Tackle Climate Change – Use Wood

Benny Chan

TBWA/Chiat/Day Office, San Francisco, California; Marmol Radziner & Associates

Preface

In 2007, on behalf of the State of California and Province of British Columbia, we signed a landmark agreement for unprecedented collaboration between our two jurisdictions. Our shared goal: reducing the climate change impacts associated with greenhouse gases.

We agreed we weren't prepared to accept the harsh consequences that a timid response to this issue would most certainly deliver, and resolved to take action—which we have since done in numerous ways. Among other things, California now has the world's first greenhouse gas standard for transportation fuels, while British Columbia has passed legislation with regard to greenhouse gas reduction targets, emissions trading and North America's first carbon levy.

In jointly writing this preface, we are reinforcing our dedication to the issue of climate change and to the partnerships and innovative thinking that we believe are critical to its resolution; the kind of thinking demonstrated by the United States and Canadian forest sectors throughout this book.

It's time for all of us to recognize that the low carbon revolution is here, as is the low carbon economy. On behalf of our two jurisdictions, we hope you'll take the time to learn why using products derived from sustainably managed forests is one of the best things each of us can do to reduce our carbon footprint.

Sincerely,

Office of the Premier, British Columbia, Canada

The Honourable Gordon Campbell
Premier of British Columbia

Arnold Schwarzenegger
Governor of California

Sponsorship and Production

This book was undertaken on behalf of the North American forest products industry by the BC Forestry Climate Change Working Group and the California Forestry Association, and in cooperation with WoodWorks.

In addition to drawing from a wide range of information materials, it could not have been produced without the support and thoughtful review of a large number of groups and individuals interested in communicating the benefits of North American forests and forest products in relation to climate change. Special thanks are extended to the European Confederation of Woodworking Industries (CEI-Bois), whose own version of this book in 2006—under the same title—inspired these works. To the many people who participated in this project, those of us who have taken on the role of compilation and production offer our sincere thanks.

Disclaimer

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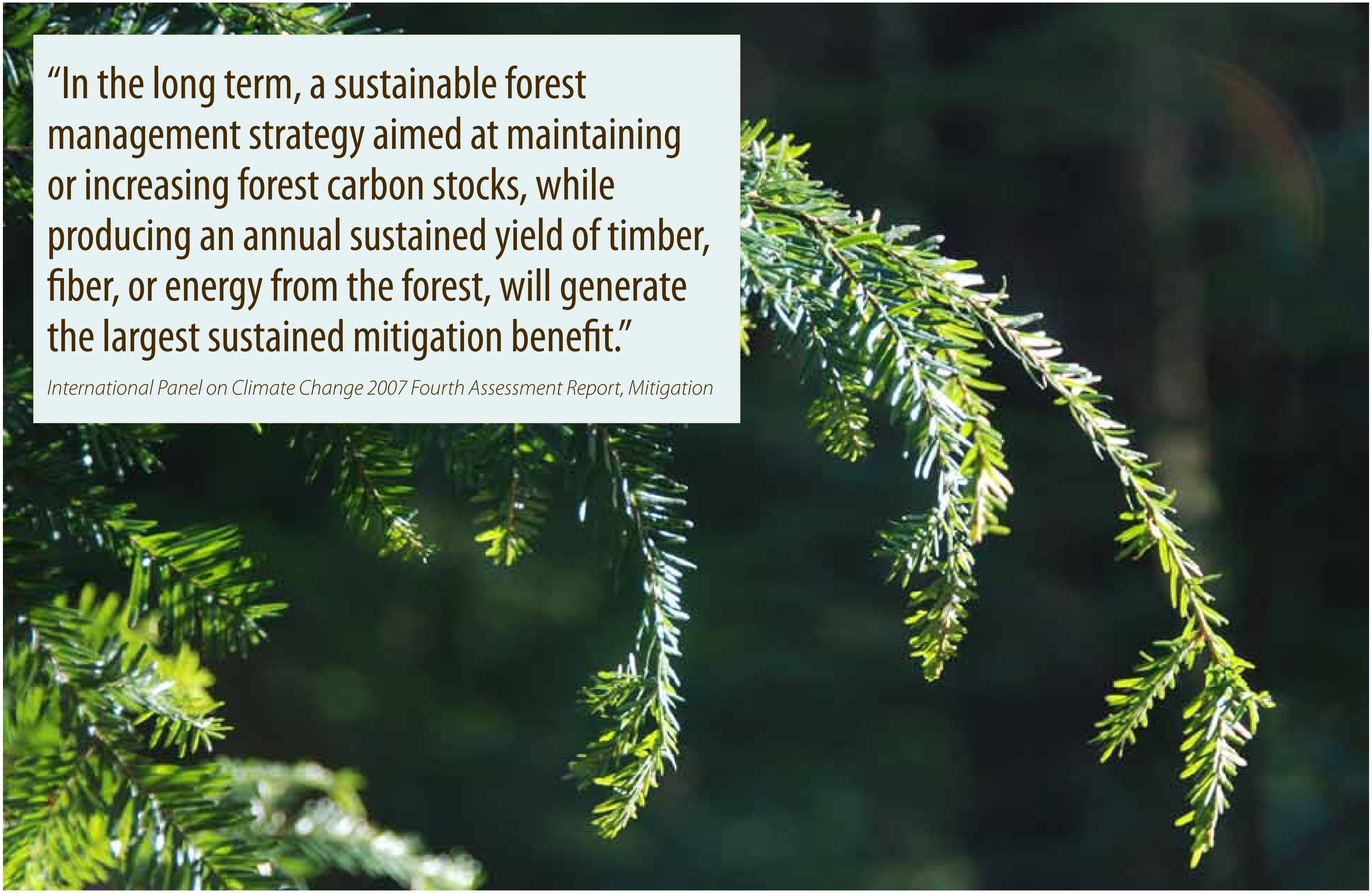
Folk Pottery Museum of Northeast Georgia, Sautee Nacoochee, Georgia; Architect Robert M. Cain



"In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fiber, or energy from the forest, will generate the largest sustained mitigation benefit."

International Panel on Climate Change 2007 Fourth Assessment Report, Mitigation

Sandy McKellar

Introduction

As climate change has emerged as the most dominant environmental issue of our time, it has become clear that forests—and forest products—can be an important part of the solution.

Put simply, sustainable forestry and forest products help to reduce or prevent greenhouse gases in the atmosphere, which are thought to be the major cause of climate change.

Most people know that forests help clean the air by removing pollutants, absorbing carbon dioxide (CO_2) and releasing oxygen (O_2). Lesser known is the fact that trees incorporate the absorbed carbon (C) into their wood, and the products made from that wood, such as lumber and furniture, continue to store the carbon indefinitely. Manufacturing processes associated with wood products require less fossil fuels and are responsible for far less greenhouse gas emissions than the manufacture of materials such as metals, plastics and cement. Forest and mill residues and other woody biomass can be used

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A house lifted off its foundation and destroyed by Hurricane Katrina, Irish Bayou, New Orleans, Louisiana

> **“Climate change cannot be won without the world’s forests,”**
> Ban Ki-moon, Secretary-General of the United Nations, September 2008

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The transportation sector is responsible for more than a quarter of North American CO_2 emissions.

as fuel to produce clean bioenergy, further reducing emissions. And because forests are renewable and sustainable, forest management and the use of wood and other forest products not only help to resolve the immediate climate change crisis but contribute to society’s long-term response.

In North America, the opportunity is especially pronounced because the United States and Canada are world leaders in sustainable forest management. In addition to forestry regulations that are among the most stringent in the world, this is evidenced by (among other things) our commitment to prompt regeneration of harvested areas and independent scrutiny of our practices.

This book has been created jointly by the U.S. and Canadian industries to explore the inter-related issues that together highlight the tremendous potential for forests and forest products to reduce atmospheric greenhouse gases. It is intended for government and business leaders who are in a position to develop policies and procurement processes that encourage the use of products from sustainably managed forests, and for architects, developers and others interested in having a positive impact through their choice of building materials.

Most important, it has been created as a call to action ...

Tackle climate change – use wood.

©iStockphoto.com/HKPNC and Sandy McKellar

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GREENHOUSE GASES, CARBON AND FOREST PRODUCTS

chapter one

According to the U.S. Environmental Protection Agency, the Earth's average surface temperature has increased by about 1.2 to 1.4°F (approximately 0.7°C) in the last 100 years. The eight warmest years on record (since 1850) have all occurred since 1998, with the warmest year being 2005.

Sandy McKellar

Greenhouse Gases, Carbon and Forest Products

Wood and paper products continue to store carbon absorbed by the trees, creating an endless cycle of absorption and storage.

Greenhouse gases, carbon and forest products are three elements in a complex story of how climate change can be addressed, in part, by using wood to replace fossil fuel-intensive materials.

It starts with an understanding of what climate change is and why increasing levels of carbon dioxide (CO_2)—one of the most common greenhouse gases—are thought to be the cause.

The story continues with how plants and in particular trees help to mitigate climate change by absorbing CO_2 from the atmosphere, utilizing the carbon (C) to produce sugars for growth and releasing the oxygen (O_2). As a tree grows, the carbon is stored in its leaves, twigs and solid woody stem, and in the soil around it. This is where the story diverges into two paths. In a typical unmanaged forest, the carbon is released back into the atmosphere in the form of CO_2 as trees decompose or die following wildfire, insect infestation or disease. If the forest is managed sustainably, the mature trees are harvested and manufactured into solid wood or paper products, which continue to store the carbon—and the forest is regenerated with young trees that once again begin absorbing CO_2.

Climate Change: Causes and Effects

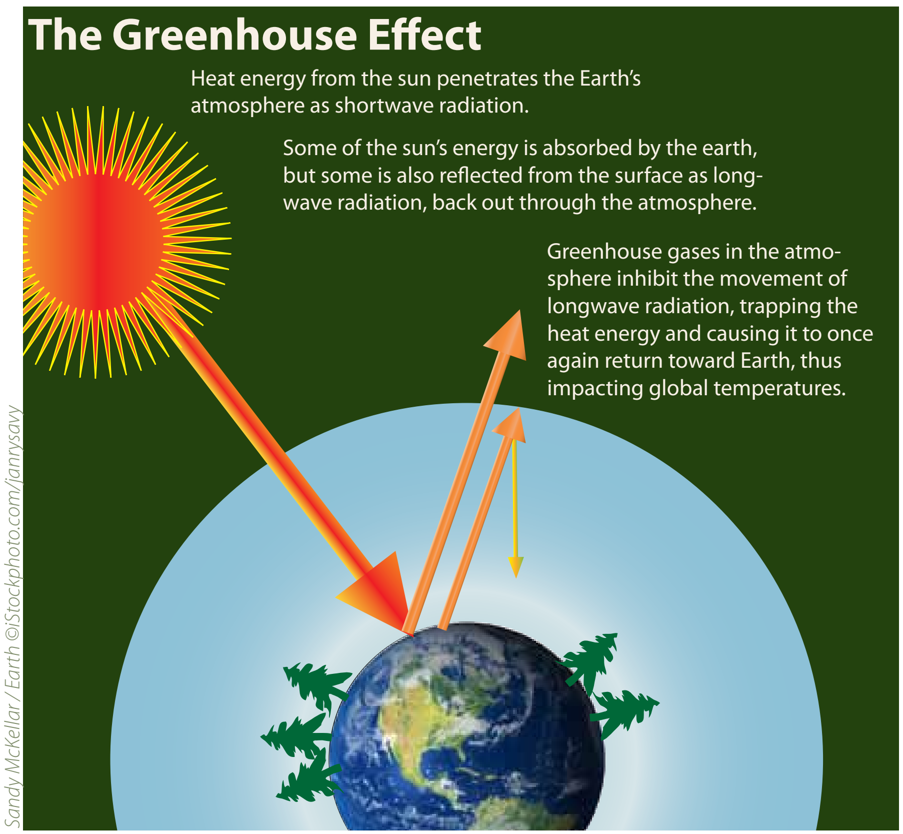
Due to the growing body of evidence that the Earth's climate is changing, climate change is now largely accepted as fact. More than simply global warming, it refers to long-term fluctuations in temperature, precipitation, wind and all other aspects of the Earth's climate and weather.

Many factors influence climate, but the one of concern to scientists is the level of greenhouse gases—most notably CO_2—in the atmosphere.

Greenhouse gases act in much the same way as the glass in a greenhouse, which lets in light and keeps heat from escaping, providing warmth for the plants inside. A similar process occurs when the sun's energy reaches the Earth; some of the energy is absorbed by the Earth's surface, some radiates back into space, and some is trapped in the atmosphere, keeping our planet warm enough for life to flourish.

While natural levels of greenhouse gases maintain ecosystem temperatures within a range that's suitable for existing life, higher levels cause the atmosphere to thicken, trapping more heat and warming the planet, which is what we're seeing now.

Predictions vary as to what will happen next, but most agree that, unless humans do something to address increasing concentrations of CO_2, temperatures will continue to rise, causing changes to precipitation and storm patterns, raising sea levels, changing the range and distribution of plants and animals, and leading to other detrimental effects on the ecosystem.



The Greenhouse Effect

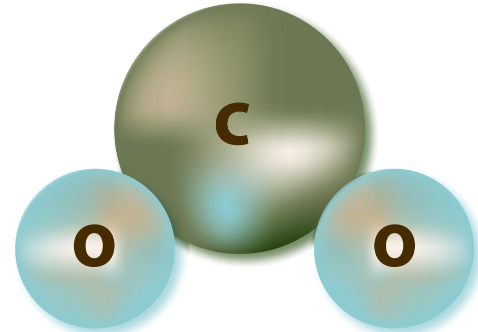
Sandy McKellar / Earth ©iStockphoto.com/janrysavy

The Carbon Cycle

The carbon cycle is the process through which carbon is cycled through the air, ground, oceans, plants and animals. Throughout this cycle, carbon is exchanged from one form to another. In scientific terms, every atom of carbon that is here now was present millions of years ago—a basic law of nature meaning that matter can be changed, but not created or destroyed.

Carbon is an element and a basic building block of life. At the simplest level, plants absorb carbon dioxide from the air during photosynthesis. The carbon is used to make sugars and starches, which in turn feed the growth of cell walls. Plants release the oxygen part of the CO_2 molecule back into the air, and that is what we breathe. The carbon cycle continues when trees are made into products such as lumber and furniture, which store the carbon indefinitely, releasing it only when the wood rots or is burned.

A typical 2,500-square-foot (232-square-meter) wood-frame home has 30 metric tons of carbon stored in its structure, the



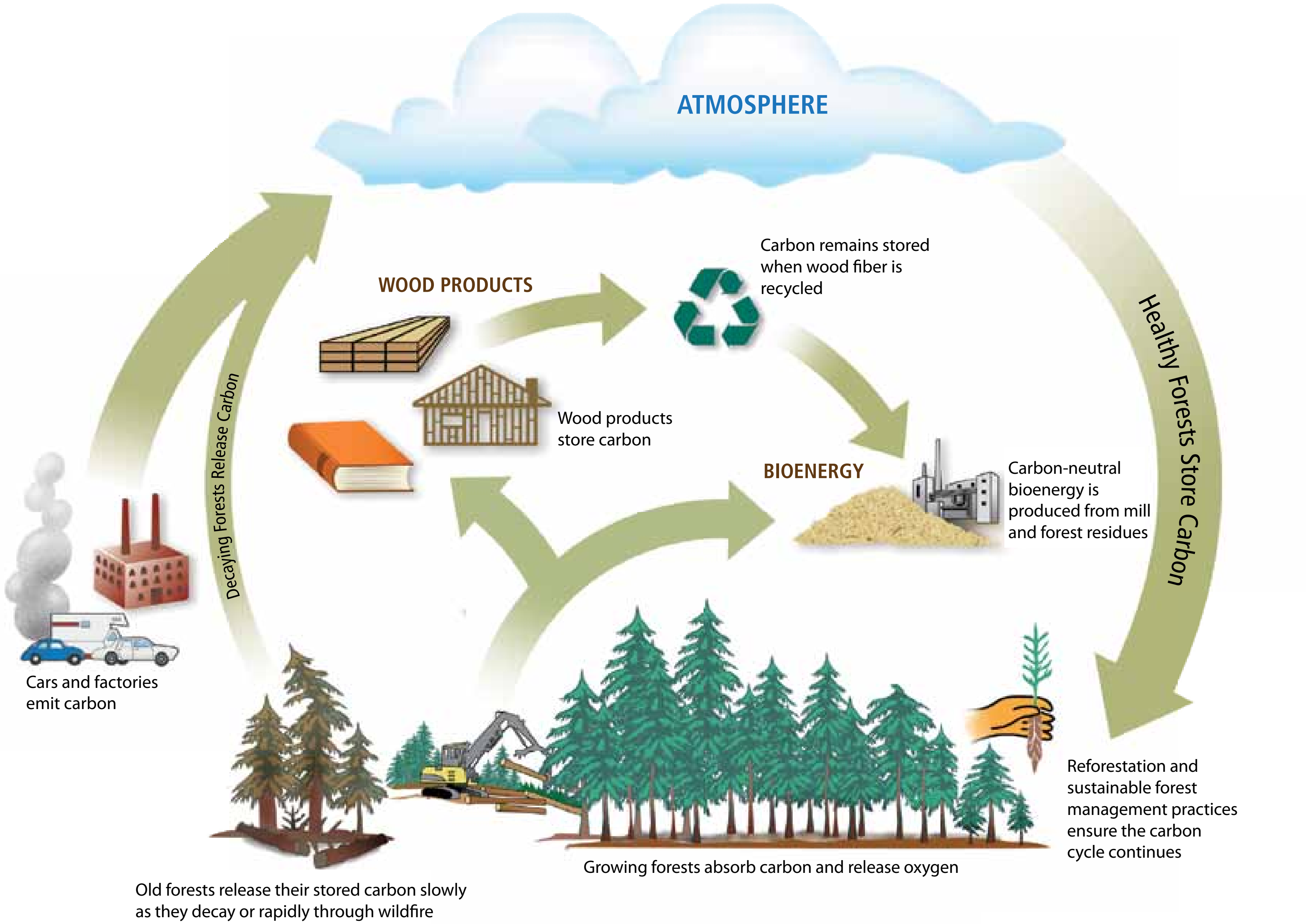
What is Carbon Dioxide?

