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TREES IN THE GREENHOUSE

Why Climate Change is Transforming the Forest Products Business

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Foreword

The world is entering an era when natural resource constraints, environmental policies, and shifting consumer values will create unprecedented demands on the private sector. Recent spikes in the prices of energy and food commodities illustrate the dynamic forces that are changing the world. In this new business context, the concept of "creative destruction"—a process by which innovation builds long-term value even as it destroys the value of the status quo—may extend beyond individual companies and apply to whole industries.

One example is the forest products business. What was once a simple business of turning trees into lumber and paper is now uniquely positioned—or exposed—to political and economic forces that are reshaping regulatory and market landscapes. Can this industry take a new position as a sustainable producer of fiber, energy, and materials to meet the world's growing needs? And can the industry be a supplier of ecosystem services—the valuable benefits provided by nature—such as carbon storage?

Global deforestation contributes approximately 18 percent of the world's greenhouse gas emissions, and forests have become a major focus of international action to address climate change. Today, 34 percent of the world's forests are designated mainly for wood and fiber production. Surprisingly, less than five percent of the world's forests are plantations, yet this five percent provides 50 percent of all wood and fiber supply. As demand grows and native forests are increasingly protected, the forest products industry stands to play a major role in meeting the world's wood and fiber needs but in a very different operating environment.

At a time when the prices of basic commodities are rising sharply, trees may also be an important source of bioenergy—ideally a source that never competes with food crops—which could dramatically affect the forest products business. Yet questions over the environmental and social impacts of bioenergy production are also mounting. Whether or not forest resources can provide a sustainable alternative to today's fossil fuel-based energy sources remains highly uncertain, creating major risks for businesses and investors.

Furthermore, at a time when the world needs to shift to a low-carbon economy, the carbon impact of sustainably-produced wood construction materials is far less than that of steel or cement. Wood products store carbon through their useful life and often require little if any fossil fuel for their production. Using wood as a substitute for other materials saves, on average, two tons of carbon dioxide per cubic meter of material. But will the world's explosive demand for construction products favor low-carbon options?

The forest products industry has a unique opportunity to provide sustainable solutions to climate change, but clear, long-term climate policies are necessary to realize this opportunity. Nonetheless, the industry is fragmented and, in many cases, divided over what represents appropriate climate policies. This report provides insights into the complex array of issues related to climate change. It will help companies, investors, and the sector as a whole to develop a more proactive and informed position on climate change policies and what constitutes an effective business response. With the right regulatory frameworks in place, both internationally and nationally, the forest products industry could be a major solutions provider to climate change while seizing some of the greatest market opportunities of the 21st century.

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MAIN FINDINGS

While risks exist, climate change presents a potentially game-changing opportunity for the forest products industry through: (1) new markets and products, (2) competitive advantages in relation to carbon-intensive substitute materials, (3) enhanced forest productivity, (4) increased demand for sustainable forest management, and (5) green preferences.

Climate change policies will be vital to realizing the opportunity. Forest products will need to be produced and consumed in a sustainable manner for the industry to create long-term value through contributions to global climate change solutions.

Climate change and policies to address it will fundamentally alter the market dynamics of the forest products industry. The management of forests and the manufacturing, use, disposal, and recycling of forest products can affect the balance of greenhouse gases in the atmosphere. Because trees are a renewable resource with an ability to capture and store carbon, forest products companies that invest in sustainable production practices may be well positioned to provide climate change solutions through new and existing business models.

The uncertainties of climate change impacts, technology developments, and policy outcomes, however, make it challenging to predict the exact financial and competitive implications of climate change on forest products companies and the industry as a whole. Many risks and opportunities that are driven by climate change will vary greatly by a company's geographic location, position in the value chain, and the sustainability of operations. The particular consequences for each forest products company will likely differ widely, with new winners and losers emerging based on strategic decisions by both investors and corporate leaders over the near and medium term. Companies with experience in sustainable forest management and supply chains may be better positioned to capitalize on new climate change regulations and market forces.

This report provides a preliminary assessment of the industry's exposure to climate change risks and opportunities. It is intended to stimulate further analysis by companies and investors to determine their own exposure to climate change and develop appropriate strategies to maximize value and minimize risk.

Five key themes with respect to the forest products sector and climate change are the following:

1. **New revenue streams and markets for forest goods and services.** Sustainably managed forest resources can provide goods and services beyond the traditional wood and paper products, including carbon sequestration/storage and biomass for transport fuels and electricity. Concerns about climate change and energy security may draw increased interest in forests to contribute solutions to these challenges to the potential benefit of well-positioned forest products companies. Sustainable forest owners and integrated producers thus are positioned to increase the value of forest resources, whereas manufacturers may have to pay higher prices for raw materials. Nonetheless, some pulp and paper manufacturers may find synergies with biofuels and bioproducts production to generate additional revenue streams.
2. **Competitive advantages in a low-carbon economy.** Because forest products can require little or no fossil fuels for production and store carbon throughout their useful life, they can have inherent climate change advantages over all other materials with which they compete, provided they are produced in a sustainable manner. This is especially true for

construction products made of wood. Indeed, under sustainable practices, the forest products industry is one of the least carbon-intensive manufacturing sectors, and with broad-based incentives to reduce greenhouse gas emissions, such as a carbon tax or a cap-and-trade system, the relative prices of and demand for forest products will likely improve. However, policy rules that compensate energy-intensive industries as well as substitution barriers to forest products may ultimately determine the impact of climate change on the industry.

3. **Changes in forest productivity.** Globally, the biological productivity of forests and the supply of forest resources are expected to increase, although the regional variability will reconfigure the availability of suitable growing regions and trade patterns, creating localized winners and losers. Climate change is predicted to affect temperature, precipitation patterns, and extreme weather events, which in turn will change forest coverage, species composition, and disturbances such as fires and insect and disease outbreaks. Moderate changes in climate are predicted to have the smallest impact on temperate forests, whereas the impact on tropical regions is uncertain but clearly important to the growth of plantation forestry. Boreal forests face many risks due to dramatic changes in the climate of these regions.
4. **Future access to forestlands.** Managed forests, which can be either plantations or regular forests that are routinely harvested, are expected to provide an increasing share of the world's fiber and wood resources as access to native forests becomes more restricted and production continues to shift toward fast-growing plantations in the tropics and subtropics. Global efforts to improve protection of native forests in these tropical and subtropical regions could also intensify the demand for new, sustainably managed forests in rapidly growing markets. National governments may develop deforestation reduction strategies in regions where competition from illegal logging currently makes sustainable forestry operations uneconomic, potentially opening new markets for the industry. Competition for land with lucrative bioenergy export crops could, however, limit the growth of plantation forestry in those regions best suited to low-cost short-rotation forestry.
5. **Green preferences.** Despite the growing global public awareness of climate change, the climate change benefits of sustainable forest products are not widely understood. Climate change offers an opportunity for sustainable forest products to be distinguished from other competing materials on their low-carbon merits, and the industry would benefit from improving consumer and government relations through promoting climate change mitigation solutions. The industry will need to address other environmental and social issues related to sustainability in their outreach efforts to gain credibility with consumers, civil society groups, and policymakers.

Though the industry as a whole may stand to gain, climate change will impact companies and investments differently based on the location of the forests, mills, and markets, the vertical integration of assets, and the sustainability of forest operations. Table 1 provides an overview of the risks and opportunities separated according to forests, mills, and markets and products. Figure 1 illustrates these risks and opportunities in a qualitative way with respect to their potential financial impact and the level of certainty.

The need for investors and forest products companies to mitigate the risks related to climate change cannot be underestimated. Next steps include:

Reevaluating forest asset strategies. Many climate change opportunities and risk management strategies are linked directly to forestlands, including the emerging demand for wood and fiber from bioenergy markets, the potential value of carbon sequestration and storage, more restrictions on native forests, and the growing competition for forestland from other sectors and uses. These issues suggest that forest assets may have a more important and a more strategic role in the sector's profitability. This is especially true for manufacturers that may face higher prices for raw materials owing to the new competition in wood and fiber markets.

In the United States and Europe during the late 1990s, forest product companies that owned forests came under heavy pressure from equity markets to not carry forest assets on their balance sheets because they tied up capital, held down returns on total assets, and faced tax liabilities. Real estate prices in the United States also offered lucrative incentives to divest or develop tracts accessible to housing markets. Traditional concerns about the security of the wood and fiber supply were muted by the development of robust pulp markets, boosted in part by Brazilian exports and low-priced wood from Russia.

This conventional wisdom of the late 1990s resulted in large divestitures of forest assets by forest products companies in the United States and Europe. But because of the higher wood and fiber prices from bioenergy competition and tariffs on Russian exports, forest products companies that own forest assets may be better positioned than pure play manufacturers to offset potential supply problems. In addition, the new markets and revenue streams for bioenergy and forest services (including carbon sequestration) could fundamentally transform the industry's business model.

Most investments in commercial timberland today are made through private equity investments structured and managed by a timberland investment management organization (TIMO). Even though the TIMOs' investment strategies differ, they appear to be well positioned to take advantage of climate change opportunities.

