining and improving the certification process. The most common suggestions to improve the certification process were to adapt standards for small landowners, followed by a simplification of the certification process, which would increase the number of landowners and companies participating in certification. The challenges for small forest owners to be certified are well known and were a major motivation behind the creation of the PEFC certification system (Nussbaum and Simula, 2005). Other responses were along the lines of making certification more affordable for small operations, charge more for certified products, and improving existing legislation. A substantial number of respondents (24 percent) expressed their opinion in negative terms, going from "eliminate certification" to considering the green movement as "a hoax." While such statements may be understandable given the difficulties of the industry to recapture their outlays for certification and green building standard systems, reality is more likely that market opportunities associated with certification and green building will increase for the hardwood industry in the future. Also, given the superior performance of wood as a material in all aspects of its life cycle (Bowyer, 2008; Falk, 2009; Wilson et al., 2005; Wilson et al., 2010), the industry has a tremendous opportunity to differentiate its material from competing materials and can, hopefully, look forward to a rewarding future.

4. Summary

The environmental movement emerged from concerns about the impact of human activity on the environment and human health. As a response, governments have enacted laws regulating and limiting potentially harmful emissions and activities, while international organizations have started programs with the aim at protecting and improving the environment, and private enterprises have incorporated sustainability into their corporate responsibility pledges. Given forests critical importance for biodiversity, carbon sequestration, climate, water and air, and the communities who live close to them, they have received considerable attention. Regulatory and voluntary systems have been created to manage forest utilization in a way that is more sustainable. Prominently, forest certification systems have emerged as market-based alternatives to foster sustainable use of the world's forests and green building standards have been created with the purpose of reducing the environmental impacts of buildings since construction activity has been identified as a major contributor to environmental degradation. These green building standards place considerable importance on using environmentally preferable materials, one of which is wood from certified forests.

For the U.S. hardwood industry, forest certification and green building systems represent both challenges and opportunities. On the positive side, these initiatives can have a positive impact on customer demand for wood products as it is generally accepted that wood as a building material and energy source has less negative impacts on the environment than do its substitutes. Challenges for a full acceptance of wood as an environmentally preferable material exist, however. Most green building standards do not consider the full life cycle of construction materials into their rating systems, favoring materials with questionable environmental merits. These systems typically also only demand proof of environmental performance (i.e., certification) for wood-based materials. Another obstacle that proponents of wood as a preferable material face is that differentiation between certified and non-certified wood products is not yet strong in the mind of the consumer. Thus, operations that are not certified and do not follow sustainable practices in their activities continue to exist and affect the public's perception of wood negatively.

The survey discussed in this manuscript among U.S. hardwood lumber manufacturers, to investigate the awareness and adoption of environmental programs, such as forest certification systems and green-building standards has uncovered potential benefits and challenges for the industry. According to survey respondents, so far, price premiums hoped for environmentally-certified lumber have not yet materialized in the market place. Also, although green building standards are poised to become an important driver for certified lumber, awareness of green building systems and standards was relatively low among respondents at the time of this survey. However, industry participants increasingly realize that being perceived by customers as a socially and environmentally responsible market participant is in their interest and may open doors to new markets. Agreement also exists among respondents that the industry needs to do more in terms of educating the public about the environmental benefits of wood as a construction material.

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References

Achard, F., Stibig, H.J., Eva, H.D., Lindquist, E.J., Bouvet, A., Arino, O., et al., 2010. Estimating tropical deforestation from earth observation data. Carbon Management 1 (2), 271–287.
Alderman, A., Salem, B., 2010. Survey research. Plastic and Reconstructive Surgery 126 (4), 1381–1389.
Alreck, P.L., 2004. The Survey Research Handbook, third ed., vol. xxv. McGraw-Hill/Irwin, Boston, 463 pp.
Anderson, R.C., Hansen, E.N., 2003. Forest Certification: Understanding Ecolabel Usage Requirements. Unpublished Report. Oregon State University.
Anonymous, 2007. Status, shortcomings of forest certification and green building programs explored at Midwest Section Meeting. Forest Products Journal 57 (1/2), 16.
Anonymous, 2008. Consumer Attitudes toward Environmentally-friendly Products and Eco-labeling. Yale School of Forestry and Environmental Studies.
Armstrong, J.S., Overton, T.S., 1977. Estimating nonresponse bias in mail surveys. Journal of Marketing Research 14 (3), 396–402.
ATFS, 2010. American Tree Farm System. Retrieved September 5, 2011, from: http://www.treefarmsystem.org/.