Carbon dioxide is a colorless, odorless gas produced both naturally and through human activities, and is the second most prevalent greenhouse gas in the Earth's atmosphere (after water vapor). Prior to the industrial revolution, its concentration was stable for millions of years at about 280 parts per million. In the past century it has risen to over 380 parts per million, a 35 percent increase. Industrialization in the developed world and deforestation in developing regions are cited as the main causes.

CO_2 is produced when organic compounds are burned in the presence of oxygen. Naturally, this occurs as part of the respiration process in plants and animals and when organic matter decomposes. However, a more significant source globally is the combustion of fossil fuels such as coal, oil and gas in power plants, car and truck engines, and industrial facilities.

Humans—through their personal and industrial activities—emit close to 30 billion metric tons of CO_2 every year, which accounts for more than 75 percent of total greenhouse gas emissions.

Sustainable Forestry Carbon Cycle



Adapted from California Forest Products Commission

Wood products are about 50 percent carbon by weight.

equivalent of driving an average passenger car for five years, or using about 3,200 U.S. gallons (12,200 litres) of gasoline.* The U.S. Environmental Protection Agency estimates that the amount of carbon stored in forest products is equivalent to emissions from 18 million U.S. cars or 13 percent of all cars on American roads today.

Human Impacts

The other major exchange of CO_2 occurs between oceans and the atmosphere. As in a forest, the process of photosynthesis is also used by marine plants (including microscopic phytoplankton), which absorb dissolved CO_2 in the oceans, use the carbon for growth and release the oxygen into the water, which fish then "breathe."

The carbon cycle is obviously very complex, and each process has an impact on the others. However, it is clear that two important exchange points for carbon have been heavily influenced by humans. First, carbon stored as coal, oil and natural gas is being burned by industry and automobiles and released into the atmosphere in large amounts. Globally, close to 30 billion metric tons of carbon are emitted through human-related processes every year, most via fossil fuel combustion.**

Second, a large number of forests—primarily in the developing world—have and continue to be cleared for agriculture, significantly reducing the amount of trees absorbing CO_2. Approximately 17 percent of the increase in CO_2 levels is attributed to deforestation, which is occurring almost entirely in developing regions.

The net impact is an upset in the natural balance, which is causing a change in the Earth's climate.

Carbon and Forest Products

Growing trees add a new ring of wood to their circumference every year, and are about 50 percent carbon by weight. When manufactured into solid wood products, this carbon remains essentially inert and stable, and is kept out of the atmosphere for the lifetime of the product—or longer if the wood is recycled for another use.

Paper products, which are generally made from smaller trees and mill residues such as wood chips, also continue to store carbon. Although paper does tend to have a shorter lifespan than solid wood, books and magazines are often two notable exceptions.

A great deal of paper is also recycled, which extends the period of carbon storage through multiple product generations.

When used for bioenergy, the woody biomass is considered carbon neutral because, in a relatively short cycle, it releases the same amount of carbon into the atmosphere as it absorbed during its lifetime. This is in contrast to fossil fuels that have helped create the current problem because they add incremental carbon to the atmosphere from CO_2 that was removed from the atmosphere hundreds of millions of years ago.

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A typical 2,500-square-foot (232-square-meter) wood-frame home has 30 metric tons of carbon stored in its structure, the equivalent of driving an average passenger car for five years.

Wood and Climate Change, FPInnovations, 2008
***Energy Information Administration, International Energy Annual 2006*

Sandy McKellar

THE ROLE OF FORESTS

chapter two

Sandy McKellar

The Role of Forests

In addition to keeping forests sustainable, forest management practices can help maximize absorption of CO_2.

Forests can help to address climate change by reducing the amount of greenhouse gases in the atmosphere.

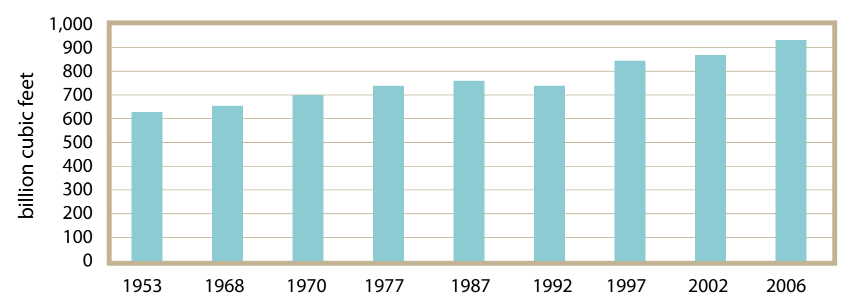
Because growing forests absorb and store carbon over an extended period of time, they are generally "carbon sinks." However, if emissions exceed absorption—through decomposition or wildfire—they also have the potential to be net carbon sources.

According to *State of the World's Forests* reports published over the last decade, the U.S. and Canada have about the same amount of forested land now as they did 100 years ago.* However, while forests in both countries have sequestered relatively high levels of carbon in recent decades, the amount fluctuates widely based on the number of wildfires and insect infestations in any given year. In Canada, for example, removals of CO_2 equivalent (CO_2e) from the atmosphere reached 155 million metric tons in 1992, a year with relatively few forest fires, while emissions of CO_2e were as high as 146 million metric tons in a year when more than 2 million hectares burned.**

In North America, forest management activities aimed at accelerating forest growth have the potential to increase the amount of carbon absorbed from the atmosphere.

Trends in Growing Stock in U.S. Timberlands, 1953 - 2006

Forest net growth has exceeded removals by 50% during this period.



U.S. Department of Agriculture (USDA) Forest Service, Forest Inventory Analysis Program, 2006

** State of the World's Forests Report, 1997 through 2009*
***The State of Canada's Forests Annual Report, 2008*

The U.S. and Canada have about the same amount of forested land now as they did 100 years ago.

Growth, Harvest and Renewal

Young, vigorously growing trees have a higher rate of CO_2 absorption than mature trees. Trees typically grow in what is described as a sigmoid curve, with growth rate being greatest in the early to middle years and dropping off as they reach maturity. In most North American forests, this drop happens when a tree is between 60 and 150 years old, depending on the species and environmental factors.

When a tree is harvested, about half of the carbon stays in the forest and the rest is removed in the logs, which are then converted into forest products. Some carbon is released when the forest soil is disturbed during harvesting, and the roots, branches and leaves left behind release carbon as they decompose. However, once the harvested area is regenerated, either naturally or by planting seedlings, the forest once again begins to absorb and store carbon.

In the case of unmanaged forests, old trees will eventually stop capturing new carbon. However, they continue to store the carbon already absorbed until they start to decay—at which point they begin releasing the carbon in the form of CO_2.

Wildfire, Insects and Disease

North American forests are a mosaic of different forest types with different forest ecologies and life cycles. Each forest has a natural rotation cycle. Many Northern pine forests, for example, live between 80 and 120 years and then succumb to either insects or disease, prior to being cleansed by fire and regenerating themselves from the seeds that come from their fire resistant cones.

In the past century, however, wildfires have no longer been allowed to burn unchecked because of the danger to human life and property. As a result, many forests have become overly dense with excess growth and debris which, combined with more extreme weather, has caused an increase in both the number and severity of fires.

This combination of changing climate and older forests is also having an impact on insects and disease, causing unprecedented outbreaks. One devastating example is the mountain pine beetle infestation that has killed or is attacking most of the mature pine forests in British Columbia, Colorado and Montana. If the

As the forest regenerates, it once again begins to absorb and store carbon.

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Mountain pine beetle damage in Rocky Mountain National Park, Colorado

Forest fire near Bailey, Colorado

Mitigating the Rapid Release of CO_2 from Wildfire

In California, a recent study by the Forest Foundation concluded that just four of the state's major wildfires in 2007 sent 34 million metric tons* of greenhouse gases into the atmosphere—which is equivalent to the emissions from 7 million cars driving for a year. Just over 9 million metric tons were emitted during the fires, and an estimated 25 million will be released over the next 50 years as the remaining timber decays.

Although California is committed to reducing greenhouse gas emissions, its efforts will be largely canceled out unless it addresses the impacts of catastrophic fires. Policies that encourage active forest management (such as thinning) to address overly dense forests are part of the solution, as they help reduce the severity of fires. Likewise, removing dead trees after wildfire and replanting the forest allows carbon that would have been released through decay to be stored in long-lasting wood products while the new trees begin absorbing more CO_2. This is a problem in public forests in particular, as private land-owners are quick to clear burned land in order both to utilize the timber and make way for new forests.

**Converted from Imperial tons*

Many forests have become overly dense, increasing the risk of catastrophic wildfires.

beetles continue to behave as they have over the past several years, the British Columbia government predicts that 80 percent of the province's pine forests will be killed by 2013.

In the U.S., warmer temperatures have also caused infestations of the southern pine beetle and red band needle blight, among others, and approximately 58 million acres (23.5 million hectares) are estimated to be at "significant risk" from insect and disease mortality.*

Forests ravaged by insects and disease are at greater risk for wildfire, which releases tremendous amounts of stored carbon in a short period of time, adding greatly to atmospheric levels.

**The State of America's Forests, 2007*

Helping the Forest Adapt

Managing forests sustainably during a general trend toward warmer conditions creates new variables, opportunities and risks. In theory, increasing levels of CO_2 and a longer growing season should increase forest growth and expand forest distribution northward. However, other variables—such as drought and the fact that certain northern tree species will not be able to adjust to warmer temperatures—may limit these effects. As a result, some forests may in the near term be more vulnerable to fire, insects and diseases. The rate of change, as well as the number and severity of extreme events, will affect both the magnitude of impacts and our ability to respond successfully.

Long-term forest planning that considers climate change can minimize potential mismatches between species and future climatic and disturbance regimes.

For example, the USDA Forest Service strategy is to make forest, range and aquatic ecosystems more resilient by (among other things) reducing overstocking, which increases the risk of fire, insects and disease, controlling invasive species and assisting species migration. A strong case can be made for planned adaptation, in which future changes are anticipated and forestry practices are adjusted accordingly.

Although many of the impacts of climate change are decades away, North American resource managers are using computer models to explore possible adaptation strategies to reduce the vulnerability of forests. By combining this predictive power with applied knowledge of local geography, tree physiology and forest genetics, foresters will be better equipped to make long-term decisions about how to ensure healthy forests in a changing climate.

Resource managers are developing strategies to reduce the vulnerability of forests.

Comparing Sustainability: Forestry Laws and Ownership

When discussing forest sustainability in a North American context, it is important to recognize that, while the U.S. and Canada have similar goals and achievements, they differ greatly in their ownership and governing laws.

In the U.S., 57 percent of the forested land base is privately owned—by corporations, investment funds and other entities, as well as some 10 million family forest landowners—and 43 percent is owned by public entities such as national, state and regional governments and government-owned institutions.

Although there is no single, over-arching policy covering U.S. forests, the legal requirements are extensive. The sustainability of U.S. practices is demonstrated by the fact that the country's forests cover approximately the same amount of land as they did 100 years ago.

In contrast, 93 percent of Canada's forests are publicly owned and regulated by government. Given Canada's vast land base and northern geography, only one quarter of the country's forested land is managed for commercial use and, of this, only one half of one percent is harvested annually. Canadian law requires prompt regeneration of all harvested areas on public lands—which is a key reason that, like the U.S., the country has virtually zero deforestation.

State of the World's Forests, 2007; The State of America's Forests, 2007.

WOOD PRODUCTS

chapter three

Forestry Innovation Investment / Ivan Hunter Photography Inc.

Nita Lake Lodge, Whistler, BC.; Architect IBI/HB Architects (IBI Group)

More Wood Products Means More Stored Carbon

The amount of carbon currently stored in U.S. wood products (including those in landfill sites) is estimated at 3.5 billion metric tons—but it's the cumulative impact over time that is most impressive in terms of climate change mitigation. The accumulation of carbon in U.S. wood products is about 60 million metric tons each year. Most of this resides in the nation's housing stock, 90 percent of which is wood framed. Assuming that a greater number of homes are built each year than deconstructed, the amount of stored carbon can be expected to grow significantly.

Carbon Storage in Wood and Wood Products, Dovetail Partners, Inc.

Wood Products

Wood products store carbon while also substituting for materials that require large amounts of fossil fuels to produce.

Wood products have many attributes that make them a smart choice when it comes to climate change. First, much of the carbon absorbed by growing trees is stored in products such as lumber and furniture, which are about 50 percent carbon by weight. Using more wood also means less fossil fuel consumption. Wood is produced with natural energy from the sun and is endlessly renewable—and life cycle assessment studies show that it requires substantially less energy to manufacture, transport, construct and maintain than materials such as steel and concrete. Wood buildings can be easily adapted or deconstructed and reused, which means they can continue to store carbon indefinitely. And using wood from sustainably managed forests helps to ensure that North American forests and their carbon storage potential continue to grow.