Assessing the potential physical impacts of climate change on forest assets. Not all forest assets will increase their productivity as a result of climate change, as the impacts are expected to vary dramatically from region to region. Good decisions to maintain or invest in forest assets over the long term require an understanding of the likely risks and benefits of climate change for local landscapes

In areas already affected by climate change, such as British Columbia, companies have commissioned scientific studies of climate-related threats to their forest assets. The majority of these effects, though, have not yet been realized, and little is known about the potential consequences for individual companies or the industry as a whole. A collaborative industry and academic analysis could offer valuable information about how future forest resources are likely to be affected. The industry would need to set up an appropriate structure with the academic community to guide the research to meet its strategic needs.

TABLE 1. Summary of Major Climate Change Risks and Opportunities Across the Forest Products Value Chain

Value Chain	Issue	Climate Change Risk-Opportunity Profile	Time-frame	Potential Financial Impact*
Forests	**Forest Productivity**	• Greater forest productivity predicted globally, but lower forest productivity possible in many locations • Disruptions to water supply for managed forestry	15 to 50 years, with some effects now	High, will vary greatly by region and location
	Forest Access	• Reduced access to native forests resulting from climate-related deforestation policies • Increased demand for sustainable forestry in regions with measures to counter deforestation and illegal logging	5 to 15 years	Low to medium, will depend on policy
	Land Use Competition	• Increased forest values • Competition for land with non-forest bioenergy crops, e.g., soy	5 to 30 years	Medium, will vary by region
Mills	**Energy Price Risk**	• Higher fossil fuel energy prices from climate change regulations • Potential to expand biomass heat and power generation	Next 5 years, effects could last long term	Medium, will depend on mill
	Raw Materials Price Risk	• Higher raw materials prices from competition with bioenergy markets and increased forest values • Policy incentives for onsite biomass power	5 to 30 years	High, if bioenergy goes to scale
	Green Procurement	• Increased demand for sustainable forest products	Next 5 to 15 years	Low
Markets & Products	**Carbon Markets**	• Acceptance of forest-related carbon credits on major carbon markets may grow or continue to stagnate	5 to 15 years	Low at first, potentially higher in future
	Bioenergy Markets	• Increased demand for forest resources from bioenergy markets • Potential rollback or expansion of policy incentives for biofuels production and biomass electricity	5 to 30 years	High, if bioenergy goes to scale
	Product Competitiveness	• Policy incentives for forest products • Improved relative prices and increased demand for forest products	5 to 15 years	Medium to high, will depend on policy
	Green Buildings	• Shifting preferences for wood products in green building standards	Next 15 years	Low
	Consumer & Government Relations	• Improved education and public acceptance of sustainable forestry as a climate change solution	Next 15 years	Low to medium

Source: World Resources Institute.

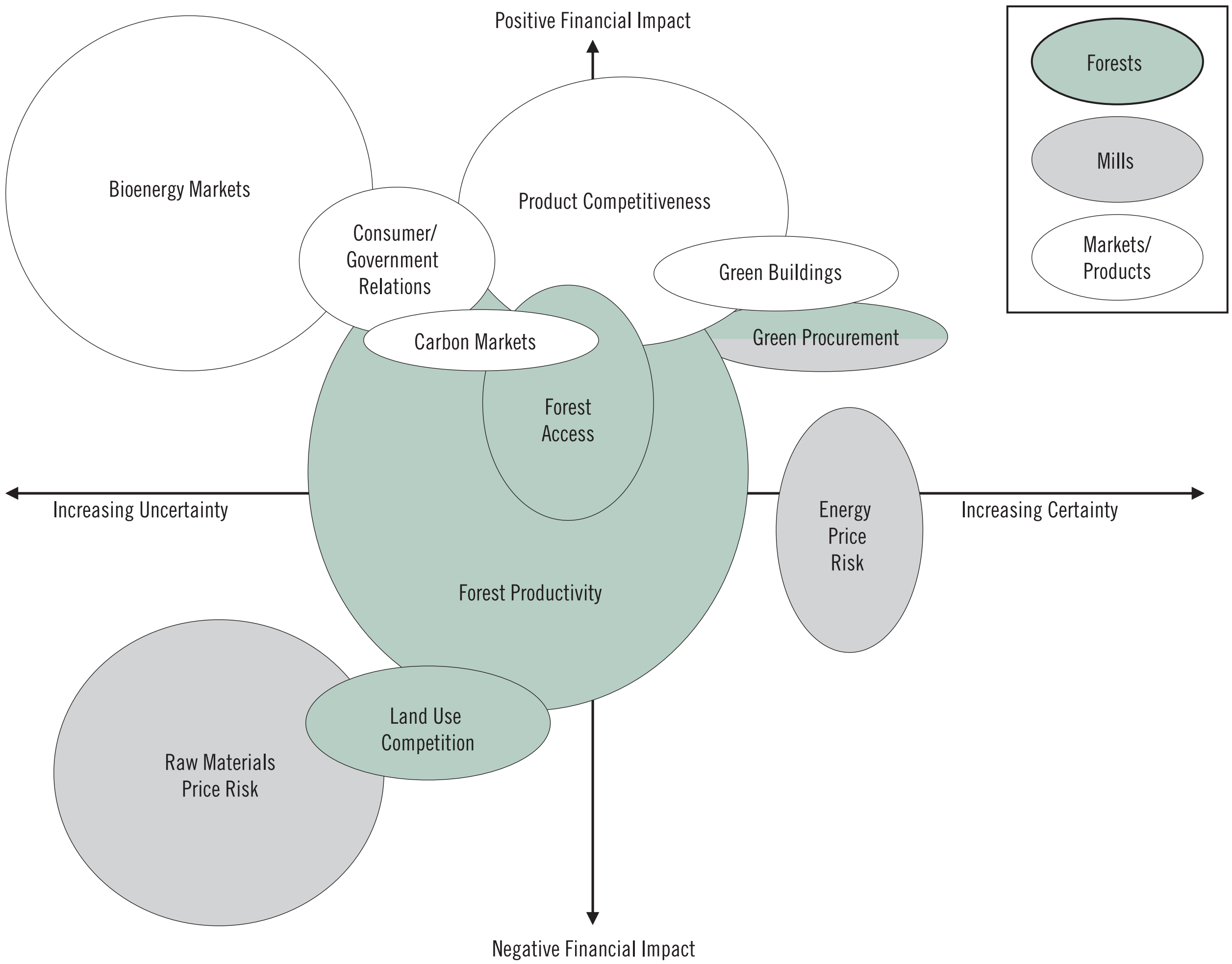
* This column presents a qualitative assessment by WRI, based on the research presented in the body of this report, of each issue's potential financial impact on the forest products sector.

The availability and quality of data on climate change and forests vary greatly. For example, most countries do not have reliable information about the specific areas of forest damaged by forest fires, insects, diseases, and weather-related destruction because they are not monitored. Therefore, the feasibility of a climate impact analysis on forest assets depends on the geographic details revealed by the existing data.

While information and analysis will improve in the future, the very nature of climate change ensures the persistence of a higher than normal degree of uncertainty about future forest productivity at the local level. Investors and companies should thus devise appropriate risk-hedging strategies to inform their investment and forest management decisions, and investors also should ask companies about their strategy for managing the impacts of climate change on their forest resources.

Monitoring bioenergy developments and analyze potential consequences. The bioenergy sector potentially offers a significant alternative use for low-quality wood fiber if sustainability, infrastructure, and technological challenges can be overcome. The use of wood for

FIGURE 1. MAJOR CLIMATE CHANGE RISKS AND OPPORTUNITIES — FINANCIAL IMPACT VERSUS CERTAINTY



Source: World Resources Institute.
Note: The size of each bubble is a qualitative assessment by WRI of the ability of an issue to affect the forest products sector over the medium to long term. The general rationale for the potential financial impact is provided in Table 1.

energy will mean new business opportunities for the forest industry as well as greater competition for raw material. Future policies and technologies will therefore greatly influence the competitiveness of bioenergy and its effect on forest resources markets. The stakes for forest products investors and companies are high:

- How can the value of forest resources be optimized?
- How will bioenergy markets affect energy and feedstock prices, which together with labor are the greatest costs in forest production?
- Can the integrated production of biofuels transform the pulp- and paper-manufacturing industry?
- What will be the impact of changes in public policy, for example, subsidies, due to growing food price and environmental concerns?

There is not yet enough data to compare alternative feedstocks and processes to predict the potential impacts of bioenergy markets on forest products economics. In addition, the parameters of the bioenergy markets are largely unknown because many of the political, technological, social, and environmental impacts are still being determined. Recent studies, for example, have brought to light serious concerns about the overall climate change benefit of biofuel development, especially with respect to deforestation and land use change issues. In this early stage, the leading companies are developing strategic partnerships and new business models to better compete in a bioenergy future. Investors thus should monitor their actions to determine which companies are best positioned to create value if and when bioenergy transforms the industry.

Evaluating the sustainability of forest management and supply chain procurement. Forest product companies will be subject to increasing regulations and policy incentives to reduce the environmental and social impacts of operations in major global markets. There is much uncertainty over the scope, framework, and stringency of, as well as interactions between, future regulatory regimes. However, companies with expertise in sustainable operations and supply chain procurement should reduce exposure and be better positioned to create value under new operating constraints and incentives related to forest management, greenhouse gas emissions, energy and water efficiency, waste reduction, and labor and community relations. In particular, investors should look for certified sustainable forest management for forestry operations and certified fiber and wood procurement from manufacturers to indicate leadership on sustainability issues that may translate into new value over the long term.