Atlee, J., 2011. Selecting safer building products in practice. Journal of Cleaner Production 19 (5), 459–463.
Austin Energy, 2010. Austin Energy Green Building. Retrieved January 9, 2011, from: https://my.austinenergy.com/.
Baker, I.C., 2009. Chain-of-custody Certification in the Appalachian Hardwood Region – Trends, Drivers, and Challenges. Unpublished Doctoral dissertation, University of Georgia, Athens, Georgia.
Bergman, R., Zerbe, J., 2004. Primer on Wood Biomass for Energy. Retrieved from: http://www.dof.virginia.gov/mgt/resources/pub-usda-fs-primer-on-wood-biomass-for-energy.pdf.
Boardman, P., n.d. China's Building Boom. Retrieved from: www.forestprod.org/internationaltrade06boardman.pdf.
Böswald, K., 1996. The Importance of Forests and Forestry for the Carbon Cycle: An Analysis for Bavaria, Germany, vol. 159, 147 pp.

Bowyer, J., 2007. Green building programs – are they really green? Forest Products Journal 57 (9), 6.
Bowyer, J., 2008. The green movement and the forest products industry. Forest Products Journal 58 (7/8), 6–13.
Bratt, C., Hallstedt, S., Robèrt, K.H., Broman, G., Oldmark, J., 2011. Assessment of eco-labelling criteria development from a strategic sustainability perspective. Journal of Cleaner Production 19 (14), 1631–1638.
BREEAM, 2011. Building Research Establishment Environmental Assessment Method. Retrieved March 25, 2011, from: http://www.breeam.org.
Brown, M.A., Southworth, F., Stovall, T.K., 2005. Towards a Climate-Friendly Built Environment. Pew Center on Global Climate Change, Arlington, VA.
Built Green, 2010. Built Green Built Better. Retrieved January 9, 2011, from: http://www.builtgreen.org/.
CaGBC, 2011. Canada Green Building Council. Retrieved March 26, 2011, from: http://www.cagbc.
California Building Standards Commission, 2010. 2010 California Green Building Standards Code. Retrieved from: http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.
CERTFOR, 2011. Sistema Chileno de Certificación de Manejo Forestal Sustentable. Retrieved July 5, 2011, from: http://www.certfor.org/.
Chang, N.B., Rivera, B.J., Wanielista, M.P., 2011. Optimal design for water conservation and energy savings using green roofs in a green building under mixed uncertainties. Journal of Cleaner Production 19 (11), 1180–1188.
Chlebek, A., Jarabac, M., 1996. The importance of forests for flood control. Lesnická Práce 75 (3), 80–82. 106.
CMES, 2010. Consejo Mexicano de Edificación Sustentable. Retrieved March 27, 2011, from: http://www.mexicogbc.
CORRIM, 2010. The Consortium for Research on Renewable Industrial Materials. Retrieved October 19, 2010, from: http://www.corrim.org/.
CSA, 2011. Canadian Standards Association (CSA). Retrieved September 5, 2011, from: http://www.csasfmforests.ca/home.
Dalecki, M.G., Whitehead, J.C., Blomquist, G.C., 1993. Sample non-response bias and aggregate benefits in contingent valuation: an examination of early, late and non-respondents. Journal of Environmental Management 38 (2), 133–143.
DGNB, 2011. The German Sustainable Building Council. Retrieved September 8, 2011, from: http://www.dgnb.de/.
Dillman, D.A., 2009. Internet, Mail, and Mixed-mode Surveys: The Tailored Design Method, third ed., vol. xii. Wiley & Sons, Hoboken, N, 499 pp.
Dykstra, D.P., Kuru, G., Taylor, R., Nussbaum, R., Magrath, W.B., Story, J., 2002. Technologies for Wood Tracking Verifying and Monitoring the Chain of Custody and Legal Compliance in the Timber Industry, 78 pp. Retrieved from: http://www.afoa.org.ar/files/Trazabilidad%20madera.pdf.
EarthCraft, 2011. EarthCraft. Retrieved September 26, 2011, from: http://www.earthcraft.org/.
EPA, 2009. Buildings and Their Impact on the Environment: A Statistical Summary. Environmental Protection Agency, Washington, DC.
EPA, 2010a. About ENERGY STAR. Retrieved October 19, 2010, from: https://www.energystar.gov.
EPA, 2010b. Indoor Air Facts – Sick Building Syndrome. Retrieved June 28, 2011, from: http://www.epa.gov/iaq/pubs/sbs.html.