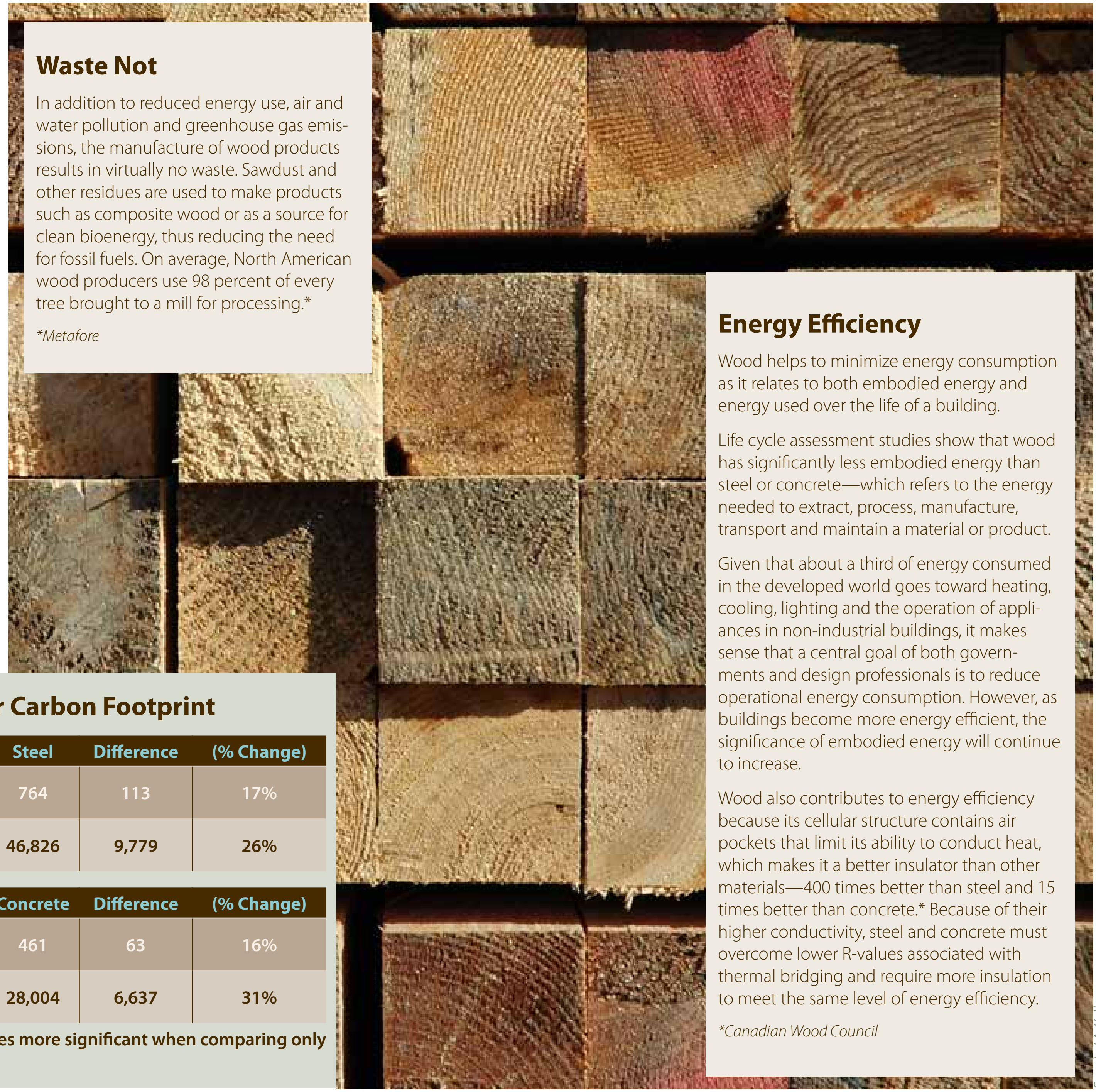
Life Cycle Assessment

Life cycle assessment (LCA) is an objective way to compare materials, assemblies and even whole structures, over the course of their entire lives, from resource extraction through manufacturing, distribution, use and end-of-life disposal. It is widely used to compare the environmental impacts of building materials such as wood, steel and concrete, and has led scientists in Europe and North America to the same conclusion: compared to the alternatives, wood buildings are responsible for less greenhouse gases, air pollution and water pollution, and require less energy across their life cycle.

The Consortium for Research on Renewable Industrial Materials (CORRIM) is one of the leading LCA organizations in North America and has conducted numerous studies on the impacts of forests and wood products on carbon emissions and storage. One study used LCA to compare homes framed with wood versus steel in Minneapolis and homes framed with wood versus concrete in Atlanta—the framing types most common to each city. In both cases, the wood-frame homes performed substantially better than their non-wood counterparts.

According to the report, the homes framed in steel and concrete required 17 and 16 percent more energy respectively (from extraction through maintenance), than the wood-frame homes. The carbon footprint was also 26 percent higher for the steel-frame house and 31 percent higher for the concrete-frame house than the homes framed in wood.

Further, the energy difference is many times more significant when comparing only those materials substituted as opposed to the entire house—because, in a completed house, there are a number of energy-intensive products common to all designs, such as concrete foundations, glass, gypsum and asphalt roofing.



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Waste Not

In addition to reduced energy use, air and water pollution and greenhouse gas emissions, the manufacture of wood products results in virtually no waste. Sawdust and other residues are used to make products such as composite wood or as a source for clean bioenergy, thus reducing the need for fossil fuels. On average, North American wood producers use 98 percent of every tree brought to a mill for processing.*

**Metafore*

Energy Efficiency

Wood helps to minimize energy consumption as it relates to both embodied energy and energy used over the life of a building.

Life cycle assessment studies show that wood has significantly less embodied energy than steel or concrete—which refers to the energy needed to extract, process, manufacture, transport and maintain a material or product.

Given that about a third of energy consumed in the developed world goes toward heating, cooling, lighting and the operation of appliances in non-industrial buildings, it makes sense that a central goal of both governments and design professionals is to reduce operational energy consumption. However, as buildings become more energy efficient, the significance of embodied energy will continue to increase.

Wood also contributes to energy efficiency because its cellular structure contains air pockets that limit its ability to conduct heat, which makes it a better insulator than other materials—400 times better than steel and 15 times better than concrete.* Because of their higher conductivity, steel and concrete must overcome lower R-values associated with thermal bridging and require more insulation to meet the same level of energy efficiency.

**Canadian Wood Council*

Wood Homes Have a Smaller Carbon Footprint

Minneapolis Design	Wood	Steel	Difference	(% Change)
Embodied Energy (GJ)	651	764	113	17%
Carbon Footprint (CO_2 kg)	37,047	46,826	9,779	26%

Atlanta Design	Wood	Concrete	Difference	(% Change)
Embodied Energy (GJ)	398	461	63	16%
Carbon Footprint (CO_2 kg)	21,367	28,004	6,637	31%

The energy difference would be many times more significant when comparing only those materials substituted.

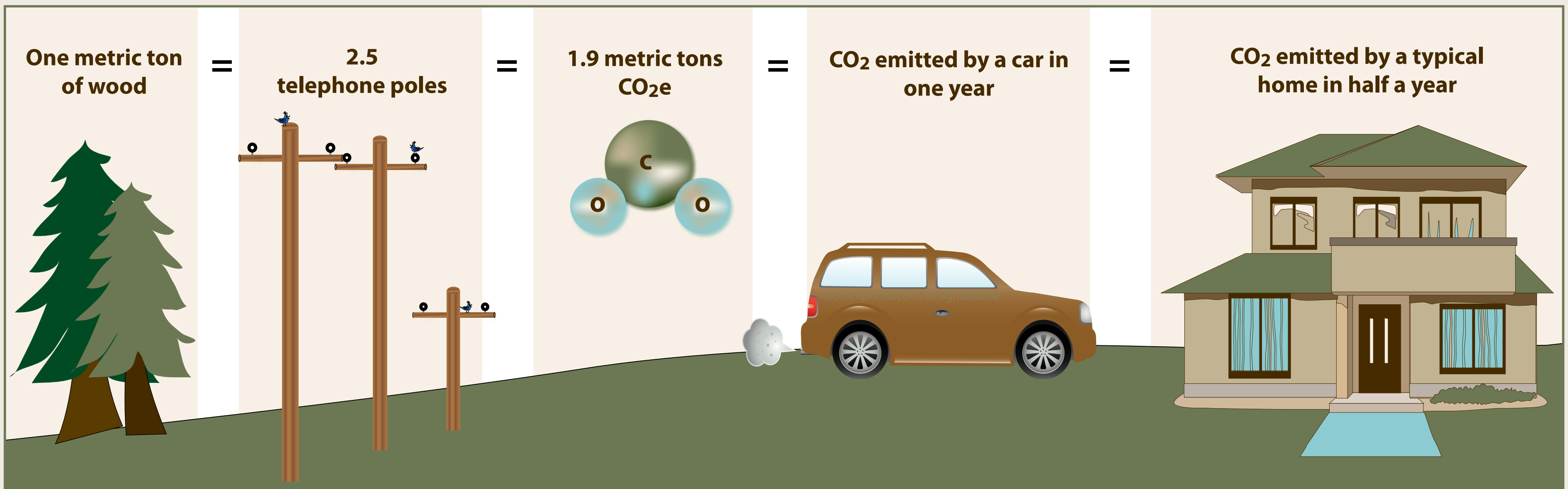
Consortium for Research on Renewable Industrial Materials

Achieving the Zero-Carbon Home

Wood products have a unique advantage: a growing tree removes more carbon from the atmosphere than the amount emitted during the entire process of making a wood product and shipping it to the construction site. As a result, wood products aren't just carbon neutral, they're carbon negative—and that represents a carbon credit, which helps offset the carbon debt imposed by other building materials.

For every metric ton of wood used, 1.9 tons of carbon dioxide equivalent is stored indefinitely. When wood is used in place of fossil fuel-intensive materials such as steel and concrete, the carbon benefit is even greater. On average, for every metric ton of wood used, 3.7 metric tons of CO_2 are avoided or displaced, resulting in a total carbon benefit of 5.5 metric tons of CO_2.

Carbon Equivalencies for Wood and CO_2



Every metric ton of wood in a home stores 1.9 tons of carbon dioxide equivalent (CO_2e), which is equal to the CO_2 emitted by an average car over the course of one year or by a house in half a year (EPA Greenhouse Gas Equivalencies Calculator).

Is wood alone sufficient to offset the carbon footprint of all the other materials that go into a typical home?

YES The Athena Sustainable Materials Institute undertook a study on the potential for carbon-neutral housing in North America and the influence that greater wood use would have on the carbon footprint of a typical home. The study showed that wood alone is sufficient, provided enough wood is used and the wood is recovered at the end of the home's life and either reused or converted to bioenergy.

Since most homes in North America are framed with wood, the increase in wood use must come in the form of wood windows, siding, shingles and cellulose insulation, and be used in place of vinyl windows, brick siding, asphalt shingles and fiberglass insulation. Taking into account the need to replace some of these wood items over the life of the structure, and assuming end-of-life construction debris is taken to a landfill with some methane capturing capacity, a typical 2,300-square-foot (214-square-meter) home is responsible for 58 metric tons of CO_2, while a home that maximizes wood use is responsible for 28 metric tons of CO_2. Although the carbon footprint is halved, it's not yet zero.

However, in an alternative end-of-life scenario—one that is fast becoming a reality—most of the wood products could be separated and used to produce clean bioenergy. The net result, after taking into account the fossil fuels replaced with bioenergy, is an output of 44 metric tons of CO_2 for the typical home and -3.4 metric tons of CO_2 for the wood-intensive home, which makes the latter carbon negative.

Aiming to drastically cut its emissions of greenhouse gases, Britain will soon mandate that all new homes be zero-carbon by 2016 and all commercial buildings by 2019. They'll do it, in part, by using more wood.

Sandy McKellar

CO_2 Emissions from a Typical and Wood-enhanced Home (metric tons of CO_2)

End-of-life Scenario	Typical Home	Wood-enhanced Home
Landfill	58	28
Biomass recovery	44	(3.4)

Provided enough wood products are used and they can be recovered and used for bioenergy, wood has a sufficiently negative carbon footprint to offset the footprint of all the other materials that go into a typical North American house. In some cases, homes are already carbon neutral—due to the combined effect of increased wood use and other energy saving strategies, such as ground and air source heat pumps, solar hot water heating, triple glazed windows, etc.

A Cradle-to-Gate Life Cycle Assessment of Canadian Softwood Lumber, 2009, and The Prospects for Carbon Neutral Housing, 2008, The Athena Sustainable Materials Institute. EPA Greenhouse Gas Equivalencies Calculator, 2009.

The Substitution Effect

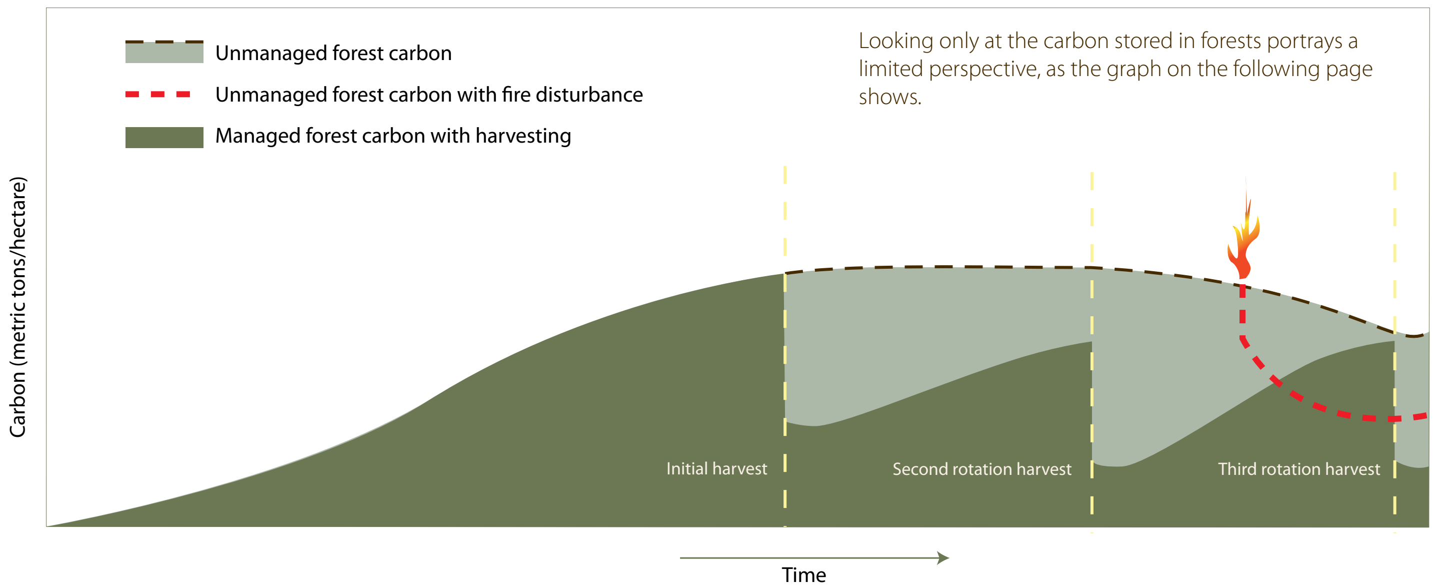
> **Most unmanaged forests will ultimately succumb to old age and release their carbon either slowly through decomposition or rapidly through fire.**

Conceptually, forests are carbon neutral, with the carbon removed from the atmosphere through photosynthesis offset by mortality and decomposition over time. However, forests are in constant flux and understanding how they behave over time is important to optimizing their carbon benefit.

As shown in the graph to the right, forests left unmanaged may sequester and store more carbon than forests that are periodically harvested—although, depending on the management regime, the reverse can also be true. Further, most unmanaged forests will ultimately succumb to old age and release their carbon either slowly through decomposition or rapidly through fire.

However, looking only at the carbon stored in forests is a limited perspective when it comes to managing forests to reduce carbon emissions. The most advanced research on forest carbon pools, developed by The Consortium for Research on Renewable Industrial Materials (CORRIM), combines the carbon stored in forests with the production of long-lived wood products and their substitution for fossil fuel-intensive materials such as steel and concrete. As shown in the graph to the right, the result is dramatically different and highlights the significant opportunity to reduce greenhouse gases.