In addition, forest products companies should consider the following:

Engagement in climate policy. Forest products companies have a major stake in the outcome of climate policy, and a clear, long-term international policy framework could benefit the industry by (1) lessening uncertainty around the physical impacts of climate change on forests, (2) creating incentives to increase the amount of sustainably managed forest in new regions, and (3) creating incentives to substitute sustainable forest products for more carbon-intensive alternatives. Furthermore, managed forests can play an important role in helping humans adapt to climate change by regulating water and providing flood and erosion control and can benefit from any future incentives to protect and expand these ecosystem services. However, these measures will require significantly more engagement by the forest industry in what is already an extremely complicated and crowded political space.

Climate change policies will affect considerably more than the future of forestry-based carbon credits. Indeed, none of the preceding measures requires forest products to be included in carbon-trading regimes in order to be realized. Given the enormity of the challenges of climate change and the potential paradigm shifts for the industry, a narrow industry focus on carbon credits for wood products may turn out to be a red herring.

Important synergies exist between environmental, industry, and government objectives that present an opportunity for multistakeholder collaboration on issues of climate change, deforestation, and illegal logging. A recent science assessment report by the Intergovernmental Panel on Climate Change stated, “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."

One potential area for meaningful collaboration is the international effort to reduce deforestation in developing countries that could give the sustainable forestry industry access and a license to operate in new, high-growth markets. If a developing country decided to reduce its rate of deforestation, it might then design incentives to encourage investment by sustainable forest companies in order to keep its mills running while removing pressures on native forests. Persuading national governments to recognize the value of sustainable forestry companies to provide a stable timber supply while meeting their goals to reduce deforestation nationally could fulfill the objectives of the forest industry, investors, and the environmental community.

How forests' carbon values can benefit the agendas of both the climate and sustainable forestry has not yet be determined. The forest products industry has an opportunity to engage constructively in climate policy debates and to shape outcomes that satisfy both public and private interests. Indeed, such an outcome is likely to bolster the industry, even if carbon credits for forest products are not included. But the window of opportunity is short, as most major climate policy decisions are likely to be made in the next five years.

Development of communication strategies for consumers and policymakers. Increasing the substitution of sustainable forest products for other materials can benefit both climate change and the industry. Nonetheless, consumer buying patterns, industrial preferences, and product regulations are unlikely to change without better outreach to stakeholders regarding the climate change–related attributes of forest products. Unless education campaigns address concerns about the sustainability of forestry practices, many consumers and policymakers will be skeptical of "greenwashing," that is, misleading environmental claims by companies about the positive environmental aspects of their products or operations.

The forest products industry has not embarked on the same level of consumer and policy outreach as competing industries such as plastic and steel have, partly because of the fragmented ownership of forest industries. This lack of communication needs to be remedied because the industry's future will be shaped increasingly by political and consumer decisions.

INTRODUCTION

The forest products industry is intrinsically linked to the global carbon cycle regulating climate change. In the future, industry trends towards globalization and agricultural production models will intensify risks and opportunities from climate change and the policies to address it. Investors concerned future carbon risks are already looking to the industry to manage risk across a portfolio. Well positioned companies and investors stand to create value from sustainable forest management and products in a carbon constrained world.

The forest products industry has a complex relationship with climate change because greenhouse gasses are both emitted and stored throughout the value chain.

Forests are a vital part of the global carbon cycle regulating climate change. The world's forests cover almost 30 percent of the world's land area and store more than 283 metric gigatons of carbon in their biomass, or about 50 percent more than the amount of carbon in the atmosphere.[1] The unsustainable harvest or conversion of forests to other land uses (or deforestation) is a significant source of carbon dioxide releases, accounting for 18 to 25 percent of total anthropogenic greenhouse gas emissions.[2] In addition, forests are susceptible to the physical impacts of climate change, such as changes in temperature and precipitation, which could impair or enhance carbon uptake as well as overall forest productivity.[*]

Global Climate Change Is One of the Most Complex and Pressing Issues of Our Times

The buildup of greenhouse gases in the atmosphere is changing the earth's climate at a rate unprecedented in history. Concentrations of greenhouse gases, which cause climate change, have risen from 280 parts per million in preindustrial times to about 380 ppm in 2008. The ten warmest years on record all have occurred since 1980, with 2005 the warmest. Some of the consequences of climate change are already being observed, such as the shrinkage of glaciers, shifts in plant and animal ranges, thawing permafrost, and more severe storms and droughts.

A change in the world's climate will significantly affect every aspect of the environment and the economy. The continual improvements in climate science have strengthened the consensus view of the scientific community that human-induced climate change is a reality and poses significant risks for the future. Great uncertainties remain, however, leaving the impacts of climate change largely unknown and unpredictable. At the very least, changes in climate would be disruptive and, at worst, could be very costly and even devastating in some regions. For example, climate change could have destructive effects on coasts, where the majority of humanity resides, as well as ecosystem damage, species extinction, and losses in food production and water supply.

Appropriate public policy responses to both mitigate and adapt to climate change are being intensely debated. Despite the broad agreement among scientists, climate change is still controversial in public policy and politics. This controversy is tied primarily to the implications of climate change mitigation on the world's energy and industrial system, which is mainly based on the consumption of fossil fuels. In order to reduce the buildup of greenhouse gases in the earth's atmosphere even to doubling (i.e., accepting as much as five times or more warming as has already taken place), global emissions would have to stop growing in this decade, to be cut 60 percent from "business as usual" by 2050, and to be lowered by more than 80 percent over the long term.

Source: IPCC, *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2001).

* Climate regulation is one of the many "ecosystem services" performed by forests. Others are provisioning of fresh water and timber, regulation of floods and water quality, as well as recreation, spiritual, and cultural values.

Between 64 to 77 percent of the world's forest area is in use or degraded, with 34 percent of forests designated primarily for wood and fiber production.[3] Of the forests in production, less than 5 percent are plantations and yet contribute almost 50 percent of raw forest materials.[4] Moreover, forest plantations are a carbon sink of approximately 200 million tons of carbon and rising, which is small compared with the forests' total amount but is not insignificant.[5]

The forest products industry both emits and sequesters greenhouse gases. The primary energy source of the forest products industry is the sun, which drives photosynthesis and the growth of biomass, which in turn is used as raw material and bioenergy. Hence the forest products industry is in a unique position with respect to other major manufacturing industries, which must rely on fossil fuels for energy and do not have a natural potential for carbon uptake. The greenhouse gas profile for the global forest products industry is composed of the carbon dioxide captured by trees and carbon stored in products in use as well as the greenhouse gases released during product manufacturing, transportation, and decomposition in landfills.

Forest products have inherent climate change benefits because they store carbon and can be recycled. The carbon sequestered from the atmosphere during photosynthesis remains in the forest products while they are in use. For example, each cubic meter of wood stores an average of 0.75 to 1.0 tons of CO_2.[6] The life span of the stored carbon can be lengthened by reusing the wood and paper fiber as raw materials for new forest products. Therefore, to avoid emissions from landfill, paper and wood can be recovered to produce carbon-neutral electricity at mills or biomass power plants.

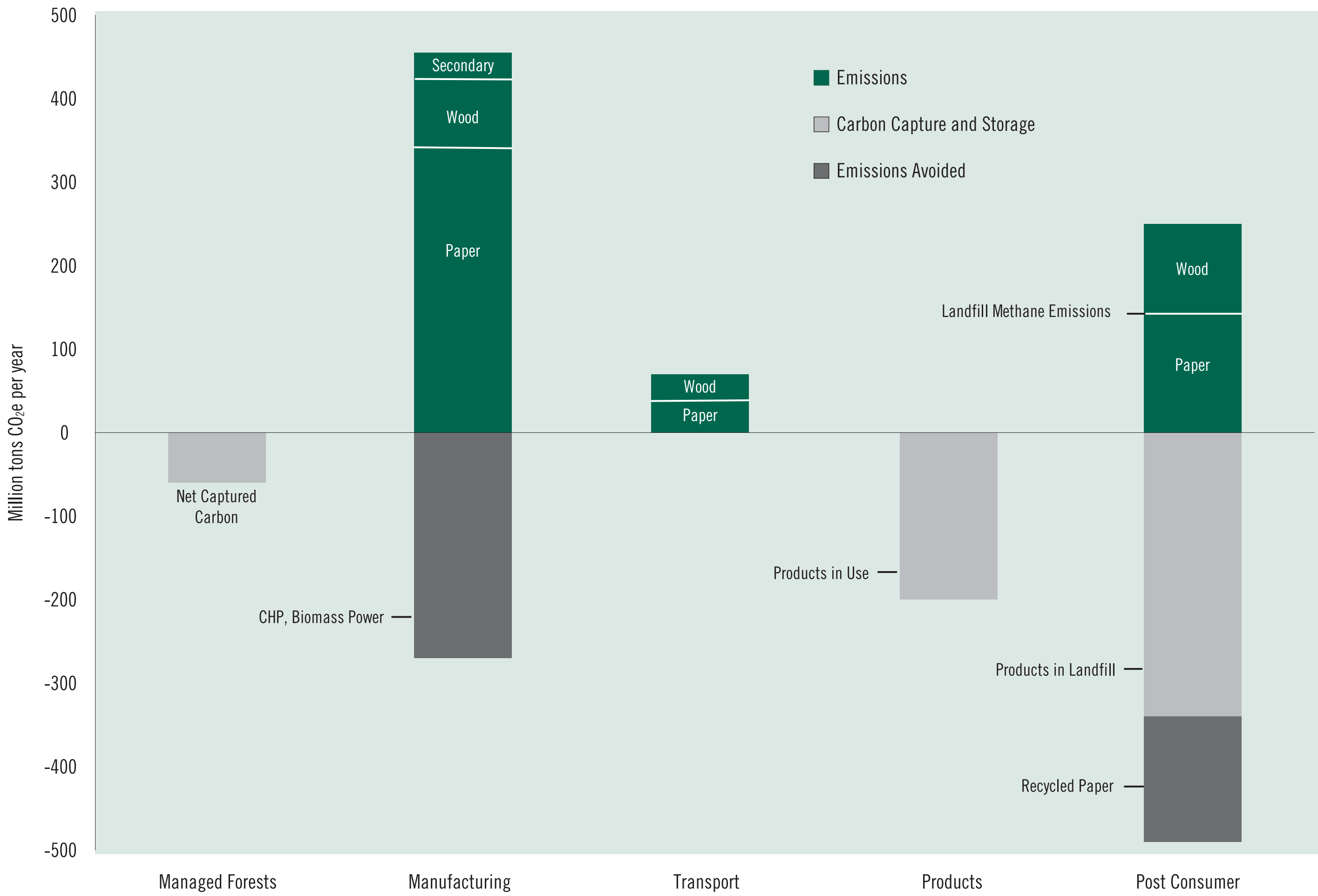
The treatment of forest products at the end of their life affects the emission of greenhouse gases. Forest products can be disposed in landfills or burned, recycled for other material applications, or used for energy. Of these options, only their disposal in landfills increases greenhouse gas emissions, and even these vary greatly.* As forest products decompose, they release methane, a potent greenhouse gas that is twenty-one times more damaging than carbon dioxide. But because wood decomposes more slowly than paper, the particular emissions from landfill depend on the landfill's anaerobic conditions and the material itself.