EPA, 2011. Green Building – Basic Information. Retrieved September 9, 2011, from: http://www.epa.gov/greenbuilding/pubs/about.htm.
Espinoza, O., Buehlmann, U., Bumgardner, M., Smith, B., 2011. Assessing changes in the U.S. Hardwood sawmill industry with a focus on markets and distribution. BioResources 6 (3), 2676–2689.
Etter, J.-F., Perneger, T.V., 1997. Analysis of non-response bias in a mailed health survey. Journal of Clinical Epidemiology 50 (10), 1123–1128.
European Commission, 2011. The Green Building Programme. Retrieved March 21, 2011, from: http://www.eu-greenbuilding.org/index.php?id=148.
Falk, B., 2009. Wood as a sustainable building material. Forest Products Journal 59 (9), 6.
FAO, 2010. Global Forest Resources Assessment 2010 –Main Report. Food and Agriculture Organization of the United Nations, Rome, Italy.
FAO, 2011a. Forestry. Retrieved June 26, 2011, from: http://www.fao.org/forestry/en/.
FAO, 2011b. State of the World's Forests 2011. Food and Agriculture Organization of the United Nations, Rome, Italy.
Fernholz, K., Bowyer, J., Stai, S., Bratkovich, S., Howe, J., 2011. Differences between the Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) Certification Standards for Forest Management. Dovetail Partners, Inc, Minneapolis, MN.
Fernholz, K., Howe, J., Bratkovich, S., Bowyer, J., 2010. Forest Certification: A Status Report. Dovetail Partners, Inc, Minneapolis, MN.
Friedman, A., 2007. Sustainable Residential Development: Planning and Design for Green Neighborhoods. McGraw-Hill, New York.
FSC, 2010. Forest Stewardship Council. Retrieved March 24, 2011, from: http://www.fsc.org/en/.
FSC, March 2011. Global FSC Certificates: Types and Distribution. Forest Stewardship Council, Bonn, Germany.
Green Building Council Brasil, 2008. Green Building Council Brasil. Retrieved March 26, 2011, from: http://www.gbcbrasil.org.br.
Green Building Council of Australia, 2011. Green Building Council Australia. Retrieved March 21, 2011, from: http://www.gbca.org.au/.
Greenpeace, 2011. Greenpeace International. Retrieved September 26, 2011, from: http://www.greenpeace.org/.
Hansen, E., Fletcher, R., Cashore, B., Mcdermott, C., 2006. Forest Certification in North America, College of Forestry – Extension Publication, (EC 1518), 12 pp. Retrieved from: http://owic.oregonstate.edu/pubs/EC1518.pdf.
Heerwagen, J., 2000. Green buildings, organizational success and occupant productivity. Building Research and Information 28 (5), 353–367.
HKBEAM, 2003. Building Environmental Assessment Method Society. Retrieved March 27, 2011, from: http://www.beamsociety.org.hk.
Howe, J., Bowyer, J., Guillery, P., Fernholz, K., 2005. Chain-of-Custody Certification: What Is It, Why Do It, and How? Dovetail Partners, Inc, White Bear Lake, MN.
Hubbard, S.S., Bowe, S.A., 2005. Environmentally certified wood products: perspectives and experiences of primary wood manufacturers in Wisconsin. Forest Products Journal 55 (1), 33.
ICC, 2011. International Green Construction Code. Retrieved September 8, 2011, from: http://www.iccsafe.org/cs/IGCC/Pages/default.aspx.
ITTO, 2011. International Tropical Timber Organization. Retrieved September 26, 2011, from: http://www.itto.int/.
JSBC, 2006. CASBEE – Comprehensive Assessment System for Built Environment Efficiency. Retrieved March 21, 2011, from: http://www.ibec.or.jp/CASBEE/english/index.htm.
Kibert, C.J., 2005. Sustainable Construction: Green Building Design and Delivery. John Wiley, Hoboken, N.J.
Koch, P., 1992. Wood versus nonwood materials in U.S. residential construction: some energy-related global implications. Forest Products Journal 42 (5), 31–42.
Koehler, D.A., 2007. The effectiveness of voluntary environmental programs – a policy at a crossroads? Policy Studies Journal 35 (4), 689–722.
Krosnick, J.A., 1999. Survey research. Annual Review of Psychology 50 (1), 537.
Lahaut, V.M.H.C.J., Jansen, H.A.M., van de Mheen, D., Garretsen, H.F.L., Verdurmen, J.E.E., van Dijk, A., 2003. Estimating non-response bias in a survey on Alcohol consumption: comparison of response waves. Alcohol Alcoholism 38 (2), 128–134.