Typical Carbon Sequestration in Managed and Unmanaged Forests

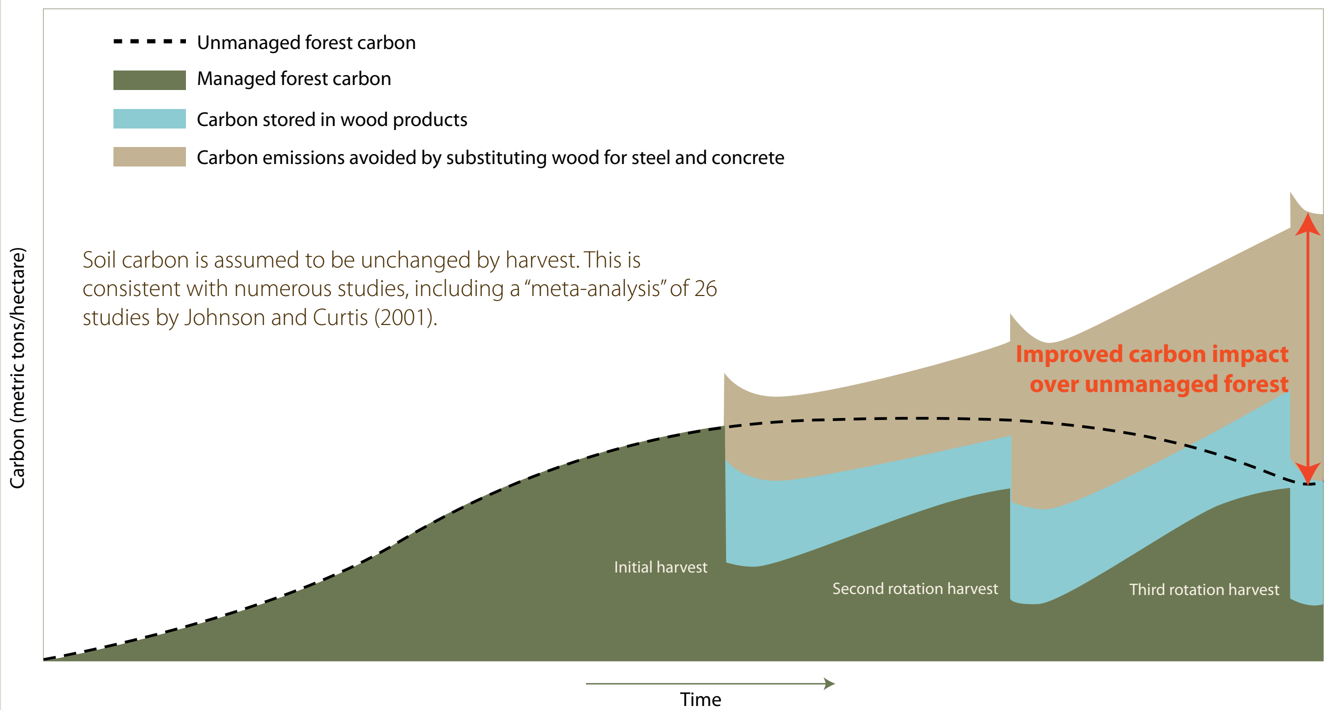


Adapted from: Kashian DM, WH Romme, DB Tinker, MG Turner, and MG Ryan. 2006, & Perez-Garcia, J., B. Lippke, J. Comnick, and C. Manriquez (2005); J. Wilson (2006); E. Oneil and B. Lippke, (2009).

> **In most countries, the substitution effect of harvested wood products is considered to be their key impact in climate change mitigation.**
>
> United Nations Economic Commission for Europe/Food and Agriculture Organization, 2008

Although each forest studied by CORRIM varies according to forest type and management practices employed—the conclusions, as represented in the graph below, have been consistent. In sum: looking at all forest carbon pools over time is essential to understanding the full implications of forest management. And the ongoing storage of carbon in forest products, combined with the emissions avoided by using these products as substitutes for other materials—such as steel or concrete—results in a permanent displacement of fossil fuel emissions and frees the land to absorb more carbon from the atmosphere. Substitution represents the largest carbon pool and increases with every rotation because it is permanent.

Carbon Benefit of Wood Products and Substitution for other Materials



Adapted from: Perez-Garcia, J., B. Lippke, J. Comnick, and C. Manriquez (2005); J. Wilson (2006); E. Oneil and B. Lippke, (2009).

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The all-wood Borgund Stave Church in Norway was built in 1150 and is still in use today.

Service Life

From a climate change perspective, the durability and adaptability of wood products—and wood buildings in particular—are important indicators of how long the carbon absorbed by growing trees is stored before being released back into the atmosphere.

In terms of durability, there are many examples of ancient, wood-frame buildings that remain structurally sound, such as Norway's beautiful stave churches, which were built hundreds of years ago and are still in use today.

However, studies show that buildings in North America often have a service life of less than 50 years, regardless of material, because we choose not to exploit their potential longevity. (In most cases, they're demolished because of changing needs or increasing land values.)

When one considers the embodied energy in these structures and the implications of material disposal, this is a significant problem—which is why one of the tenets of sustainable design is that buildings should last 100 years or more.

However, while some people interpret this as a call for increasingly durable materials, the foremost requirement is in fact the use of building systems and materials that can adapt to changing needs either through renovation or deconstruction and reuse.

Because of their light weight and workability, wood structures lend themselves to dismantling and are typically very easy to adapt to other uses.

Wood structures lend themselves to dismantling and are typically very easy to adapt to other uses.

In a survey of buildings demolished between 2000 and 2003 in Minneapolis/St. Paul, wood buildings had the longest lifespans.

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BIOENERGY

chapter four

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Carbon Neutrality of Biomass

The International Panel on Climate Change (IPCC) and other climate change experts have concluded that carbon dioxide emissions from biomass are part of the natural carbon cycle. Because no more carbon is released than was absorbed during the lifetime of the biomass, and because this cycle is relatively short, biofuels such as organic waste, wood residues and agricultural fiber are considered carbon neutral and are not counted in greenhouse gas emissions calculations.

Bioenergy

The generation of clean, renewable energy from woody biomass is a growth industry with the potential to significantly reduce our dependence on fossil fuels.

Bioenergy is electrical and thermal (or heat) energy derived from biomass fuels, which are organic materials available on a renewable basis and include residues and/or byproducts of the logging, sawmilling and paper-making processes. Biomass is an abundant, clean and renewable substitute for fossil fuels such as coal, natural gas, gasoline, diesel and fuel oil, and is viewed as increasingly important by governments, utilities and the forest industry. In addition to climate change mitigation, its benefits include helping to reduce North America's dependence on foreign oil and enhancing the economic development of rural communities.

It is worth noting that sawmill and forest harvest waste and stands killed by insects or disease, if not used for bioenergy, will release their stored carbon back into the atmosphere as CO_2—either slowly as they decompose or quickly if subjected to wildfire. Utilizing these forest residuals as a replacement for traditional fossil fuels means reduced greenhouse gas emissions.

In addition to providing clean, renewable energy that replaces the need for fossil fuels, bioenergy helps to reduce waste in landfill sites, which are themselves a source of greenhouse gas emissions.

Bioenergy Production

The U.S. and Canadian governments both support an increased role for energy derived from biomass. In particular, they view it as a way to lower greenhouse gas emissions by reducing consumption of oil and gas, while supporting the growth of forestry, agriculture and rural economies. Studies by the U.S. government have found the country's combined forest and agriculture land resources have the potential to sustainably supply more than one-third of its current petroleum consumption.*

**Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*

Three potentially large sources of forest biomass not currently being used in abundance are harvesting residues, particularly those left at the roadside, thinning treatments done in conjunction with efforts to reduce forest fire hazards (mostly in the U.S.) and salvage and recovery of beetle-killed timber (mostly in Canada).

Biomass is already an important source of energy for the North American forest products industry. It is common, for example, for companies to have cogeneration facilities—also known as combined heat and power—which convert some of the biomass that results from wood and paper manufacturing to electrical and thermal energy in the form of steam. The electricity is used to power equipment and the steam is used to, among other things, dry lumber and supply heat to the dryers used in paper-making.

The forest industry is unique in this regard as it has more cogeneration capability than all other industries combined and nearly all paper and wood products mills produce the majority of their electricity using cogeneration technology. On average, the U.S. forest products industry generates 65 percent of its energy needs from renewable biomass, while the Canadian industry meets almost 60 percent of its energy needs from sources other than fossil fuels.

Bioenergy Fiber Sources

The most cost-effective sources of biofuel from U.S. and Canadian forests are the unused residues (bark, sawdust and shavings) from the milling of logs into forest products and from forest harvesting. This is because the biomass is already in hand and, if it isn't used, often requires additional cost and effort for disposal.

Milling residues are estimated at 104 million and 22 million bone dry metric tons (BDT) of biomass per year, in the U.S. and Canada respectively, with most already used for energy or made into wood products. Estimates of unused residues in the U.S. (including those from secondary manufacturing) are 6 million BDTs per year. In Canada, the estimate is about 3 million BDTs, but another 2 million BDTs per year are available over a 10-year period in the form of leftover bark piles.

Harvesting residues, on the other hand, are large and mostly unused in both countries. The USDA Forest Service estimates that forest lands subject to traditional logging and reforestation can produce about 29 million BDTs of recoverable biomass. Canadian estimates of harvest residues available at the roadside are 13 million BDTs.

Another economic source is biomass from thinning of overly dense forests and from non-merchantable forests after disturbances such as insect infestations. In the U.S., vast areas of forestland have become overstocked as a result of wildfire management strategies that don't encourage thinning or permit the natural course of cleansing through fire. The USDA estimates that 54 million BDTs of biomass are available annually. In Canada, the mountain pine beetle infestation alone has killed the equivalent of 500 million BDTs of biomass and, at predicted rates of spread, represents an opportunity of 25 to 35 million BDTs over 20 years.

Catalyst Paper

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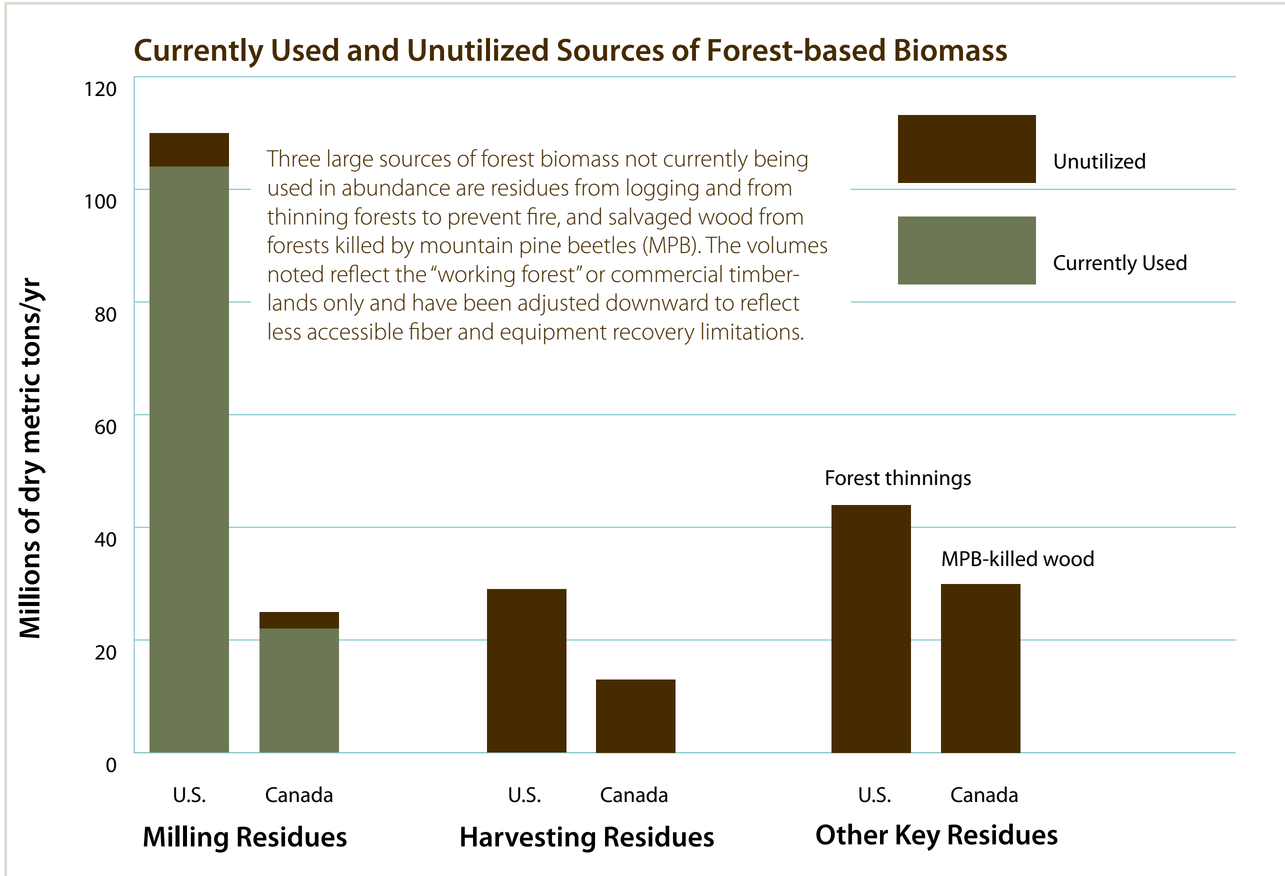


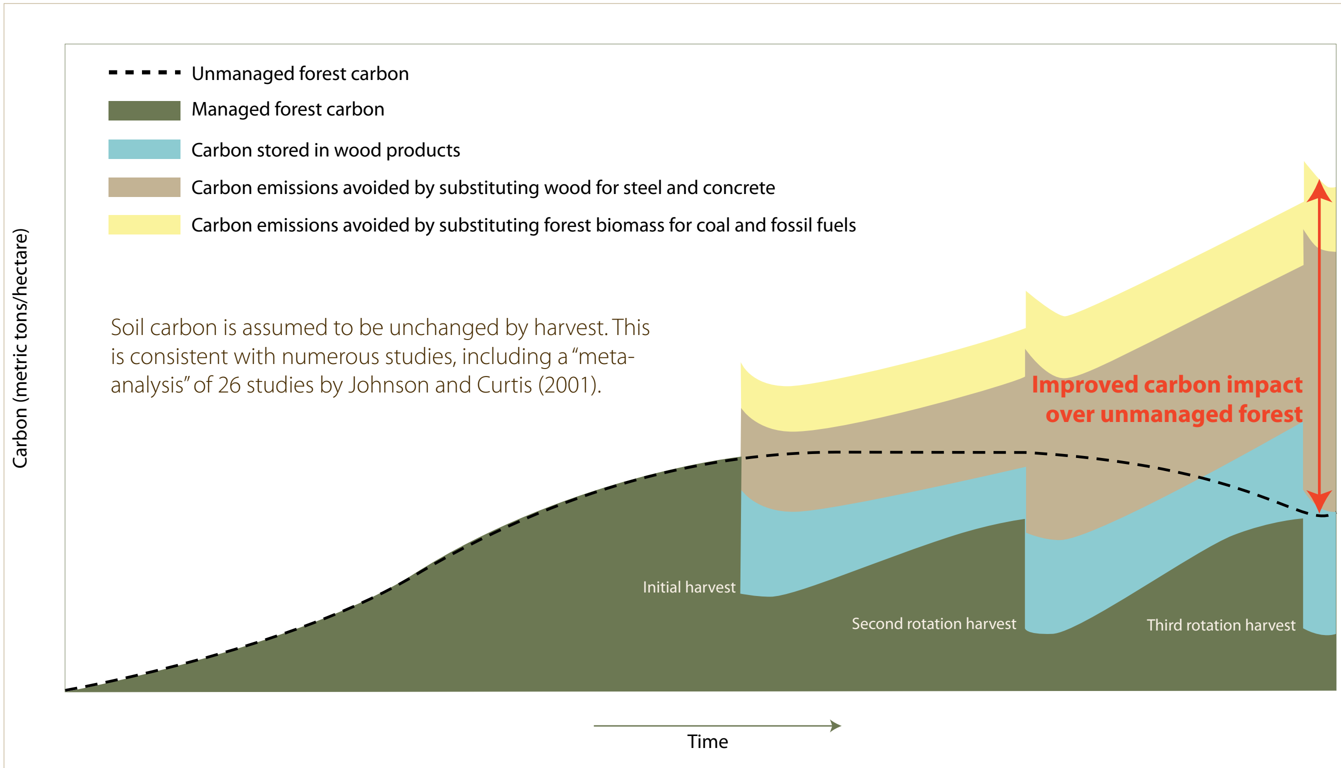
A 2005 joint study sponsored by the U.S. Departments of Energy and Agriculture on Biomass as Feedstock for a Bioenergy and Bioproducts Industry, and a study prepared for Environment Canada by Climate Change Solutions titled Canada Report on Bioenergy 2008.

As explained in the previous chapter, looking at all of the carbon pools over time is essential to understanding the potential carbon benefit of forest management and—like wood products—forest biomass has been shown to have the potential to contribute significantly. Bioenergy produced from forest thinning and forest harvesting residuals, both of which have the potential to increase considerably, is carbon neutral and can substitute for fossil fuel-based energy and result in additional avoided CO_2 emissions.

Building on the representative graph on page 27, CORRIM studies have also estimated the carbon benefit of increased use of forest thinnings and forest

The carbon benefit of substitution is significant, cumulative and permanent.

Carbon Benefit of Producing Energy from Forest Biomass



Adapted from: Perez-Garcia, J., B. Lippke, J. Comnick, and C. Manriquez (2005); J. Wilson (2006); E. Oneil and B. Lippke, (2009).

harvesting residuals, and they have been shown to be substantial. For example, bioenergy residuals from a mountain pine beetle-infested forest in British Columbia suggest an additional carbon benefit of 10 to 20 percent is possible. Similarly, forest thinning in fire-prone areas of Washington State suggests benefits of 25 to 50 percent, although the majority of it is due to greater volumes of long-lived wood products and the resulting reduction in fire hazard. Regardless, just like the impact of wood product substitution for steel and concrete, the carbon benefit of increased use of thinnings and harvest residuals is significant, cumulative over each rotation and permanent.