Greenhouse gas emissions during the industry value chain are largely offset by carbon capture and storage. In February 2007, the National Council for Air and Stream Improvement (NCASI) analyzed the global carbon profile of the forest products industry.[7†] The council found that most of the industry's greenhouse gases were emitted while used as energy for pulp and paper manufacturing and that most of the methane was released from products decomposing in landfills. The largest quantities of carbon are stored in forest products during their use and

* Greenhouse gas estimates can vary dramatically depending on how debris is calculated. In one study, the net carbon emissions calculated for a wood-frame, multi-story apartment building ranged from -5 to +38 metric tons of CO_2 equivalents, depending on end-of-life assumptions. See P. Borjesson and L. Gustavsson, "Greenhouse Gas Balanced in Building Construction: Wood versus Concrete from Life-Cycle and Forest Land-Use Perspectives," *Energy Policy* 28 (2000):575–588.

† The Heinz Center conducted a similar analysis for two forest product chains: (1) pulp and paper for the production of magazine-grade paper used for *Time* and *InStyle* magazines, and (2) the production of dimensional lumber for construction, remodeling, and do-it-yourself projects sold at Home Depot. See Stith T. Gower et al., "Following the Paper Trail: The Impact of Magazine and Dimensional Lumber Production on Greenhouse Gas Emissions: A Case Study" (Washington, DC: Heinz Center, 2006).

FIGURE 2. GREENHOUSE GAS EMISSIONS, CAPTURE, AND STORAGE BY FOREST PRODUCTS VALUE CHAIN



Source: Reid Miner, *The Greenhouse Gas and Carbon Profile of the Global Forest Products Industry,* National Council for Air and Stream Improvement (NCASI) (Research Triangle Park, NC: NCASI, 2007).

in landfills, whose conditions limit their decomposition. Overall, the industry's global direct and indirect emissions are 775 million tons of CO_2 equivalent per year; 600 million tons of CO_2 equivalent per year are captured/stored; and 270 million tons of CO_2 equivalent per year are avoided through the generation of biomass power and the combined heat-and-power systems during both manufacturing and recycling. Figure 2 summarizes the findings across the value chain. Due to the study's global scope, the results are associated with a degree of uncertainty, and the different regions, value chains, and products vary widely.

The NCASI report concluded that the net emissions from the global forest products industry value chain are expected to decline in the future. This assessment is based on the expected reduction in the carbon intensity of manufacturing, the assumption that better landfill management and methane-capture technology will result in fewer landfill methane releases, and the belief that the greater demand for forest products will raise the total carbon sequestration in these products over time.

Trends in the forest products industry, notably the globalization of production and consumption, will offer the industry more climate change challenges and opportunities.

The production and consumption of forest products are shifting from North America and western Europe to tropical regions and emerging economies. In the past, forest products were traded between North America and western Europe for consumption in these regions. But more recently, the natural advantages of forest resources have become less important, and the development of the forest industry has been driven more by the comparative economic advantages, including labor costs, levels of research and technology, and access to capital.[8] Table 2 lists the trade balance by region of hardwood and softwood fiber.

The growth of the forest products markets has slowed considerably in North America and western Europe but has grown substantially in China, Southeast and South Asia, and eastern Europe. In almost all parts of the world, the demand for pulp and paper has been the most rapidly expanding forest product, based on the rise in population and incomes. In sum, the demand for paper and fiber has shifted from the mature western markets to the emerging markets in the east and south.

Over the last decade, the production of pulp and paper in Latin America has expanded rapidly, resulting in a sixfold increase in net exports. Conversely, production in the Asia Pacific region has not grown as fast as consumption, leading to a significant increase in net imports.[9] Between 1990 and today, the Asian paper industry has risen from 24 percent to 36 percent of the world's consumption of pulp and paper. Although new hardwood pulp mills are being planned in Southeast Asia, they face a diminishing supply of wood as competing land uses and unsustainable practices threaten the supply of fiber from primary forests. Near-term investments in fast-growing hardwood plantations thus will be needed to ensure the industry's future in that region.[10] But these plantations will mitigate climate change only if they relieve pressures on primary forests and do not create incentives to convert primary forests into managed forests.

The total production of industrial roundwood has barely changed since the mid-1980s, despite the greatly increased global economic activity. The reasons for this stagnation include the economic collapse of Russia and other former Soviet states, resulting in a

TABLE 2. Locations of Softwood and Hardwood Fiber

	Surplus	Neutral	Deficit
Softwood	Russia Western Canada Southeast United States Southern Cone Eastern Europe	South Africa Southeast Asia Australia	China India Western Europe Eastern Canada Mexico
Hardwood	Brazil Southern Cone Canada Eastern Europe Russia South Africa Australia	Southeast Asia	China India Western Europe United States Mexico

Source: JP Management Consulting, CIBC World Markets.

decline in wood harvests in the early 1990s; the substitution of other materials for wood; the global growth of recycling; and the industrialized economies' slowing consumption rates.[11] But even though total production has remained relatively constant, the origin and composition of production have changed. Whereas most timber had been taken from natural (primary) forests, it now is being very gradually replaced by plantation wood. Timber production also has moved from North America and Europe to Latin America, Australia, New Zealand, Indonesia, Malaysia, China, and South Africa.

Globalized markets are increasing transport emissions and logistics challenges. Transport distances from forests to mills to market are growing. As a result, transport-related emissions of carbon dioxide are rising, becoming a larger percentage of emissions in a company's overall greenhouse gas profile. The efficiency and method of transport thus will be important to managing carbon dioxide emissions and costs, especially with the constraints on oil supply and the climate change regulations raising the prices of petroleum and diesel.

The forestry sector is slowly changing to an "agricultural" production-and-processing model. Better knowledge and technology have greatly improved forest management. Now less timber is harvested from native forests, and the reliance on natural regeneration is gradually declining and being replaced by managed forests in planted and natural stands. These developments are shifting the comparative advantage in wood production away from countries with large forest resources (mostly in the Northern Hemisphere) toward countries where trees grow quickly: the tropics and subtropics. As a result, the supply of wood and fiber will depend on the future availability of land for forest plantations and their environmental and social costs.[12]

Although forest plantations account for only 2.5 percent of the world's forests, in 1995 they provided approximately 25 percent of industrial roundwood production.[13] In 2007, this area increased to just under 5 percent but supplied 50 percent of wood and fiber needs.[14] Most plantation forests supply softwood, with pine being the most popular species, accounting for 30 percent of all plantation species.[15] Notable is the increase in plantation hardwood fiber for pulp and paper production. The restricted access to old-growth forests for environmental concerns has led to a demand for hardwood fiber from eucalyptus plantations, located primarily in Brazil. As a result, eucalyptus pulp grew to 43 percent of the hardwood pulp market in 2005, compared with 29 percent in 1980.

Land-use concerns will intensify as production moves to tropical regions. In some cases, the increase in number of managed forests has relieved the pressure on native forests, but in other cases it has been the primary cause of deforestation. A number of factors has converged to intensify the competition for arable land, including population growth, agriculture, emerging bioenergy industries, transport infrastructure, climate change impacts, and water supply. Managing the environmental and climate change impacts of land-use changes will be a major challenge for governments, companies, and local communities.

Government policy will continue to shape developments in the industry. Many of the preceding changes have been influenced by policies regarding industrial development, trade, land use, technology, and the environment.[16] In the future, policies addressing energy security, climate change, water scarcity, food supply, and biodiversity concerns are likely to become more prevalent and far-reaching, and developments in the forest products industry will be greatly influenced by the responses to these issues.