LEI, 2011. The Indonesian Ecolabelling Institute. Retrieved June 28, 2011, from: http://www.lei.or.id/.
Lenz, H., 1967. The Economic Importance of Forests, vol. 30, 24 pp.
McGinley, K., Cubbage, F.W., 2011. Governmental regulation and nongovernmental certification of forests in the tropics: policy, execution, uptake, and overlap in Costa Rica, Guatemala, and Nicaragua. Forest Policy and Economics 13 (3), 206–220.
Mitchell, P., 2009. Environmentally Preferable and Sustainable Wood, . North Carolina's Value Added Wood Products Newsletter, (December), 4 pp. Retrieved from: http://www4.ncsu.edu/~pmitchel/Dec09.pdf.
MTCC, 2006. Malaysian Timber Certification Council. Retrieved June 29, 2011, from: http://www.mtcc.com.my/.
National Association of Home Builders, 2011. National Green Building Program. Retrieved September 9, 2011, from: http://www.nahbgreen.org/.
New Zealand Green Building Council, 2008. The New Zealand Green Building Council. Retrieved March 21, 2011, from: http://www.nzgbc.org.nz.
Nussbaum, R., Simula, M., 2005. The Forest Certification Handbook. Earthscan, London; Sterling, VA.
Office of Energy Efficiency and Renewable Energy, 2011. Energy Independence and Security Act. Retrieved September 9, 2011, from: http://www1.eere.energy.gov/femp/regulations/eisa.html.
Ofori, G., Briffett, C., Gang, G., Ranasinghe, M., 2000. Impact of ISO 14000 on construction enterprises in Singapore. Construction Management and Economics 18 (8), 935–947.
Ozanne, L.K., Vlosky, R.P., 2003. Certification from the U.S. consumer perspective: a comparison from 1995 and 2000 53 (3), 13–21.
Ozolins, P., 2010. Assessing sustainability in developing country contexts the applicability of green building rating systems to building design and construction in Madagascar and Tanzania. From: http://scholar.lib.vt.edu/theses/available/etd-05062010-150249/.
PEFC, 2011a. PEFC Global Certification: Forest Management and Chain of Custody. Retrieved September 5, 2011, from: http://pefc.org/images/stories/documents/Global_Stats/2010-06_PEFC_Global_Certificates.pdf.
PEFC, 2011b. Statistical Figures on PEFC Certification. Updated on 28/02/2010 Retrieved March 24, 2011 from: http://register.pefc.cz/statistics.asp.
PEFC, 2010. Chain of Custody of Forest Based Products – Requirements. PEFC Council, Geneva, Switzerland (Vol. PEFC ST 2002:2010, pp. 33).
Perera, P., Vlosky, R., Dunn, M., Hughes, G., 2008. U.S. home-center retailer attitudes, perceptions and behaviors regarding forest certification. Forest Products Journal 58 (3), 21.
Perera, P., Vlosky, R.P., 2006. A History of Forest Certification. Working Paper #71. Louisiana Forest Products Development Center, Louisiana, 14 pp.
PFEC, 2011. Programme for the Endorsement of Forest Certification. Retrieved April 6, 2011, from: http://www.pefc.org/.
Reijnders, L., van-Roekel, A., 1999. Comprehensiveness and adequacy of tools for the environmental improvement of buildings. Journal of Cleaner Production 7 (3), 221–225.
Retzlaff, R., 2008. Green building assessment systems. American Planning Association. Journal of the American Planning Association 74 (4), 505.
RuGBC, 2011. Green Building Council Russia. Retrieved September 8, 2011, from: http://www.rugbc.org/.
SFI, 2010. Sustainable Forest Initiative. Retrieved September 5, 2010, from: http://www.sfiprogram.org/.

SFI, 2011. Sustainable Forest Initiative Certification Database. Sustainable Forest Initiative Inc.. Retrieved September, 2011, from: http://64.34.105.23/PublicSearch/MainSearch.aspx.
Smith, T., Fischlein, M., Suh, S., Huelman, P., 2006. Green Building Rating Systems: a Comparison of the LEED and Green Globes Systems in the U.S. The Western Council of Industrial Workers.
Sustainable Forest Initiative, 2009. Consumer and Customer Research Reinforces the Power of SFI as a Sign of Responsible Forestry. Sustainable Forest Initiative, Washington, DC.
Sutton, W.R.J., 1999. International Forestry Report. Evergreen Forests Limited, 7 pp.
The Economist, December 2, 2004. The rise of the green building. The Economist 5.