Although the current economic and political policy environment does not yet result in large scale bioenergy use and substitution of this sort, governments across North America have recognized this opportunity and are rapidly moving in this direction.

Catalyst Paper

PULP AND PAPER PRODUCTS

chapter five

Catalyst Paper

Pulp and Paper Products

The pulp and paper industry has significantly reduced greenhouse gas emissions while increasing its recycled content.

Wood currently provides the basis for approximately 90 percent of global pulp production. Pulp is used predominantly as a major component in the manufacture of paper and paperboard, though smaller quantities also find their way into a diversity of products, including rayon fabric, photographic films, cellophane, tooth paste and ice cream, among others.

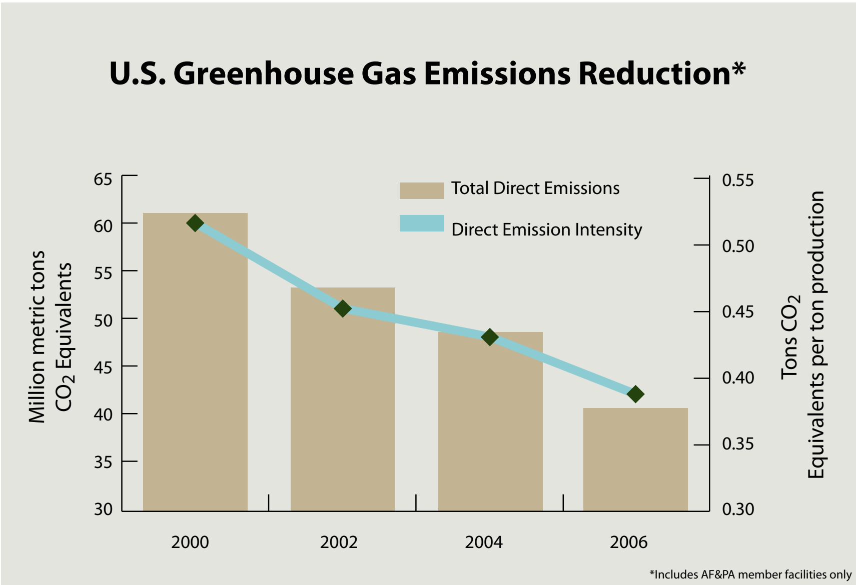
In terms of its impact on climate change, issues specific to the pulp and paper sector include efforts to reduce greenhouse gas emissions during the manufacturing process and increase the amount of paper recovered for recycling and bioenergy.

Reducing Greenhouse Gas Emissions

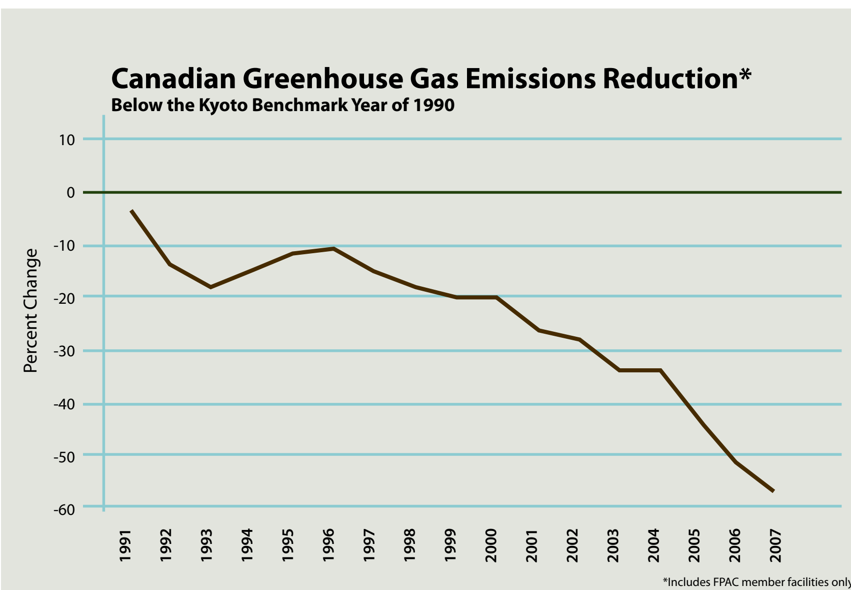
In the United States, members of the American Forest and Paper Association (AF&PA) decreased their use of fossil fuels and purchased energy by 56 percent between 1972 and 2006. In 2000, they collectively pledged to reduce their greenhouse gas intensity (i.e., the amount of CO_2 released per Imperial ton of production) by 12 percent by 2012—an objective they have since surpassed. On an intensity basis, these companies have already achieved a reduction of 13.6 percent, while reducing emissions on an absolute basis (i.e., total CO_2 released) by 24.6 percent. About half of this amount can be attributed to efficiencies while the other half was the result of decreases in production and changes to the 2000 baseline.

Studies show the forest industry's unique opportunity to achieve carbon neutrality.

In Canada, members of the Forest Products Association of Canada (FPAC) reduced their use of fossil



American Forest & Paper Association

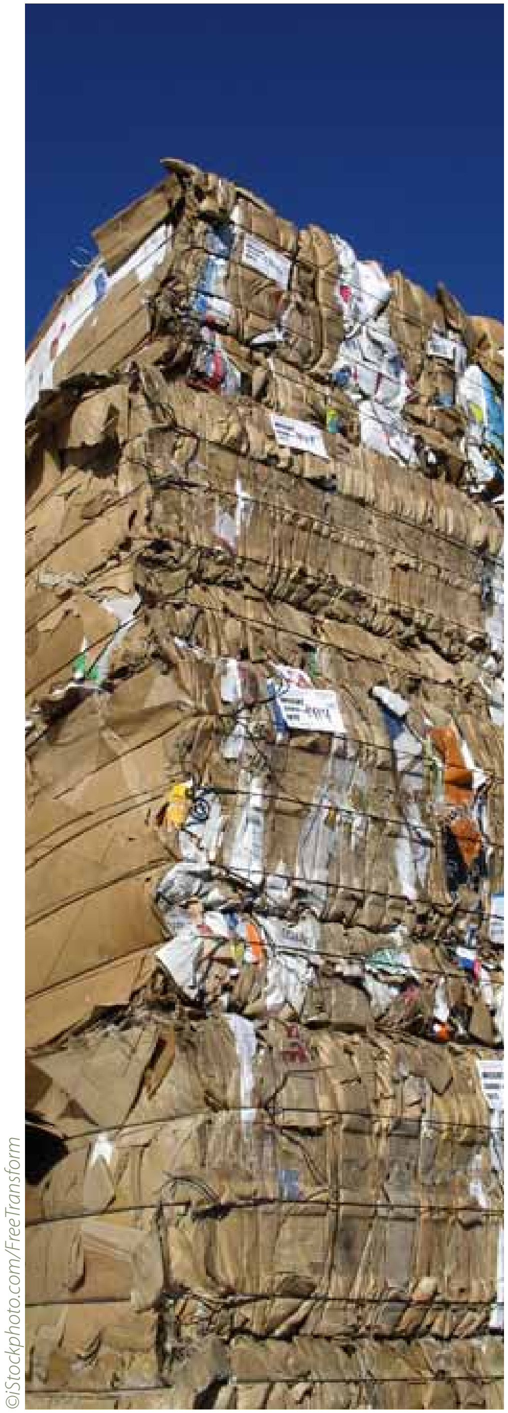


Forest Products Association of Canada

fuels by 58 percent since 1990 and, as of 2007, meet 60 percent of their energy needs with renewable sources. As a result of this and other efficiency measures, they reduced greenhouse gas emissions by 57 percent, and improved greenhouse gas intensity by 61 percent—even while companies increased their production by as much as 8 percent.

Please note that differences between U.S. and Canadian industry improvements are primarily due to differences in reporting periods as both have achieved similar levels of efficiency.

Based on work by the National Council for Air and Stream Improvement—which considers the full life cycle of the forest products value chain and shows the industry's unique potential to be carbon neutral—the Canadian industry has also stated its intention to achieve this goal by 2015, without the purchase of offset credits. Simply put, this means taking more greenhouse gases out of the atmosphere than it contributes.



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Increasing Recycled Content

Used paper and paperboard products make up the largest single category of material disposed of in North American municipal landfills. Because decomposing wood and paper products release greenhouse gases into the atmosphere, recovering or diverting these materials from landfills not only provides fiber content for recycled paper products, it helps to address climate change.

Recycling in the U.S.

Nearly 80 percent of American paper mills use recovered fiber to make some or all of their products, and about 140 mills use recovered paper exclusively. In 2007, the industry goal to recover 55 percent of paper consumed in the U.S. was achieved five years ahead of schedule when recovery reached an all-time high of 56 percent. Close to 50 million metric tons* of paper were recovered, which adds up to more than 360 pounds (163 kilograms) for every man, woman and child in America, and each ton saved almost three cubic yards (2.3 cubic meters) of landfill space.

In response to meeting this goal, the industry set an aggressive new goal of 60 percent paper recovery by 2012. Each point gain means that almost 1 million additional tons of paper have been recovered—enough to fill more than 14,000 railcars.

Recycling in Canada

Eighty-two percent of the paper made in Canada comes from recovered paper (26 percent) and sawmill residues (56 percent). Canada recycles almost three times as much as it did two decades ago—and uses 5 million metric tons of recycled paper every year.

FPAC members support all programs that encourage greater recovery of waste paper, and have as an objective that "no usable paper should be sent to landfill."

In 2003, they announced a targeted recovery rate of 55 percent by 2012—which has since been exceeded. The 2008 recovery rate was estimated at 64.6 percent, although the change was due to a 2 percent increase in recovery combined with an 8 percent reduction in paper and paperboard consumption.

Recycling and the Environment

While paper with recycled content is generally an excellent environmental choice, there are several factors to consider. For example, waste paper collection and transportation to recycling facilities have an impact on CO_2 emissions, as will the type of processing required to create desired end products. The most effective strategy from an environmental standpoint is to be aware of the issues and take them into account when making product choices.

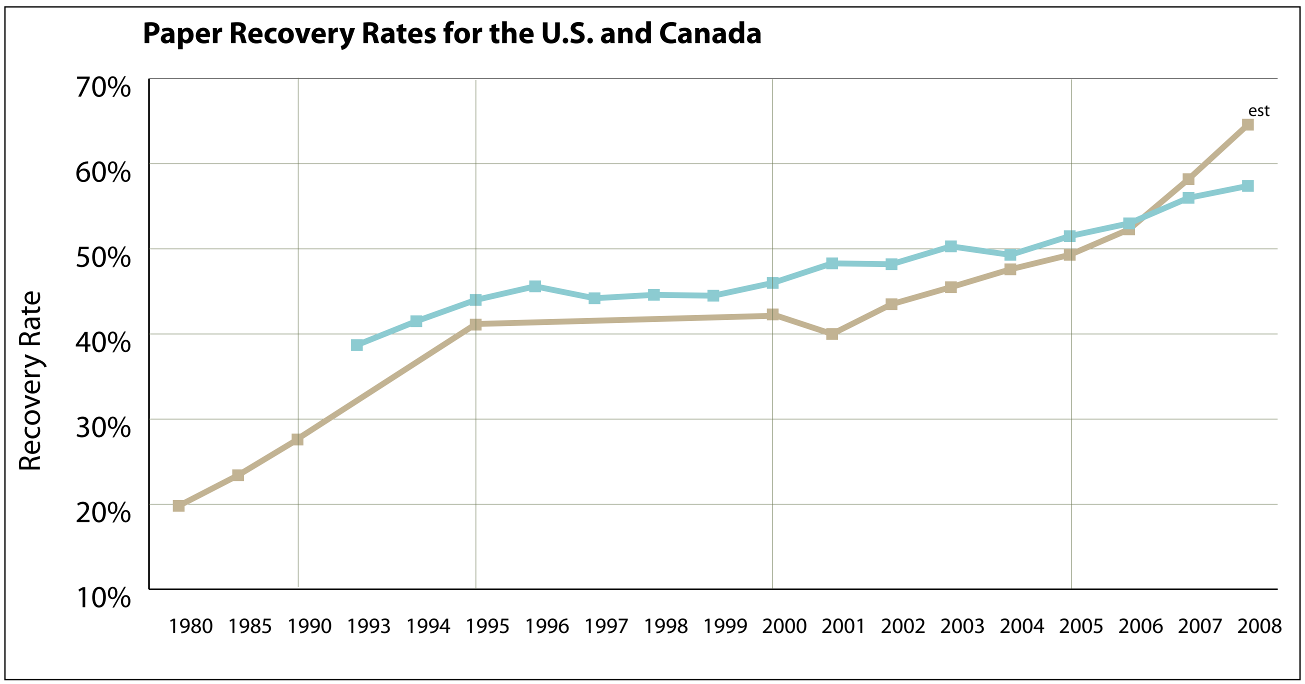
Recycled fiber is a scarce and valuable resource that needs to be used wisely. Although advancements in technology allow producers to include up to 100 percent recycled fiber in new paper and paperboard products, it is most effective for products suited to its lower brightness and strength. Simply put, recycled fibers in products such as bags, cardboard and newsprint result in far better use of the resource, allowing more of the incoming waste paper to be used and less to be rejected. As paper grade quality increases, there is a tipping point

*Converted from Imperial tons.

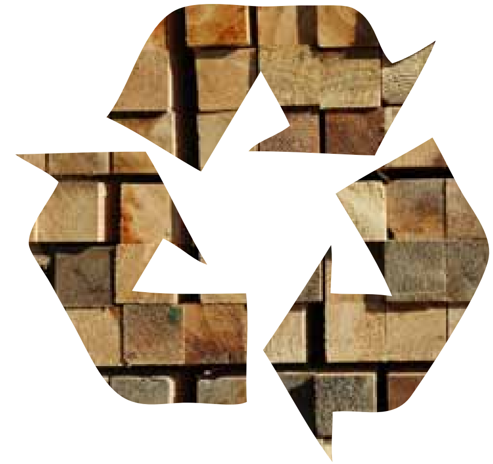
Diverting paper and wood waste from landfill sites reduces greenhouse gas emissions.

at which the amount of recycled fiber can actually diminish the environmental returns because of required processing.

Another reality is that the paper industry cannot survive on recycled fiber alone. Each time paper is recycled, its fibers become progressively shorter and weaker to the point that, after four to seven cycles, they're no longer strong enough to use. Therefore, a key component of the paper cycle is fresh fiber from sustainably managed forests.



American Forest & Paper Association; Pulp and Paper Products Council



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SUSTAINABLE FOREST MANAGEMENT

chapter six

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Sustainable Forest Management

North American forest practices are world-leading—which means carbon-positive management is widespread.

Sustainable forest management is a necessary prerequisite to ensuring that North American forests have the potential to be net carbon sinks, which means the amount of carbon sequestered in the forest is greater than the greenhouse gases released back into the atmosphere as a result of wildfire or decay.

The United States and Canada together have about 15.5 percent of the world's total forest cover and, although the two countries differ in terms of forest ownership and laws, governments and the forest industry on both sides of the border share a demonstrated commitment to sustainability.

United States

In the U.S., the majority of forests are privately owned and sustainable forestry practices are a prerequisite for landowners seeking to ensure a positive return on investment over the long term. Publicly owned forests are managed to ensure sustainability with emphasis on providing a range of societal values such as parks and other protected areas, wildlife habitat and timber production.

- The U.S. has approximately the same amount of forested land as it did 100 years ago.
- Although economically vital to landowners, timber harvesting is kept well below sustainable limits. Private landowners plant about 4 million trees each day—or five trees each year for every man, woman and child in America.*
- During the past 50 years, less than 2 percent of the standing tree inventory was harvested each year, while net tree growth was 3 percent. In 2007, the volume of annual net timber growth was 36 percent higher than the volume of annual timber removals.**

*American Forest & Paper Association
**State of America's Forests, 2007

Canada

With most Canadian forests publicly owned, forest companies operate under some of the most stringent sustainability laws and regulations in the world.

- ✧ As in the U.S., Canada's rate of deforestation has been virtually zero for more than 20 years. Canada has 91 percent of its original forest cover, more than any other country. *
- ✧ Less than one half of one percent of Canada's managed forest is harvested each year, and areas that are logged must by law be promptly regenerated.