The wide-ranging impacts of climate change and the policies to address it present both strategic risks and opportunities for investment, corporate leadership, and value creation.

Climate changes will require a different approach to managing the environment. Current practices in business risk management typically regard the environment as presenting problems of regulatory compliance, potential liability from industrial accidents, and the release of pollution. But climate change presents different risks because it is both global and long term, causes essentially irreversible harm, and will require a wide range of policy responses. Accordingly, ignoring the financial and competitive consequences of climate change could lead to inaccurately evaluating a company's overall risk profile.

Although these consequences may seem obvious for power companies and energy-intensive industries like chemical manufacturing, they also apply more broadly. In response, business leaders ranging from Wal-Mart to the Bank of America to Johnson & Johnson have adopted institutional policies for the effects of climate change on everything from operations to customers and suppliers. Moreover, the most important distinctions are not between sectors but within sectors in which risk mitigation and product strategies can create competitive advantages.

Assets of the forest products industry are generally characterized by natural and market factors that will be influenced by climate change. [17] In the case of forestlands, investment returns are generated by the biological growth and increasing unit value of the timber as it grows older. The primary risk to forest assets is natural catastrophe, including fire, pest infestation, and disease. Climate change is expected to increase the frequency and intensity of such disturbances through changes in temperature, precipitation, and storm events.

A Financial Analyst's Perspective

"We are likely at an inflection point regarding the perception of wood resource availability. The combination of five shocks will likely shift the perception at the global level from 'relative abundance' to 'relative scarcity' of wood fiber:

1. Continuing growth in Asia's wood deficit;
2. Reduction in supply of illegal logs;
3. Increase in Russian Log Export Tax;
4. Insect infestations in Western Canada; and
5. Growth of the Bioenergy sector."

Source: Don Roberts, "Five Reasons Wood Is Going to Become Increasingly Scarce," CIBC World Markets client presentation, June 2007, Toronto.

Climate change issues are a cause of three of these five "shocks:"

- Approaches to reduce illegal and unsustainable logging are at the forefront of international climate policy discussions and will likely be included in future climate change policy regimes (see p. 31).
- The infestation of pine mountain beetles in western Canada is a consequence of physical climate change, with milder winters allowing the insects to travel farther north into previously unreachable territories (see p. 23).
- The interest in bioenergy is being fueled by both climate change and energy security concerns, with the ability of forest resources to supply a significant percentage of bioenergy feedstocks, thereby increasing the competition for the forest product industry's primary inputs (see p. 37).

Converging Perspectives on Climate Change Opportunities in the Forest Products Industry

"Stora Enso basically views climate change as a business opportunity, offering great potential for forest product companies to be recognized for their inherent strengths from a climate change point-of-view, as well as for their opportunities to provide future solutions to the challenges."

Stora Enso, Response to the 2004 Carbon Disclosure Project

"Wood plays a major role in combating climate change. …Greater use of wood products will stimulate the expansion of Europe's forests and reduce greenhouse gas emissions by substituting for fossil fuel intensive products."

European Commission's DG Enterprise, 2003

"Forestry is the crucial investment."

Z/Yen, *A Portfolio Approach to Climate Change Investment and Policy,* 2007

"Tree plantations should be used to maximize environmental benefits—such as taking pressure off natural forests—and local livelihood opportunities, while also providing fiber for products and energy on an eco-efficient basis. Encouraging the wider use of sustainable forest management is important. The industry should be encouraged to further develop and implement forest management and process technological improvements to increase the volume of sustainably produced fiber for raw materials and energy."

World Business Council on Sustainable Development, 2007

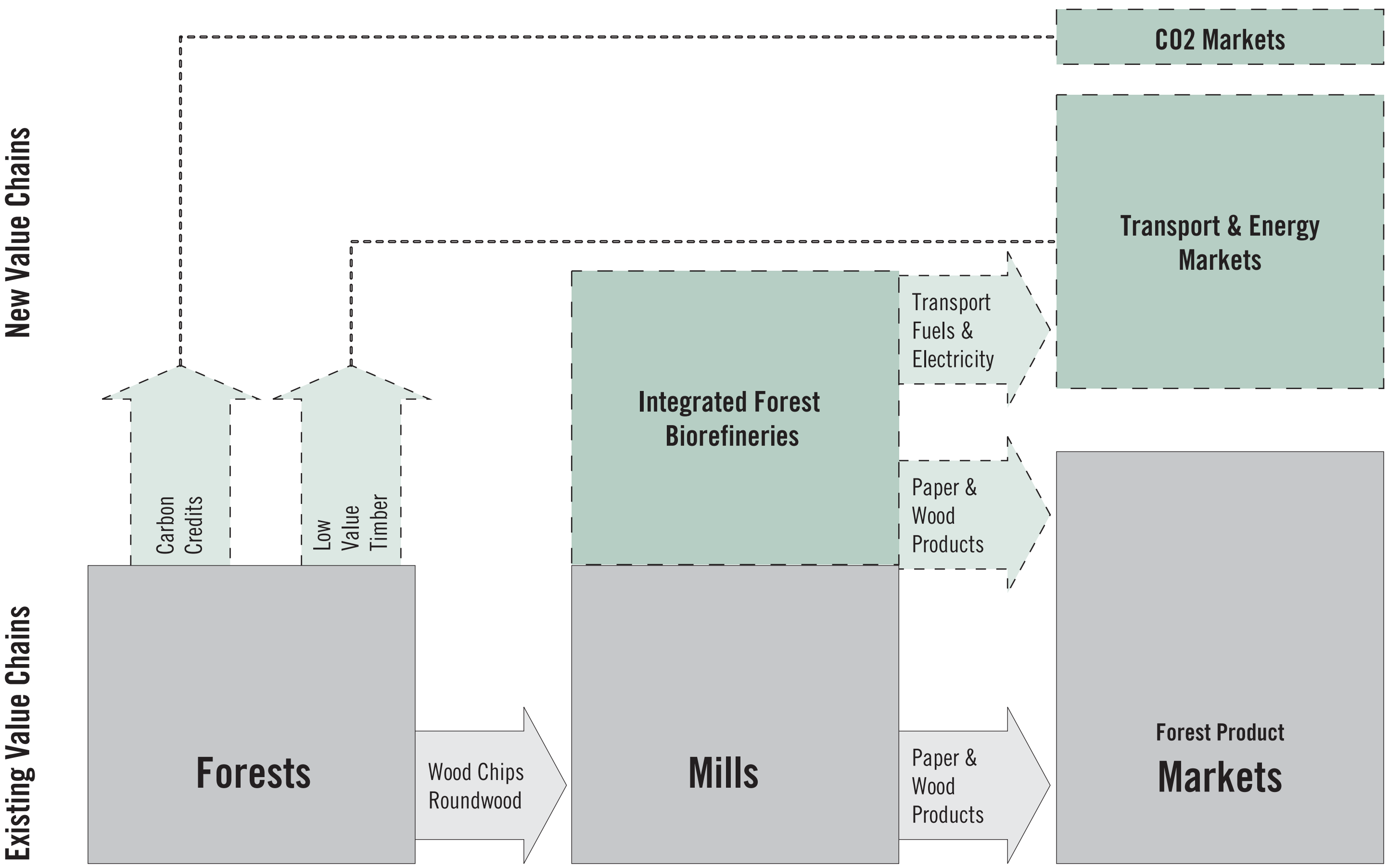
Industry assets are susceptible to short-term price volatility, inefficiencies in global supply and demand, and other market risks. Regional changes in forest productivity due to climate change are difficult to predict, thereby adding another layer of uncertainty to global market dynamics. Historically, forest assets have appreciated when supplies are forecast to tighten. Conversely, climate change is expected to improve forest productivity on a global scale while increasing regional variability, further complicating the relationship between supply and asset appreciation.

The forest products industry needs long planning horizons for decisions regarding forest management and mill capital expenditures, which in turn will require a large investment of capital for land, inventory, mills, and equipment. Many of the political and technological developments that will address climate change are unknown, but they are likely to influence the performance of future assets. As a result, important decisions that will shape the exposure of assets to new risks and opportunities are being made before climate change impacts are understood. In addition, the industry's sensitivity to energy and raw materials prices are likely to be affected by climate change and bioenergy policies, also ensuring that its future financial performance will be influenced by climate change.

In addition to the effects on existing business models, climate change will likely create new markets and products for the industry. Forest resources can provide raw materials for forest products, carbon sequestration credits to be sold on a carbon market, and bioenergy feedstocks to produce transport fuels and electricity. Furthermore, some manufacturing facilities may be well positioned to become integrated forest biorefineries, producing transport fuels, chemicals, and electricity, as well as wood and paper products. See figure 3 for the effects of climate change on new value chains.

Companies within the forest products industry will differ in their exposure to the risks and opportunities created by climate change. The industry is made up of companies with different degrees of vertical integration, operating in diverse geographical regions and mar-

FIGURE 3. EXISTING AND NEW VALUE CHAINS IN THE FOREST PRODUCTS INDUSTRY



Source: World Resources Institute.

kets, producing assorted products, with various levels of sustainably managed supply chains. The impacts of climate change will vary according to these factors, ensuring that no two companies will have the same exposure to climate change risks and opportunities. See figure 4 for an overview of major forest product company profiles by size, nationality, vertical integration, and type of product markets.