The Green Building Council of South Africa, 2011. Green Building Council of South Africa. Retrieved March 21, 2011, from: http://www.gbcsa.org.za.
The Green Building Initiative, 2011. Green Building Initiative. Retrieved September 9, 2011, from: http://www.thegbi.org.
U.S. Census Bureau, 2006. Value of Products Shipments: 2005.
U.S. Forest Service, 2008a. Forest Certification – And Its Implications for America's National Forests, 5 pp. Retrieved from: http://www.fs.fed.us/projects/forestcertification/qas.pdf.
U.S. Forest Service, 2011. Forest Certification. Retrieved September 5, 2011, from: http://www.fs.fed.us/projects/forestcertification/.
U.S. Forest Service, 2008b. Who Owns American Forests?. Amherst, MA.
U.S. Green Building Council, 2009. Green Building Facts. U.S. Green Building Council, Washington, DC, 3 pp.
U.S. Green Building Council, 2010. LEED 2009 for New Construction and Major Renovations Rating System. U.S. Green Building Council, Washington, DC.
U.S. Green Building Council, 2011. Leadership in Energy and Environmental Design [Power Point Presentation]. U.S. Green Building Council, Washington, DC.
U.S. Green Building Council, 2011. LEED projects directory. In PublicLEEDProjectDirectory.xls (Ed.), Microsoft Excel. Washington, DC., U.S. Green Building Council.
UNEP, 2011. United Nations Environment Programme. Retrieved May 19, 2011, from: http://www.unep.org/.
United Nations, 1987. Report of the World Commission on Environment and Development: Our Common Future. Retrieved March 23, 2011, from: http://www.un-documents.net/wced-ocf.htm.
USAID, 2004. Bolivia Sustainable Forest Management – BOLFOR Final Report. USAID, Washington, DC, 98 pp.
USGBC, 2011. Leadership in Energy and Environmental Design. Retrieved March 25, 2011, from: http://www.usgbc.org.
Van Kooten, G.C., Nelson, H.W., Vertinsky, I., 2005. Certification of sustainable forest management practices: a global perspective on why countries certify. Forest Policy and Economics 7 (6), 857–867.
Vidal, N., Kozak, R., Cohen, D., 2005. Chain of custody certification: an assessment of the North American solid wood sector. Forest Policy and Economics 7 (3), 345–355.
Visseren-Hamakers, I.J., Glasbergen, P., 2006. Partnerships in forest governance. Global Environmental Change 17 (3–4), 408–419.
Vlosky, R., Gazo, R., Cassens, D., Perera, P., 2009. Changes in value-added wood product manufacturer perceptions about certification in the United States from 2002 to 2008. (Promjene shvaćanja postupka certificiranja proizvođača finalnih proizvoda od drva u Sjedinjenim Američkim Državama od 2002. do 2008. godine.), 60 (2), 89–94.
WGBC, 2010. World Green Building Council. Retrieved March 25, 2011, from: http://www.worldgbc.org/.
Wilson, J.B., Lippke, B., Comnick, J., Johnson, L.R., Perez-Garcia, J., Dancer, E.R., et al. (Eds.), 2005. Special Issue: The Environmental Performance of Renewable Building Materials in the Context of Residential Construction, vol. 37. Society of Wood Science and Technology.
Wilson, J.B., Lippke, B., Oneil, E.E., Puettmann, M.E., Bowe, S.A., Wagner, F.G., et al. (Eds.), 2010. Special Issue: Extending the Findings on the Environmental Performance of Wood Building Materials, vol. 42. Society of Wood Science and Technology.
WWF, 2011a. Forest Certification. Retrieved April 6, 2011, from: http://wwf.panda.org/what_we_do/footprint/forestry/certification/.
WWF, 2011b. Importance of Forests. Retrieved March 27, 2011, from: http://wwf.panda.org/about_our_earth/about_forests/importance/.
WWF, 2011c. WWF for a Living Planet. Retrieved May 19, 2011, from: http://wwf.panda.org/.
Yoshida, J., 2009, September 6, 2011 Green Buildings in Japan: Current State and Research Opportunities. In: Berkeley Conference on Green Building, the Economy, and Public Policy. Retrieved from: http://urbanpolicy.berkeley.edu/greenbuilding/yoshida.pdf.
Yudelson, J., 2008. The Green Building Revolution. Island Press, Washington.
Zhang, X., Shen, L., Wu, Y., 2011. Green strategy for gaining competitive advantage in housing development: a China study. Journal of Cleaner Production 19 (2–3), 157–167.