Forest Conservation

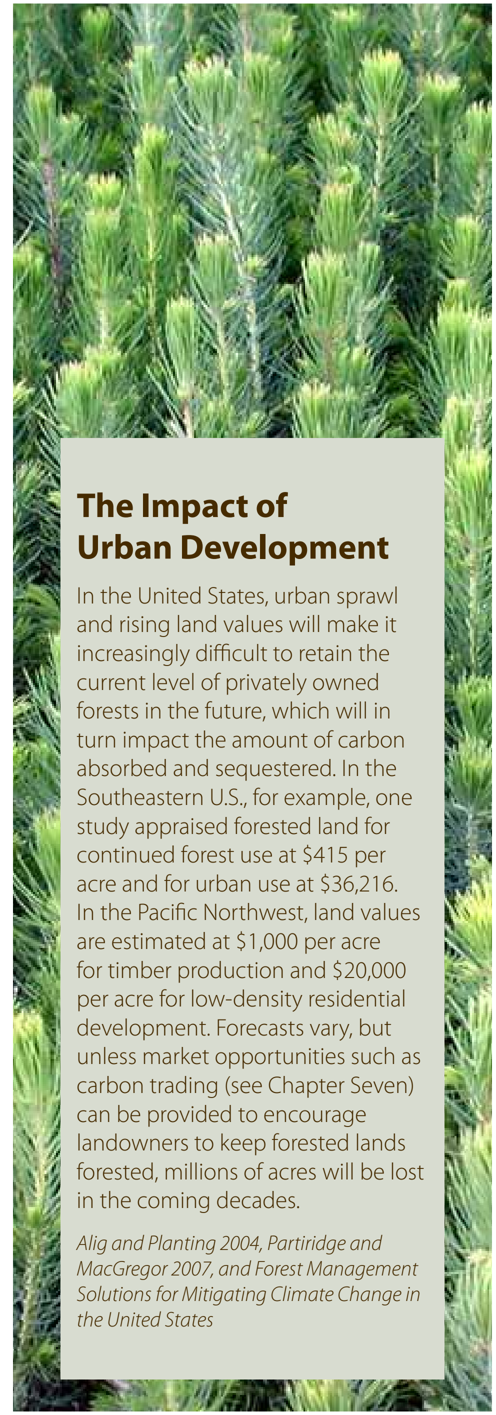
Setting aside a range of biologically and ecologically diverse ecosystems across the land base is an important management strategy. It ensures valuable areas are set aside for scientific studies, recreational and tourism opportunities, and the fulfillment of cultural and spiritual needs.

Provided the forests remain healthy and don't become a major source of greenhouse gases, the ideal scenario is to protect viable, representative examples of an area's natural diversity, while maintaining a network of working forests where a sustainable and healthy forest industry can thrive.

In the United States, approximately 20 percent of the nation's forests, or 753 million acres (305 million hectares), are included in some sort of conservation initiative. These range from full restriction (where the forest is kept in its natural state and disturbances such as fire are either left to proceed unimpeded or mimicked through management), to areas with some fire suppression as well as limited uses that may degrade the natural state (such as recreation), to areas with some limited, low-intensity logging or localized mining permitted.

Canada has set aside more than 99 million acres (40 million hectares) of forest, which is more than any other country in the world.

Setting aside representative parts of the land base helps to maintain biodiversity.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The Impact of Urban Development

In the United States, urban sprawl and rising land values will make it increasingly difficult to retain the current level of privately owned forests in the future, which will in turn impact the amount of carbon absorbed and sequestered. In the Southeastern U.S., for example, one study appraised forested land for continued forest use at $415 per acre and for urban use at $36,216. In the Pacific Northwest, land values are estimated at $1,000 per acre for timber production and $20,000 per acre for low-density residential development. Forecasts vary, but unless market opportunities such as carbon trading (see Chapter Seven) can be provided to encourage landowners to keep forested lands forested, millions of acres will be lost in the coming decades.

Alig and Planting 2004, Partiridge and MacGregor 2007, and Forest Management Solutions for Mitigating Climate Change in the United States

Forest Products Association of Canada

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In addition to ensuring that harvested areas are reforested, laws are obeyed and there's no unauthorized or illegal logging, all of the major certification programs cover the key elements of sustainability such as the conservation of biological diversity, maintenance of wildlife habitat, soils and water resources, and the sustainability of timber harvesting. They require annual surveillance audits as well as public disclosure through audit reports, and require forest companies to engage with indigenous people affected by their forestry operations.

Forest Certification

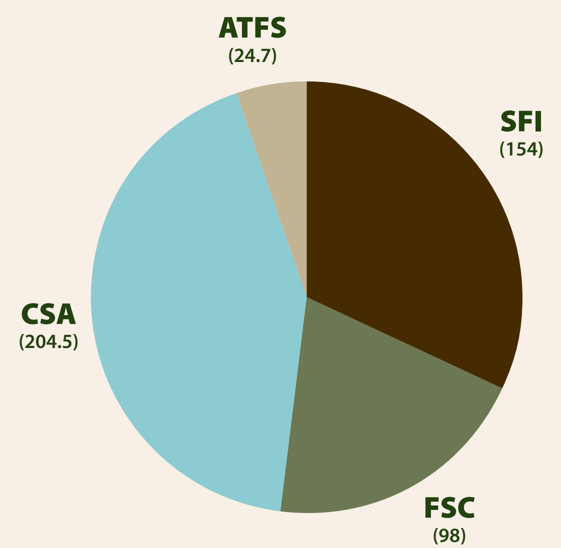
Forest certification is a mechanism for ensuring that forests are managed sustainably to maintain and enhance the long-term health of forest ecosystems. Consumers are demanding that forests be managed in a way that meets society's current needs without compromising future forest health and productivity. Third-party certification systems ensure that forest management practices maintain all the values we look for from our forests.

North America has more certified forest than any other jurisdiction.

In the U.S. and Canada, many forest companies have embraced independent sustainable forest certification as a way to demonstrate superior performance.

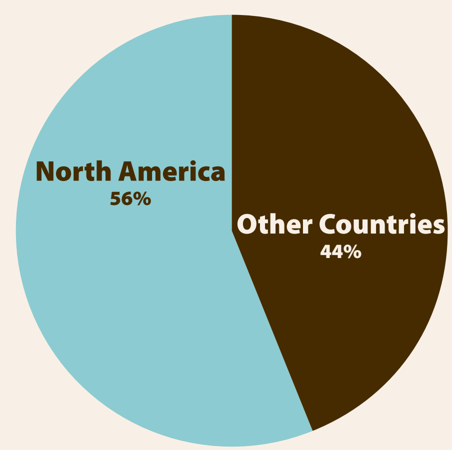
Area Certified in North America

Numbers in Millions of Acres



2008 year-end data from www.pefc.org, www.fscus.org, www.fsccanada.org, www.fsc.org, www.certificationcanada.org, www.mtc.com.my

Area Certified Worldwide



2008 year-end data from www.pefc.org, www.fscus.org, www.fsccanada.org, www.fsc.org, www.certificationcanada.org, www.mtc.com.my

It involves the third-party assessment of a company's practices against a standard that goes beyond regulatory requirements and takes into consideration environmental, economic and social values.

As of January 2009, more than 470 million acres (190 million hectares) were certified through one of the four main certification programs in use in North America: the Sustainable Forestry Initiative (SFI), Forest Stewardship Council (FSC), Canadian Standards Association's Sustainable Forest Management Standard (CSA) or American Tree Farm System (ATFS). Among developed countries, which have the vast majority of certified forests, North America has more than any other jurisdiction.

Deforestation

Deforestation is the permanent removal of forests where the land is converted to other uses such as agriculture or housing. Globally, it accounts for 17 percent of the world's greenhouse gas emissions.

The forests most vulnerable to destruction are in tropical regions of the world, where the rate of deforestation was estimated at 32 million acres (13 million hectares) a year from 1990 to 2005.

While not an issue in North America, deforestation accounts for 17 percent of global CO_2 emissions, mainly from tropical forests.

According to the *State of the World's Forests Report, 2007,* "the world lost about 3 percent of its forest area from 1990 to 2005; but, in North America, total forest area remained virtually constant." The U.S. reported an annual increase in forest area of 0.12 percent in the 1990s and 0.05 percent from 2000 to 2005, while Canada reported no change.

When forested land is converted for other uses, a portion of the deforestation can be offset by afforestation—such as the planting of trees on land that has been bare of trees for a long time.

Illegal Logging

Illegal logging contributes to deforestation, habitat destruction and climate change, given the loss of forest cover and subsequent loss of CO_2 absorption. It also undermines the viability of legally harvested and traded forest products, and is a serious detriment to forest sustainability.

Root causes of illegal logging include poverty, weak governance and corruption. Although much of the illegally harvested wood goes into timber and other products, a significant amount is also used for basic energy needs such as cooking and heating.

Illegal logging is not an issue in North America thanks to its multifaceted governance structure for sustainable forest management, which includes well-developed public policies, legislation and regulations, enforcement, regular monitoring and public reporting. However, recognizing its global importance, the U.S. and Canada are committed to working with international organizations to find solutions that minimize the impacts of illegal logging on the world's forests, people who depend on those forests, and forest product markets.

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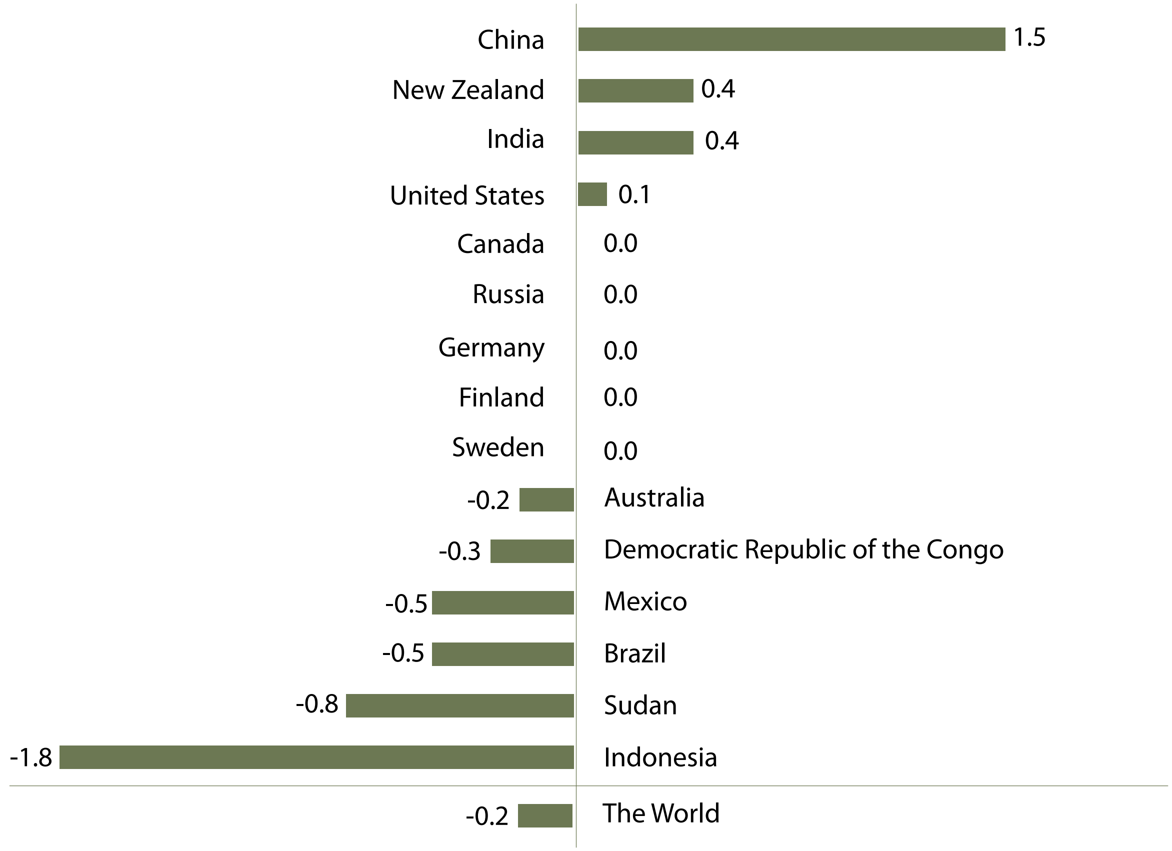
Annual Percent Change in Forest Cover 1990 - 2005
Among countries with major forest lands



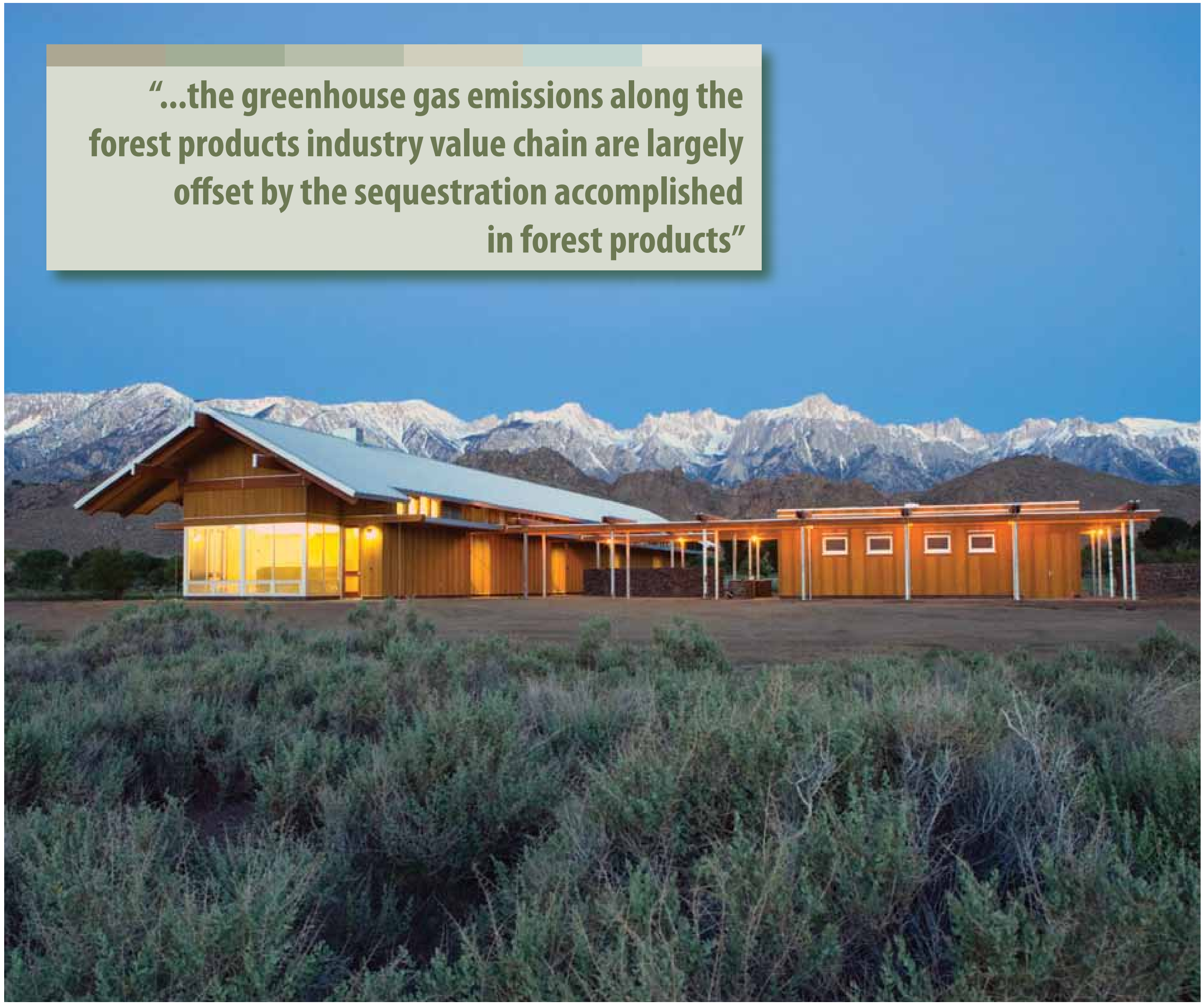
United Nations Food and Agriculture Organization, State of the World's Forests 2007

Carbon Neutrality

More than any other sector, the forest industry has an opportunity to mitigate climate change by becoming carbon neutral—which, once achieved, will mean companies are responsible for keeping at least the same amount of greenhouse gases out of the atmosphere as they contribute through direct and indirect emissions.