The current surge in investors' interest in the forest products industry is driven by diversification and sustainability. In the context of sustainable investing, forest products equities are already valued for their new services and products, such as carbon sequestration and renewable energy, which can lower an investment portfolio's carbon intensity. Recently, the London Accord, a collaboration of investment banks, research houses, academics, NGOs, British Petroleum, and the city of London, released its final report in December 2007. The research examined the links among investment, finance, and "carbon" returns, as well as interactions between public policy and investment decisions.*

* See http://www.london-accord.co.uk/index.htm.

FIGURE 4. FOREST PRODUCT COMPANIES BY VALUE CHAIN AND MARKETS *(in US $billion 2006 revenues)*

<table>
<tr><th rowspan="2">FORESTS / PULP/CHIPS / MILLS</th><th colspan="8">MARKET</th></tr>
<tr><th>Chips</th><th>Wood Products</th><th>Lumber</th><th>Pulp</th><th>Packaging</th><th>Publishing</th><th>Paper</th><th>Consumer Products</th></tr>
<tr><td>INTEGRATED WOOD PRODUCTS</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Masisa $0.9 (Chile)</td><td></td><td>85%</td><td>8%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>WOOD PRODUCTS MANUFACTURING</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Louisiana Pacific $2.2 (US)</td><td></td><td>78%</td><td>13%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>INTEGRATED FOREST PRODUCTS</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>International Paper $21.9 (US)</td><td></td><td colspan="2">11%</td><td></td><td>34%</td><td></td><td>26%</td><td></td></tr>
<tr><td>Weyerhaeuser $18.5 (US)</td><td></td><td colspan="2">22%</td><td colspan="5">44%</td></tr>
<tr><td>Stora Enso $18.3 (Finland)</td><td></td><td colspan="2">11%</td><td>23%</td><td>31%</td><td>18%</td><td></td><td></td></tr>
<tr><td>Svenska Cellulosa $13.7 (Sweden)</td><td></td><td colspan="2">16%</td><td>32%</td><td></td><td></td><td></td><td>52%</td></tr>
<tr><td>UPM-Kymmene $13.2 (Finland)</td><td></td><td colspan="2">13%</td><td></td><td></td><td>46%</td><td>24%</td><td></td></tr>
<tr><td>Metsäliitto $11.6 (Finland)</td><td>13%</td><td colspan="2">18%</td><td colspan="3">50%</td><td>7%</td><td>12%</td></tr>
<tr><td>Nippon Paper Group $9.9 (Japan)</td><td></td><td colspan="2">8%</td><td colspan="5">76%</td></tr>
<tr><td>Temple Inland $6.8 (US)</td><td></td><td colspan="2">20%</td><td></td><td>58%</td><td></td><td></td><td></td></tr>
<tr><td>Sappi $4.9 (South Africa)</td><td></td><td colspan="2">20%</td><td></td><td colspan="4">80%</td></tr>
<tr><td>Abitibi Consolodated $4.3 (Canada)</td><td></td><td></td><td>18%</td><td></td><td></td><td>55%</td><td></td><td></td></tr>
<tr><td>PAPER PRODUCTS MANUFACTURING</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Kimberly Clark $16.7 (UK)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>76%</td></tr>
<tr><td>Packaging Corp $2.2 (US)</td><td></td><td></td><td></td><td></td><td>96%</td><td></td><td></td><td></td></tr>
<tr><td>INTEGRATED PAPER PRODUCTS</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Oji Paper $10.4 (Japan)</td><td></td><td></td><td></td><td></td><td colspan="4">88%</td></tr>
<tr><td>Mondi $7.5 (UK)</td><td></td><td></td><td></td><td></td><td>55%</td><td></td><td>33%</td><td></td></tr>
<tr><td>Smurfit-Stone $7.1 (US)</td><td></td><td></td><td></td><td></td><td>95%</td><td></td><td></td><td></td></tr>
<tr><td>MeadWestvaco $6.5 (US)</td><td></td><td></td><td></td><td></td><td>73%</td><td></td><td>18%</td><td></td></tr>
<tr><td>Asia Pulp and Paper $4.4 (Singapore)</td><td></td><td></td><td></td><td colspan="5">~100%</td></tr>
<tr><td>Suzano $1.4 (Brazil)</td><td></td><td></td><td></td><td>44%</td><td colspan="4"></td></tr>
<tr><td>MARKET PULP</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aracruz $1.7 (Brazil)</td><td></td><td></td><td></td><td>~100%</td><td></td><td></td><td></td><td></td></tr>
</table>

Source: World Resources Institute.

A key finding of the London Accord's climate research project was that forestry was crucial to investors seeking to stabilize carbon dioxide concentrations in the next two decades. "Forestry might be the most significant part of any portfolio, investment or policy," concludes management consultants Z/Yen's contribution to the London Accord's project. The report combined thousands of possible investment portfolios for the next twenty-five years, ranging from biofuels to nuclear, solar, hydropower, and carbon capture, sequestration, and storage to analyze what rational investors might do under various climate change scenarios.[18]

Cheuvreux, an equity research and institutional brokerage, contributed a report to the London Accord project that examined the European forest products industry's exposure to the risks and opportunities of climate change. The report concluded that "paper and pulp companies owning substantial forestland, such as SCA and Holmen, are becoming increasingly attractive from both a financial and environmental standpoint for investors looking for sustainable exposure to climate change."[19]

Sustainable forestry projects that have the potential of improving the livelihoods of communities in developing countries have attracted the attention of investors. In June 2007, ABP invested $60 million in the Global Solidarity Forest Fund (GSFF) to develop a number of sustainable timberland projects, mainly in Mozambique, which would serve both sustainable development and forestry-sector objectives. The GSFF is an example of direct investment by a large financial institution to ensure that financed projects are managed sustainably. With the negotiations of international climate change now focused on reducing deforestation, sustainable forestry projects are likely to attract even more financing from private investors seeking carbon credit opportunities.[20]

Timberland investment management organizations (TIMOs) can benefit from climate change opportunities through the increase in forest values and the demand for sustainable forestry projects. Most investments in commercial timberland today are made through private equity investments structured and managed by a TIMO rather than the forest products industry. A timberland investment is essentially a specialized form of long-term bond, because the movement of financial markets does not affect timber growth or subsequent harvests. A forest that holds mature timber will generate cash each year from the harvest and sale of timber, and these harvests can be modeled and forecasted with a reasonable degree of accuracy over many years, even decades. Because of its unique nature, timberland often performs differently from securities or other investment assets. As such, it can offer an excellent opportunity for diversification when added to a broad portfolio of investments. The principal owners of timberland are private, nonindustrial landowners ($150 billion) and the forest products industry ($50 billion).[21]

Several TIMOs have already developed strategies regarding sustainable forestry. The Phaunos Timber Fund (Phaunos), established in 2006 as a tradable company making global timberland- and timber-related investments, seeks investments that meet or exceed the guidelines set out in the Sustainable Forestry Initiative.* To date, the fund has invested in sustainable forestry projects in number of developing countries under deforestation pressures, including Indonesia, China, and Brazil. New Forests, a forestry investment management and advisory business, specializes in institutional and private equity investments that generate returns from both traditional timber products and environmental assets, such as carbon, biodiversity, and water. Expanding on the TIMO concept, New Forests created the EIMO, or Ecosystem Investment Management Organization, to generate value based on the ecosystem services provided by forests. [22] New Forests has also committed to carbon-neutral operations.

Although this report does not specifically address it, TIMOs face risks and opportunities similar to those of the forest products industry. See Forests (pp. 23–33) and Markets and Products (Carbon Markets, p. 42 and Bioenergy Markets p. 49) for climate change issues related to TIMOs.

* The Sustainable Forestry Initiative (SFI) program is a comprehensive system of principles, objectives and performance measures that combines the perpetual growing and harvesting of trees with the long-term protection of wildlife, plants, soil and water quality. See http:// www.aboutsfi.org.

OUTLINE OF CLIMATE CHANGE RISKS AND OPPORTUNITIES

Climate change risks and opportunities usually have four manifestations in the forest products industry: physical, regulatory, supply chain, and reputation/communication.

Physical: Examples of the direct and indirect physical effects of climate change on forests are changes in temperature, droughts, floods, storms, fires, and insect infestations. In addition, the degradation of key ecosystem services, such as water flows, also may hurt the productivity of managed forests.

Regulatory:

- *Climate Policy.* International, regional, national, and state climate change policies create incentives and costs regarding the emissions of carbon dioxide and other greenhouse gases.
- *Bioenergy Policy.* Targets, subsidies, and other policy mechanisms promote the development and commercialization of biomass-based transport fuels and power generation.

Supply Chain: The effects of higher raw material and energy costs are driven by climate and bioenergy policies on supply chain and cost structure. In addition, the end users of forest products increasingly look upstream to the environmental attributes of their raw materials, creating preferences for low-carbon paper and wood manufacturing.

Reputation/Communication: Forest products are often viewed negatively with respect to environmental attributes, owing to the prevailing belief that the use of wood hurts forests. The forest products industry also has not been as successful as other industries in working with policymakers on climate change solutions such as green building standards.

TABLE 3. Climate Change Drivers by Value Chain in Forest Products Industry

Driver		Forests	Mills	Markets and Products
Physical		Forest Productivity (p. 23)		
Regulatory	CO_2 Trading	Carbon Markets (See Markets and Products)		Carbon Markets (p. 42)
	Carbon-Neutral Mandates			Product Competitiveness (p. 61)
	Price of CO_2 Emissions		Energy Price Risk (p. 34)	
	Reduction of Deforestation	Forest Access (p. 31)		
	Bioenergy Policy	Land Use Competition (p. 33) Bioenergy Markets (See Markets and Products)	Raw Materials Price Risk (p. 37) Bioenergy Markets (See Markets and Products)	Bioenergy Markets (p. 49)
Supply Chain			Green Procurement (p. 39)	Green Buildings (p. 64)
Reputation				Consumer and Government Relations (p. 64)

Table 3 gives examples of how the drivers of climate change may affect the forest products industry, listing the issues covered in the remainder of this report. Each issue was chosen according to its potential financial significance for the global forest products industry, through an extensive literature review as well as input from experts in environmental, forestry, climate change, finance, and public policy fields. In this report, each issue is described separately by value chain, although it is the interaction of these conflating issues across value chains that will ultimately determine the financial significance of climate change and climate change policies to the industry.

Because this report focuses on financially significant issues, the implications of the full life cycle of greenhouse gases for forest products with regard to waste, recycling, and energy uses are not described. These "postconsumer" practices contribute about one-third of the industry's direct and indirect emissions but also provide opportunities to avoid emissions through recycling, waste management practices to avoid methane releases, and energy generation. Most of the decisions regarding the postconsumer treatment of forest products are made at the household, municipal, or site level. As a result, the industry's balance of life-cycle greenhouse gases could be improved by better public- and private- sector management. But unless the industry is made accountable for postconsumer emissions in future climate regimes, it may not have an incentive to try to reduce these emissions.

Furthermore, despite the anticipated increase in the industry's emissions of transportation-related greenhouse gases, transport is not discussed in this report because of the lack of global data and the specificity of the challenges and opportunities, which depend on the geographical location of forests, mills, and markets. In any case, the greatest risks facing the transport sector are increases in energy costs that would alter trade flows and production economics.

Forests

FOREST PRODUCTIVITY

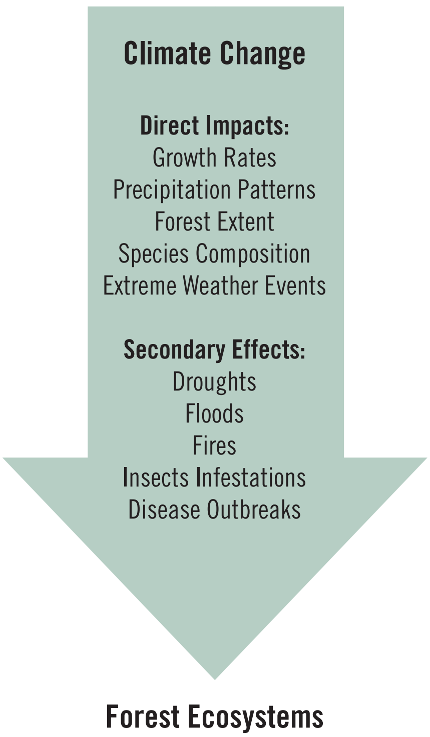
The research on climate change contains many unanswered questions. Although several predictions and forecasts have been confirmed or strengthened in the past few years, there is still uncertainty about the long-term impacts on forests and how they will interact with an evolving climate.[23] It is known that the effects of climate change are likely to be specific to the region and to include gains in forest productivity, reduced access to forestland, increased costs for road and facility maintenance, direct damage from higher risks of wildfires and insect outbreaks, and the effects of wetter winters and early thaws on logging. The results could affect global timber supplies, market prices, and the cost of insurance.[24]

The evidence indicates that changes in climate will profoundly affect forest productivity.

At least one-third of the world's forests are likely to be affected by climate change.[25] The existing literature suggests that climate change is likely to alter the growth rates of forests, to increase the fragmentation of forest landscapes through large-scale biome shifts, to change the composition of species, and to lead to more disturbances, such as fires, pests, diseases, and catastrophic events.[26] Figure 5 shows how these changes may interact with one another to affect forest productivity differently across geographical regions.

The greatest impacts of climate change on forests in the near and medium terms are expected to come from disturbances like fires and insects. Over the longer term, changes in temperature and precipitation are likely to alter the composition of species and the location of forest landscapes. Even though some species will migrate and adapt to new climatic conditions, others may not survive, owing to the additional stresses of population growth and competition for land use that will fragment existing forest systems and reduce the available area of potential forest coverage.

FIGURE 5. CLIMATE CHANGE IMPACTS ON FOREST ECOSYSTEMS



Source: Adapted from Robledo and Former, *Adaptation of Forest Ecosystems and the Forest Sector to Climate Change* (Rome: FAO, 2005).

Climate change impacts on forest growth rates will vary dramatically by region, and world productivity is likely to increase. In general, slightly higher temperatures and a greater accumulation of CO_2 in the atmosphere will accelerate the growth rate of species in forest ecosystems. Moderate climatic changes have led to gains in forest growth rates globally, particularly in tropical forests. Productivity rises when there are no water limitations, deforestation, new fires, or hotter and drier summers at middle and high latitudes.[27]

Other factors, however, combined with higher temperatures may limit productivity gains or even result in a loss. For example, if higher temperatures cause drought, growth rates may fall, and if drier conditions also result in fires, productivity may drop even further.[28] By themselves, higher temperatures can also lower forest growth rates by increasing the evaporation of water from plants into the air and thus depress growth owing to water stress.[29]

Climate change affects all growth indicators in different ways in different places, with gains in some regions and losses in others. Higher growth rates, as well as some lower rates, in boreal forests have been recorded in Canada and Alaska, but overall forest productivity in temperate forests in North America, northern Europe, most of central Europe, parts of southern Europe, and Japan has increased.

Growth rates also will change in plantation forests. In Australia, the productivity of exotic softwood and native hardwood plantations (e.g., *Pinus radiata* and Eucalyptus) is likely to rise, although acclimation processes and environmental feedbacks through nutrient cycling will probably limit this increase. Without changes in rain patterns, warming may lengthen the growing season in southern Australia and also lead to more fires and pests.[30]

In Brazil, the growth rate of forest plantations may fall if the climate becomes drier because of reduced water vapor transport from Amazonia. Despite this, changes in temperature and more CO_2 could be beneficial to plantation yields. Higher concentrations of CO_2 increase the water efficiency of eucalyptus and possibly other plants and could stimulate nitrogen fixation.[31]

Droughts and changes in rainfall threaten forest productivity. Climate change affects forests' seasonal and diurnal rainfall quantity and patterns. Longer and shorter dry seasons have been predicted in different parts of the world. Longer dry seasons will result directly in water shortages that can affect productivity, risk of fire and insect outbreaks, and tree mortality and perhaps lower the resilience of the ecosystem.[32] Conversely, more intense rainfall will exacerbate soil erosion and flood damage, resulting in more polluted streams. Such conditions would make forestry operations more difficult.

In Australia, the reduced rainfall predicted in near-term scenarios could hurt productivity and increase the risk of fire.[33] In addition, more droughts have been forecast during the critical growing phase of forests in Amazonia and Europe.[34]

Climate change will alter the geographical location of forests as well as the composition of species in forests. Temperature can determine the location of optimal habitats of species, thereby affecting their geographic distribution. Climate projections suggest a displacement of climatic zones suitable for forests by 150 to 550 kilometers over the next century.[35] Other projections predict both the disappearance and emergence of climate zones.* Existing climatic regions are estimated to disappear in 4 to 48 percent of the world's land area, and new climate zones are predicted to emerge in 14 to 39 percent of the world's land area.[36]

Vegetation models suggest that forests might replace between 11 and 50 percent of the tundra, although this transition may be affected by disturbances that the models may have not considered.[37] In Finland, Scandinavia, and northern Russia, the northward movement of Norway spruce and Scotch pine species into tundra regions has already been observed.[38]

One global model shows that the potentially suitable area for tropical rainforests could expand by 7 to 40 percent, but another model that considers human-driven land-use changes shows a decrease of about 5 percent in Latin America's forests. This means that the drivers of deforestation would probably not allow tropical forests to expand to occupy those areas that climate change could make climatically suitable for them.[39]

In Europe, studies suggest that forests are likely to expand in the north, decreasing the area of tundra, and contract in the south. Native conifers are likely to be replaced by deciduous trees in western and central Europe, and the distribution of several tree species is likely to drop in the Mediterranean. The area of temperate forests will likely increase at higher elevations.[40]

Studies of North America indicate that all major forest types will expand northward and most will expand in area over the next fifty to one hundred years, caused by slight warming and more efficient water use, associated with more atmospheric CO_2. But if the warming continues, the greater use of water at higher temperatures will overwhelm the CO_2 effect and could lead to significant decreases in forest area. Furthermore, changes in forest ecosystems are likely to be determined by changes in disturbance regimes and/or catastrophic events.[41]

Higher temperatures and less precipitation in Mexico would reduce the extent of cool temperate (coniferous and oak forests) and warm temperate life zones but would expand the dry and very dry tropical forest zones.[42] These changes would put national cellulose and paper production at risk because high and medium forestry production areas are located in these zones.