After examining the issue from U.S., Canadian and global perspectives, the National Council for Air and Stream Improvement (NCASI) reported* that "the greenhouse gas emissions along the forest products industry value chain are largely offset by the sequestration accomplished in forest products." These emissions are expected to remain constant or slowly decline over time, while sequestration in forest products and avoided emissions related to the use of biomass, cogeneration and recycling are predicted to increase.

"…the greenhouse gas emissions along the forest products industry value chain are largely offset by the sequestration accomplished in forest products"



Marcy Wong & Donn Logan Architects

Lone Pine Visitor Center, Lone Pine, California; Marcy Wong & Donn Logan Architects

**The Greenhouse Gas and Carbon Profile of the Global Forest Products Industry, NCASI*


Sandy McKellar

OPPORTUNITIES AND CHALLENGES

chapter seven

Kelly McCloskey

Opportunities and Challenges

Globally, it is clear that forests—and forest products—have the potential to significantly reduce greenhouse gases in the atmosphere.

As such, they represent an important opportunity to help avert a climate change crisis. This opportunity to be part of the solution is particularly pronounced in North America, which has as much forested land now as it did 100 years ago and is a leader, not only in sustainable forest management, but the manufacture of quality wood and paper products, and clean bioenergy.

Further, positive action in this regard—by governments and industry—will result in an increasing competitive advantage. With growing pressure on the world's natural resources, preference is already being given to suppliers who can demonstrate the sustainability of their practices. As more people come to understand the climate change benefits associated with substituting wood products for fossil fuel-intensive materials, using renewable biomass to generate clean energy, and actively managing the forest to increase CO_2 absorption while reducing wildfires, insects and disease, greater preference will also be given to companies and countries that excel in these areas.

Increased Wood Use

Wood products are a natural choice in the fight against climate change for the many reasons described in this book. It therefore makes sense that, as more people accept the urgency of climate change and seek to do their part, demand will increase for wood products that can be substituted for non-wood alternatives.

One notable example is the use of raised floor construction systems as an alternative to concrete slab-on-grade homes, which are common in areas such as the southern U.S. Another is non-residential construction—including everything from hospitals and office buildings to schools and multi-family housing—which has traditionally been dominated by steel and concrete. To demonstrate the possibilities, five case studies are included at the end of this book, including one on the new Olympic Speed Skating Oval in Richmond, British Columbia. A signature structure of the 2010 Olympic Games, the Oval has an innovative six-acre (2.4 hectare), free-spanning wood roof and includes lumber from trees killed by the mountain pine beetle.

Increased Production of Bioenergy

The development of clean, renewable energy is an important part of any climate change strategy and is a focal point of government policy and research both in the United States and Canada.

The environmental benefits associated with the use of woody biomass in particular—instead of fossil fuels or, in fact, any other biofuel crop—will mean that technology or systems currently in their infancy (such as those needed for the widespread production of ethanol) will evolve rapidly.

The production of bioenergy also offers financial benefits to the forest industry, which will further drive expansion and contribute to sustainability. As the cost of fossil fuel-based energy increases, cogeneration and other green energy systems will help to reduce manufacturing costs.

Jonathan Hillyer

Twin Creeks Science and Education Center, Gatlinburg, Tennessee; Lord Aeck & Sargent Architecture

The production of bioenergy is an important part of any climate change strategy.

Reducing Emissions Through Product Substitution

Within the building sector, three markets offer particularly good opportunities to reduce greenhouse gas emissions through increased wood use and are being pursued by the wood industry.

In parts of the United States where concrete slab-on-grade is a common residential building style, there is a tremendous opportunity to increase the use of wood through raised floor construction, which, in addition to its environmental attributes, provides greater protection against natural forces such as floods and high winds. In the U.S. South, an educational campaign is underway to actively promote this type of construction and provide builder support.

Likewise, the multi-family and non-residential construction markets offer substantial opportunities. Although many architects and engineers tend to think of steel and concrete for these types of buildings, there is usually no reason—identified in building codes or elsewhere—that wood cannot perform as well or better. Estimates of the opportunity reach 10 billion board feet equivalent, which is about 300 percent more than the amount currently being used in non-residential construction. To raise awareness of the possibilities, the forest industry has two programs, WoodWorks in the U.S. and Wood*WORKS!* in Canada. Both provide free educational and technical resources for design and building professionals, and offer one-on-one support from design through construction.

Forest Carbon Standards Committee

The Forest Carbon Standards Committee (FCSC) was formed in 2008 by a binational group of stakeholders with a history of involvement in the development of forest carbon offset protocols and standards. The FCSC has undertaken a standards development process accredited by the American National Standards Institute (ANSI) in order to develop forest carbon measurement protocols, with the objective of setting consistent approaches to be used by both countries.

This effort is uniquely supported by a binational spectrum of leading organizations representing both U.S. and Canadian interests. This consortium is working together to specifically advance the health of North American forests, expand forestry markets and sustain a vibrant forest products industry. Sponsoring organizations include the American Forest & Paper Association, Society of American Foresters, Forest Products Association of Canada, and Canadian Institute of Forestry. The full committee embodies a diverse set of more than 30 organizational participants, including industry stakeholders, landowners, environmental groups, and carbon traders, among others.

The purpose of the FCSC is to develop and maintain standards for the measurement, reporting, and verification of forest carbon offsets under current and emerging greenhouse gas emission reduction programs in the U.S. and Canada. The FCSC builds on existing protocols and standards—matching their approaches to known forest science and practice—to determine innovative ways to satisfy emerging emission reduction policies and markets. For more information: forestcarbonstandards.org.

When it comes to forest products and climate change, North American producers have a distinct competitive advantage.

Intensive Forest Management

Forestry practices have long sought to achieve objectives such as improved wood quality and faster regeneration of harvested stands. Now they're also helping to address climate change—because a forest that grows more quickly, remains healthy and is promptly regenerated, also absorbs more CO_2.

However, in addition to intensive management, "active" management is also an important part of the equation. Active management involves thinning the forest, removing dead trees and clearing debris at various points in its development. It helps to reduce the number and intensity of wildfires and protects against the spread of insects, both of which result in significant CO_2 emissions.


Sandy McKellar

A forester can use soil sample characteristics to determine forest fire history and ecosystem characteristics.

Carbon Trading

Carbon trading, or "cap and trade," systems are a regulatory approach used to control greenhouse gas emissions by providing economic incentives for achieving reductions. Companies can exceed their limits if they purchase credits or carbon offsets, which in turn provide financial rewards to those whose emissions are lower than allowed.

Trading in greenhouse gas emissions has been underway in the United States since 2003, when the Chicago Carbon Exchange (CCX) became the world's first global venue for emissions trading and offsets. The Montreal Climate Exchange, which is affiliated with the CCX, launched a futures market for Canadian CO_2 emissions in May 2008. A number of regional initiatives are in development—such as the binational Western Climate Initiative—and national systems are now also being considered in both countries.

In short, carbon markets are gaining momentum and forestry is likely to play a role in all of them. What remains unclear is whether carbon storage in harvested wood products and avoided emissions through substitution will be properly recognized so as to facilitate the substantial benefits available. Given the forest sector's light carbon footprint, a well-structured carbon trading system could help to maximize the benefits described in this book, while helping to support the economic health of the industry and the sustainable practices that are essential to helping tackle climate change.

To help ensure this doesn't happen, a consortium of forestry and environmental leaders has come together to establish voluntary consensus forest carbon standards certified for use in the U.S. and Canada under the rules of the American National Standards Institute (ANSI) and Standards Council of Canada (SCC). (See sidebar on previous page.)

Duda/Paine

Duke Integrative Medicine, Duke University Medical Center, Durham, NC; Duda/Paine Architects, LLP

Tackle Climate Change – Use Wood

Governments around the world are implementing policies that encourage greater use of forest products.

UNITED KINGDOM – Changes in national building regulations are encouraging multi-story wood buildings; the largest timber-frame building in the United Kingdom is nine stories.

FRANCE – The government recently announced measures encouraging the building sector to increase the use of timber tenfold by 2020.

NEW ZEALAND – As part of its promotion of a carbon-neutral public service, the government is requiring that wood or wood-based products be considered as the main structural materials for new government-funded buildings up to four floors.

CANADA – The governments of British Columbia and Quebec have recently announced policies encouraging the use of more wood.

The BC government's "Wood First" policy will require wood to be the primary building material in all new public buildings. The province's building code has also been changed to allow six-story multi-family residential buildings, up from four stories.

In Quebec, the government's wood-use strategy encourages all levels of government to commit to adopting a charter to use wood in all public buildings.

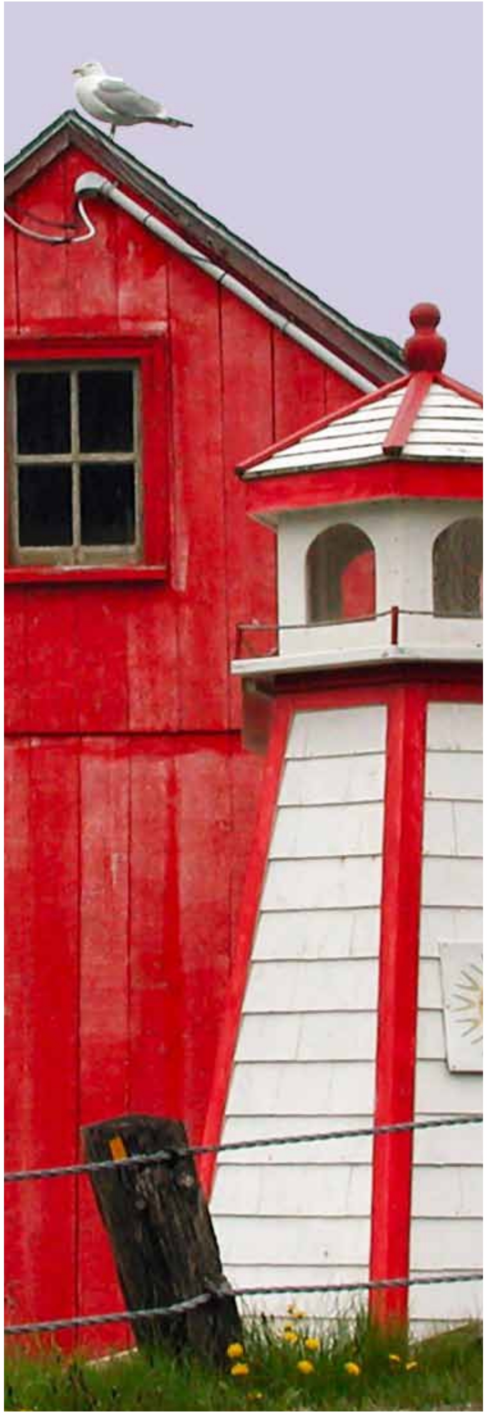
UNITED STATES AND CANADA – Both governments are encouraging increased production and use of bioenergy from woody biomass, as evidenced by (among other things) their research into the widespread production and use of cellulosic ethanol.

EUROPEAN UNION – Members of the EU have agreed that 20 percent of their total energy output will come from renewable energy sources (i.e., biomass, biogas, wind, solar, hydro and geothermal energy) by 2020.

In recent years, there has been an increasing focus on 'responsible use' as an appropriate strategy for addressing a wide range of environmental issues. It is a common-sense mantra we must now take up with respect to climate change:

Choose wood products from sustainably managed forests over materials that require large amounts of fossil fuels to manufacture. Extend their lives through recycling and reuse to maximize the carbon storage potential. Manage forests to reduce the risk of wildfire, insects and disease, and encourage the use of forest debris to produce clean bioenergy.

In other words, make sound environmental choices today that maximize the potential of forests and forest products to be part of the climate change solution.



Sandy McKellar

Sandy McKellar

CASE STUDIES

HMC Architects

Case Studies

This section features five examples of very different buildings, and illustrates the carbon benefits of using wood.

These buildings were chosen to demonstrate the potential for carbon storage and avoided greenhouse gas emissions across a range of building types; however, they also individually and collectively represent wood's tremendous and in many ways untapped potential.

Calculating Carbon Storage and Avoided CO_2 Emissions

The case studies provide an estimate of the total carbon benefit of wood based on the volume of wood used and how much carbon it stores, and the greenhouse gas emissions avoided by using wood instead of steel or concrete.

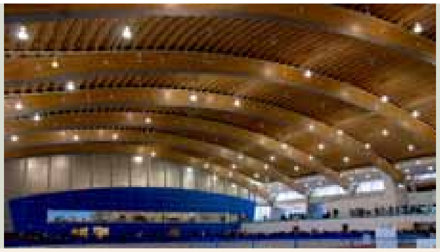
Since wood is on average 50 percent carbon by weight, calculating the volume of carbon stored in each building was relatively straightforward. These estimates were provided by the research organization, FPInnovations.

The calculation of avoided emissions is more complex. In order to ensure an accurate result, each building would have to undergo a full life cycle assessment of its wood design as well as the comparable designs in steel and concrete. Since this is beyond the scope of this book, the estimates provided (with the exception of the Stadthaus building) reflect an average displacement of twice the amount of carbon dioxide sequestered, which is derived from a literature review* of 48 studies of hundreds of typical buildings, also by FPInnovations. However, it must be noted that several of the buildings described in these case studies are in many ways unique and, as such, the average displacement may under or over estimate the actual amounts.

Converting the carbon benefit into equivalencies such as *"the number of passenger vehicles off the road for a year"* or *"the energy required to operate a typical single family home"* was done using the U.S. Environmental Protection Agency's Greenhouse Gas Calculator.

**Sathre, R. and J. O'Connor, 2008, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations .*

The Case Study Buildings



The Richmond Olympic Oval is the largest structure built for the 2010 Winter Olympic Games in Vancouver, British Columbia, and includes an astonishing six-acre (2.4 hectare), free-spanning wood roof.

At nine stories, **The Stadthaus Building** in the United Kingdom is the world's tallest mixed-use wood structure—which, in addition to its climate change benefits, cost 15 percent less than its concrete alternative.

Within the outer glass walls of the **Experimental Media and Performing Arts Center** at Rensselaer Polytechnic Institute in Troy, New York, a giant wood hull houses a state-of-the-art concert hall.

Although wood schools are common in California because of their seismic performance, cost and speed of construction were the main influencing factors for **Harada Elementary School**.

In the southern U.S., **raised floor construction** is gaining popularity for its performance under extreme conditions such as floods and high winds, as well as its practicality and cost-effectiveness.

Sandy McKellar

STADIUM SPANS

Richmond Olympic Oval

Richmond, British Columbia

The Richmond Olympic Oval is the largest structure to be built for the 2010 Olympic Winter Games and a precedent-setting example of advanced wood engineering and design—thanks to a six-acre, free-spanning wood roof that utilizes conventional materials in a truly remarkable way.

Designed to house a 400 meter speed-skating track with temporary capacity for approximately 8,000 guests during the Olympics, it will be converted afterwards into a multi-purpose arena capable of hosting a wide variety of sporting events.

The building is arranged on three levels, the highest of which is a vaulted sports hall with a great arched roof. Springing from inclined concrete buttresses, the main arches are comprised of twinned glulam members held at an angle to each other by a steel truss. They span the 330-foot (100 meter) width of the arena and support a total of 452 WoodWave Structural Panels®. The panel system is comprised of the same standard lumber used in wood-frame construction throughout North America—including 1 million board feet (2,400 cubic meters) of SPF (spruce, pine, fir) construction-grade dimension lumber and 19,000 sheets of exterior grade Douglas-fir plywood.

Climate Change Advantage

Although wood buildings are by their nature climate change friendly, two things about the Oval stand out as unique. First is the fact that, prior to the WoodWave roof system, the possibilities associated with using regular dimension lumber for large and long span buildings had been largely unexplored. As such, the Oval could have a compounding influence as similar techniques are applied to other large buildings.

Another distinctive characteristic is that virtually all of the lumber used in the roof was harvested from sustainably certified forests impacted by the mountain pine beetle. By making use of this wood instead of leaving it to decay or succumb to fire, it will continue to store the carbon absorbed by the trees—while the affected forests are regenerated with new trees that once again begin the cycle of absorption.

Sandy McKellar

V	**Volume of wood used: 3,820 cubic meters**
C	**Carbon sequestered and stored: 2,940 metric tons of CO_2**
	Avoided greenhouse gases: 5,880 metric tons of CO_2*
	Total potential carbon benefit: 8,820 metric tons of CO_2
	1,615 passenger vehicles off the road for a year
	Energy to operate a home for 803 years

For more information on the Richmond Oval and its innovative WoodWave roof, a detailed case study is available from the Canadian Wood Council, cwc.ca.

Owner:
City of Richmond

Architect:
Cannon Design

Roof Design:
StructureCraft Builders Inc.

Construction Manager:
Dominion Fairmile Construction

Project Management:
MHPM Project Managers Inc.

Sandy McKellar

**Estimate only, as described on page 62.*

Waugh Thistleton Architects

NEW HEIGHTS

Stadthaus Building

London, United Kingdom

To create the world's tallest mixed-use wood building, architect Andrew Waugh utilized a material he had been interested in for some time—cross-laminated timber (CLT)—which, because of its large panel format and structural characteristics, offered unique design possibilities.

A partnership between the Metropolitan Housing Trust and Telford Homes, the Stadthaus has 19 private apartments, 10 social housing units, and a residents' office. The upper eight stories are made from CLT panels that comprise a cellular structure of load-bearing walls, including stairways and elevator cores, and timber floor slabs. The building uses a platform configuration, with each floor set on the walls underneath and joints secured with screws and angle plates.

The ground floor is made from cast concrete with short pile foundation, though Waugh has since indicated that he could have used timber and will likely do so in the future. The cladding is a mixture of wood pulp and cement tile and includes 5,000 individual panels in a pattern designed to mimic the shadows on the site, thus creating texture without the use of brick.

Climate Change Advantage

Although the developers were primarily interested in the cost and time savings associated with a wood building, climate change was a critical part of the architect's proposal to government. By using wood instead of the area's usual concrete slab construction, he proposed to substantially reduce greenhouse gases in the atmosphere—through avoided emissions and because the building would continue storing carbon over its lifetime. Although two previous proposals for the site had been turned down, the energy savings alone earned Waugh a strong endorsement from local building authorities and the project was able to proceed.

Waugh Thistleton Architects

V	**Volume of wood used: 950 cubic meters**
C	**Carbon sequestered and stored: 760 metric tons of CO_2**
	Avoided greenhouse gases: 320 metric tons CO_2*
	Total potential carbon benefit: 1,080 metric tons of CO_2
	179 passenger vehicles off the road for a year
	Energy to operate a home for 89 years

Owner:
Telford Homes PLC / Metropolitan Housing Trust

Architect:
Andrew Waugh, Waugh Thistleton Architects

Structural Engineer:
Techniker Ltd. / Jenkins & Potter Consulting Engineers

Timber Supplier:
KLH UK Ltd.

Mechanical Engineer:
Michael Popper & Associates / AJD Design Partnership

Waugh Thistleton Architects

**Substituting CLT for concrete in a nine-story building is particularly unique and thus a separate estimate of avoided emissions was provided by FPInnovations. It is an initial estimate only and subject to refinement.*

Grimshaw

SIGNATURE DESIGN

Experimental Media and Performing Arts Center at Rensselaer Polytechnic Institute

Troy, New York

The Experimental Media and Performing Arts Center (EMPAC) at Rensselaer Polytechnic Institute is a laboratory for performing arts and science, providing state-of-the-art immersive environments for the senses of sight and sound.

The centerpiece of the building is a concert hall contained inside an enormous three-dimensionally curved wooden "hull"—which is clad in western redcedar tongue-and-groove planks.

Grimshaw selected the wood both for its aesthetic qualities and technical performance. The hull was subjected to a stringent series of flame spread tests and judged to inherently conform to the required fire protection rating. The design team collaborated extensively with the millwork contractor, who constructed a full-scale mock-up of a section of the hull to allow the development of architectural details and mechanical fastening techniques.

Designed to accommodate symphonic music as well as jazz, amplified music, presentations film and dance, the concert hall is configured in the traditional "shoe box" format, as a long, narrow room of wood and masonry construction. The floor and lower walls are finished in maple, while the upper walls are clad in a combination of precast stone and acoustic panels made of gypsum.

Climate Change Advantage

In addition to the stored carbon and avoided greenhouse gas emissions that resulted from the wood hull, the EMPAC building includes other environmental advantages. Among other things, the cedar was sourced from sustainably managed forests in British Columbia and the building was designed with energy efficiency as a major objective. The latter was recognized in the building's achievement of LEED® Silver through the Leadership in Energy and Environmental Design green building rating system.

Grimshaw Architects

Volume of wood used: 86,000 linear feet of cedar plank

Carbon sequestered and stored: 40 metric tons of CO_2

Avoided greenhouse gases: 80 metric tons of CO_2*

Total potential carbon benefit: 120 metric tons of CO_2

22 passenger vehicles off the road for a year

Energy to operate a home for 11 years

Owner:
Rensselaer Polytechnic Institute

Design Architect:
Grimshaw

Structural Engineer:
Buro Happold

Construction Manager:
Turner Construction

Acoustician:
Kirkegaard Associates

Millwork Contractor:
Architectural Woodwork Industries

**Estimate only, as described on page 62.*

Paúl Rivera/Archphoto


HMC Architects

SPEED OF CONSTRUCTION AND COST

Harada Elementary School

Corona, California

In California, where wood schools are common because of their ability to withstand seismic forces, wood-frame construction is increasingly being chosen for its low cost compared to masonry and steel—which was the main reason HMC Architects chose wood for Harada Elementary.

Bordered by housing developments on all sides, the school is symbolic of the rapid growth of the community and a tribute to Jukichi Harada, a local business owner and civil rights pioneer, and his family. Based on a structure that includes wood-frame walls, roofs and second level floors, the design is intended to stimulate—through color, shape, texture, pattern, natural light and spatial variety.

Self-contained classrooms featuring nine-foot ceilings provide a sense of openness for students and flexibility for teachers, with pullout workrooms and other movable elements. In total, the school includes a two-story classroom building, kindergarten building, covered kindergarten play area, administration building, multipurpose building, cafeteria, media center, exercise courts, student gathering area, and parking.

Harada also features sustainable design elements that enhance the learning environment, such as an outdoor classroom where students can expand on their learning experience. The layout of the buildings forms a natural amphitheater with a raised central platform that allows for outdoor activities. This spatial organization also serves as a barrier from the outside world, creating a protected haven for students on campus.

Climate Change Advantage

In addition to the climate change advantages related to the use of wood—specifically, the amount of stored carbon and avoided greenhouse gas emissions—Harada Elementary School includes energy efficiency features such as skylights to reduce demand for lighting.

HMC Architects

HMC Architects

V	**Volume of wood used: 655 cubic meters**
C	**Carbon sequestered and stored: 490 metric tons of CO_2**
	Avoided greenhouse gases: 990 metric tons of CO_2*
	Total potential carbon benefit: 1,480 metric tons of CO_2
	270 passenger vehicles off the road for a year
	Energy to operate a home for 135 years

Owner:
Corona-Norco Unified School District

Architect of Record:
HMC Architects

Contractor:
Neff Construction (CM)

Framing Contractor:
West-Helm Construction Inc.

HMC Architects

**Estimate only, as described on page 62.*

Southern Forest Products Association

EXTREME ENVIRONMENT

Raised Floor Home

New Orleans, Louisiana

Home XE (Extreme Environment) is a 2,181-square-foot (203-square-meter) home designed following Hurricane Katrina to demonstrate that raised floor construction, which is perhaps best known for practical benefits such as access to plumbing, comfort and curb appeal, is also ideally suited to resisting high winds, floods and other natural forces common to the Gulf Coast.

Like many homes in New Orleans, the foundation starts with driven piles topped with an even concrete slab at ground level, known as "slab-on-grade." However, this is where the similarities end. Twelve piles, which are proven to offer superior resistance to flood surge, rise eight feet above grade to support the first and second floor living areas. This is well above the Federal Emergency Management Agency (FEMA) Base Flood Elevation, which both protects the home and saves the home owner up to 50 percent on flood insurance premiums. Strong, building code-approved connections between walls, floors and other parts of the home also help to resist rising waters and wind speeds of up to 150 miles per hour (240 kilometers per hour).

Showcased as part of the National Association of Home Builders' 2008 Green Homes Tour, Home XE is built primarily from pressure-treated Southern pine wood products, which are locally sourced from sustainably managed forests.

Climate Change Advantage

From a climate change perspective, this home is unique in that it underscores both the massive amount of carbon stored in the North American housing stock, which is predominantly wood framed, as well as the potential to increase these benefits by using more wood.

At the time of this writing, a detailed life cycle assessment is underway to quantify the incremental wood used (and thus carbon stored) and emissions avoided from not building this house on a concrete slab. Thus, for the purpose of this document, the carbon benefit is assumed to be the same as an average 2,500-square-foot (232-square-meter) single family home. However, it's worth noting that a home built with raised floor construction is assumed to utilize about one-third more wood than a typical wood-frame home, and would therefore store one-third more carbon.

Southern Forest Products Association

Southern Forest Products Association

V	**Volume of wood used: 15 cubic meters**
C	**Carbon sequestered and stored: 30 metric tons of CO_2**
	Avoided greenhouse gases: 60 metric tons of CO_2*
	Total potential carbon benefit: 90 metric tons of CO_2
	16 passenger vehicles off the road for a year
	Energy to operate a home for eight years

Developer:
Toni Wendel

Partner:
Southern Pine Council / RaisedFloorLiving.com

Southern Forest Products Association

**Estimate only, as described on page 62.*

Kelly McCloskey

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Kelly McCloskey


Sandy McKellar

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Forest Products Association of Canada, www.fpac.ca

Forestry Innovation Investment, www.naturallywood.com

FPInnovations – Forintek Division, www.forintek.ca

International Panel on Climate Change, www.ippc.ch

National Council for Air and Stream Improvement, www.ncasi.org

Natural Resources Canada, www.nrcan-rncan.gc.ca

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Southern Pine Council, www.southernpine.com

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United Nations Framework Convention on Climate Change, http://unfccc.int

United States Department of Agriculture Forest Service, www.fs.fed.us

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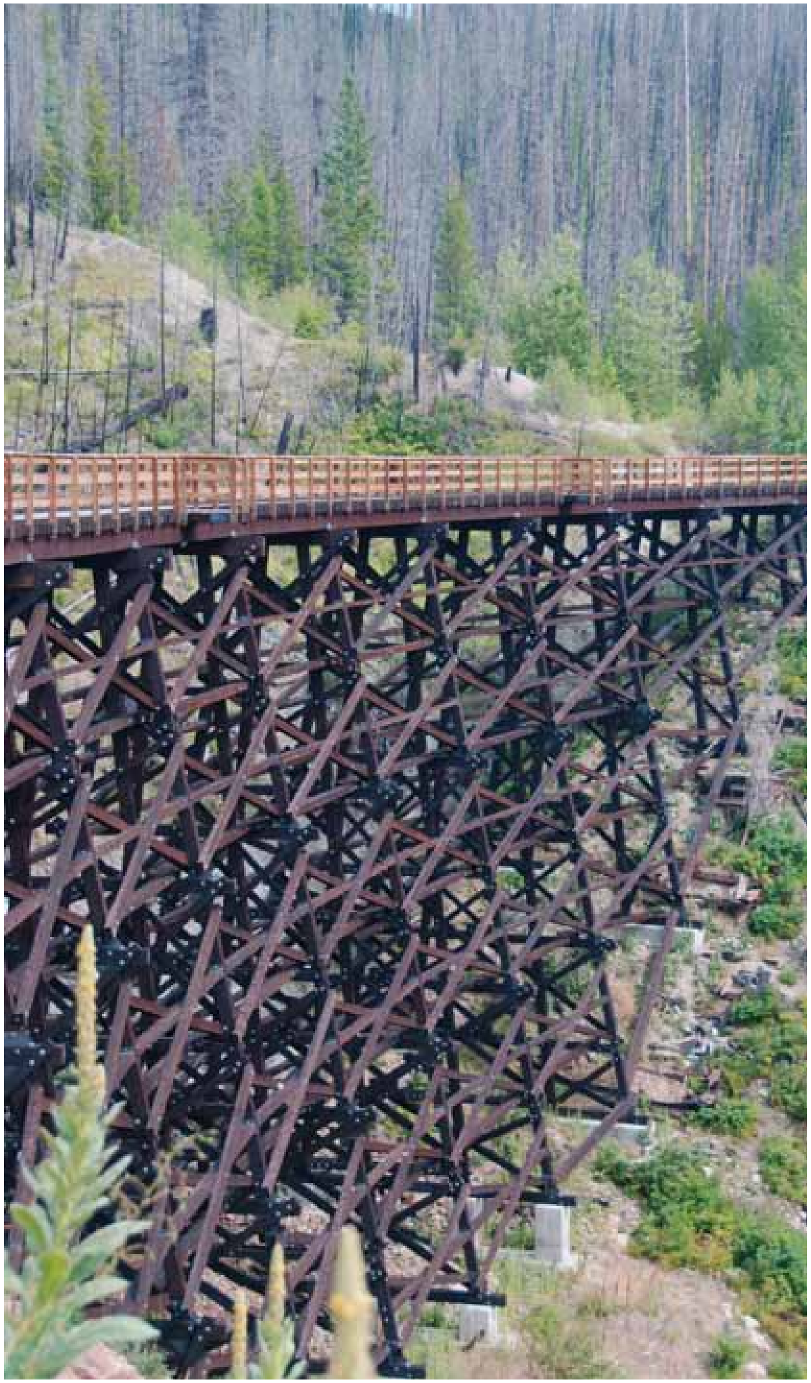


Sandy McKellar

Award Winners


Western Red Cedar Lumber Association, www.wrcla.org

Tseshaht First Nation Tribal Multiplex, Port Alberni, British Columbia; Lubor Trubka Associates Architects | Recognized by the Western Red Cedar Lumber Association

Timothy Hursley & Cesar Rubio

Cathedral of Christ The Light, San Francisco, California; Skidmore, Owings and Merrill LLP | Recognized by the North American Wood Design Awards

Benny Chan

Ahmanson Founders Room, Los Angeles, California; Belzberg Architects | Recognized by WoodWorks US

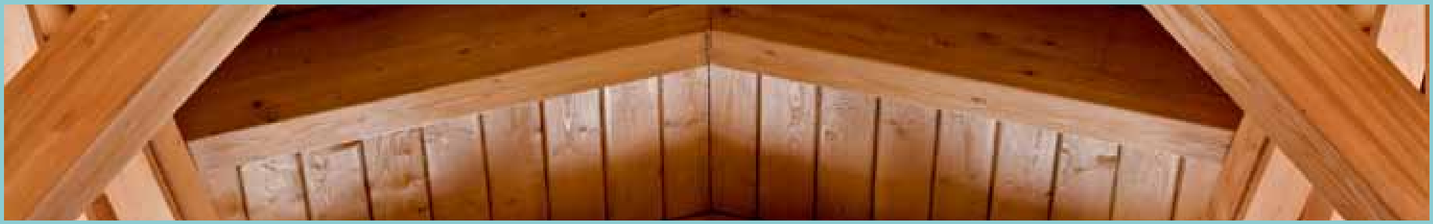
Cuningham Group Architecture

Epic Systems Corporation Learning Center, Verona, Wisconsin; Cuningham Group Architecture | Recognized by WoodWorks US

The Simcoe WaveDeck, Toronto, Ontario; West 8 + DTAH | Recognized by Wood *WORKS!*

Helliwell + Smith Blue Sky Architecture Inc.

Elma Bay Residence, Black Creek, British Columbia; Helliwell + Smith Blue Sky Architecture Inc. | Recognized by Wood *WORKS!*



In recent years, there has been an increasing focus on ‘responsible use’ as an appropriate strategy for addressing a wide range of environmental issues. It is a common-sense mantra we must now take up with respect to climate change:

Choose wood products from sustainably managed forests over materials that require large amounts of fossil fuels to manufacture. Extend their lives through recycling and reuse to maximize the carbon storage potential. Manage forests to reduce the risk of wildfire, insects and disease, and encourage the use of forest debris to produce clean bioenergy.

In other words, make sound environmental choices today that maximize the potential of forests and forest products to be part of the climate change solution.

Duda/Paine