* A climate zone is an area of the Earth's surface that possesses a distinct type of climate. There are eight major climatic zones, roughly demarcated by lines of latitude. These consist of the tropical zone near the equator, two subtropical and two temperate zones, one boreal zone in the northern hemisphere, and the two polar ice caps.

Key Climate Change Productivity Impacts by Biome

Tropical forests are at risk, but impacts are uncertain.

To date, higher temperatures and atmospheric CO_2 levels have led to observed gains in forest productivity. However tropical forests are particularly at risk of changes in rain patterns, higher temperatures, tropical storms, changes in seasonality, and fires. Climate events such as El Niño may exacerbate these effects. As a result, the impacts of climate changes on overall tropical forest productivity are being debated, without enough information to support any firm conclusion.

Temperate deciduous forests may improve productivity and increase in size.

Temperate deciduous forests are predicted to experience an increase of 2.6° C above 1970 levels by the mid-twenty-first century. Accordingly, by 2050 these forests are expected to supply more of the demand of forest products. The impacts are likely to be less extreme for temperate deciduous forests than for other forest types: temperate forests may invade other ecosystems, with a predicted increase in area of between 7 and 58 percent. Besides expansion, the impacts may include greater productivity and greater decomposition of organic matter in soils.

Boreal/Taiga forests are the most threatened forest ecosystem.

The temperatures of boreal forest zones are predicted to rise 4.0°C above 1970 levels by the mid-twenty-first century. Boreal/Taiga forests are expected to be the most significantly affected by biome, with experts estimating that between 25 to 40 percent of the biome could be lost. The likely impacts include increased growth due to warmer conditions; northward movement into tundra areas (although climate may shift faster than some tree species, which could lead to significant dieback); a greater risk of disturbances (particularly fires and pests); and subsequent losses in productivity.

Sources: UNEP, *Forest in Flux. Climate Change: the Threat to World Forests* (Nairobi: UNEP, 2005); Nigel Dudley, *Forests and Climate Change* (Gland, Switzerland: WWF International, 1998); P. Bubb, I. May, L. Miles, and J. Sayer, *Cloud Forest Agenda* (Cambridge: UNEP/WCMC, 2004); IPCC, *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2001). 2001.

The establishment of species assemblages that can successfully adapt to changing climate conditions remains a major challenge for managed forests. Foresters can help mitigate the impacts of climate change while sequestering additional carbon with strategies like the following:[43]

- Planting species adapted to conditions predicted by climate change models.
- Planting drought-resistant (deep-rooting) species in drought-prone habitats.
- Planting species that more efficiently sequester and store carbon.
- Establishing plantations that help species migrate with climate shifts.
- Establishing gene-bank plantations to assess genetic variations and ability to adapt to climate changes.
- Maintaining genetic and biological diversity.
- Using seeds specific to climate zones.

Disturbances, including insect and disease outbreaks, fires, and extreme weather events are specific to regions and are predicted to become more frequent, with as yet unknown effects on timber and fiber production. Changes in these disturbances over long periods of time will modify the forest age-class distribution from older to younger forests.[44] More disturbances also may lead to rapid structural changes in species composition, succession dynamics, and rates of nutrient cycling.[45] Modeling studies project elevated risks of forest disturbances, although the overall effect on timber production is uncertain. Fire, insects, and extreme events have not been modeled well.[46]

The interaction of multiple disturbances should be considered to better understand the impacts of climate change. For example, windthrow or severe drought can be aggravated by pathogen damage or wildfires. The following disturbances, in concurrence with other climatic changes, threaten to compromise overall health and resilience of forest ecosystems:

Outbreaks of Insects and Diseases. Effects of insect infestation vary from defoliation to timber damage and massive forest diebacks. Insect outbreaks are very likely aggravated by climate change, particularly those insects whose temporal and spatial distributions depend on climatic factors. The forecast is for more frequent or longer outbreaks, whose range may move northward or poleward or to higher elevations.[47] Because the effects on commercial forestry due to increased insect and pathogen activity are specific to the region, they are difficult to predict.

Changes in temperature and drought conditions appear to play an important role in insect outbreaks, resulting in more insect-induced tree mortality across boreal forests. Analyses in North America project an increase in the frequency of outbreaks of mountain pine beetle, spruce budworm, eastern hemlock looper, jack pine budworm, and spruce budworm. In Australasia, the greater incidence of pests and pine needle blight could be a major risk to production forestry because *Pinus radiate* constitutes 91 percent of the exotic plantation forests in New Zealand and 86 percent in Australia.[48]

Fires. Climate change is expected to increase the risk of fire (especially in areas where precipitation remains the same or declines), owing to factors such as lightning, a longer fire season, more intensive fires, and more frequent fires.[49] A moderate increase in precipitation combined with greater productivity could also favor the generation of more flammable fuels. In turn, more fires will result in changes in the vegetation structure that also may aggravate the risk of fires.

The area in North American boreal forests burned by wildfires increased from 6,500 km^2/year in the 1960s to 29,700 km^2/year in the 1990s.[50] Canada's burned area alone now exceeds 60,000 km^2/year.[51] Fire rates are also expected to rise in Europe because of the predicted increase in dead plant material from the lower decomposition rates caused by higher CO_2 levels. More dead organic matter combined with drier climatic conditions may exacerbate the fire hazard, particularly in the Mediterranean zone. Australia and Africa also are projected to have more and more intensive fires.[52]

Forestry operations will also be more exposed to the risk of fires. Climate change will interact with fuel type, ignition source, and topography in determining the risk of future damage to the forest industry, especially to paper and pulp operations.[53]

Extreme Weather Events. Other disturbances associated with extreme weather may become more important locally. Such disturbances can lead to extensive mortality and ecosystem change and take place in relatively short periods of time.[54] Other disturbances and extreme events include:

TABLE 4. Examples of the Impacts of Simulated Climate Change on the Forest Products Industry

Reference	Scope	Production Impact	Economic Impact
Sohngen et al. 2001; Sohngen and Sedjo 2005	Global	2045: production up by 29% to 38% in North America and Russia, increases in Latin America and Oceania.	2045: lower prices, high-latitude losses, low-latitude gains.
		2145: production up by 30%, increases in North America, Latin America, and Russia.	2145: prices increase up to 80% (no climate change), 50% (with climate change), high-latitude gain, low-latitude loss. Benefits go to consumers.
Solberg et al. 2003	Europe	Increased production in western Europe. Decreased production in eastern Europe.	Price drop with an increase in welfare to producers and consumers. Increased profits for forestry industry and forest owners.
Perez-Garcia et al. 2002	Global	Harvest increases in the U.S. West (2% to 11%), New Zealand (10% to 12%), and Latin America (10% to 13%). Harvest decrease in Canada.	Demand satisfied; prices drop with an increase in welfare for producers and consumers.
Lee and Lyon 2004	Global	2080s: no climate change, increased industrial timber harvest by 65% to 150%, triple production in emerging regions.	No climate change; pulpwood price increases 44%; solid wood increases 21%.
		2080s: with climate change: increased industrial timber harvest by 25% to 56%, production dominated by eastern Siberia and U.S. South.	With climate change: pulpwood price decreases 25%, solid wood decreases 34%, global welfare 4.8% higher than in no-climate-change scenario.
Nabuurs et al. 2002	Europe	18% extra increase in annual stemwood increment by 2030, slowing down in longer term.	Both decreases or increases in prices are possible.
Alig *et al.* 2002; Joyce et al. 2001	United States	Increase in timber inventory by 12% mid term, 24% long term, and small increases in harvest. Major shift in species and an increase in burned area by 25% to 50%. Generally, high-elevation and northern forests decline, southern forests expand.	Reduction in log prices; producer welfare reduced compared with no-climate-change scenario, lower prices; consumers gain and forest owners lose.

Source: IPCC, *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report* (Cambridge: Cambridge University Press, 2007).

- *Windthrow.* Windthrow damage has increased steadily in Europe to reach losses between 120 million and 193 million cubic meters in 1990 and 1999, respectively; the latter figure was a result of three storms over a period of three days and is equivalent to two years of harvest.[55]
- *Hurricanes*. An example is Hurricane Gudrun in January 2005, which damaged more than 60 million cubic meters of timber in Sweden, reducing the country's log trade deficit by 30 percent.[56]
- *Tornadoes*, *flooding*, *avalanches*, *and landslides*.

The impacts of extreme weather events on commercial forestry vary by region. Besides direct damage to trees, other consequences are higher costs for road and facility maintenance, reduced access to forestland, effects of wetter winters and early thaws on forest operations, and higher insurance costs.[57]

Along with other supply and demand factors, the effects of climate change on forests are predicted to increase the world's supply of wood and fiber while depressing prices, with mixed results for the industry's welfare. Economic models predict an increase in the world's timber supply and enhanced market share in developing countries with a moderate rise or fall of up to +/- 20 percent. The models are inconclusive, with several showing a net

TABLE 5. Global Status of Ecosystem Services

	Degraded	Mixed	Enhanced
Provisioning	Capture fisheries Wild foods Biomass fuel Genetic resources Biochemicals, natural medicines, and pharmaceuticals Fresh water	Timber Fiber (e.g., cotton, hemp, silk)	Crops Livestock Aquaculture
Regulating	Air-quality regulation Regional and local climate regulation Erosion regulation Water purification and waste treatment Pest regulation Pollination Natural-hazard regulation	Water regulation Disease regulation	Carbon sequestration
Cultural	Spiritual, religious, or cultural heritage values Aesthetic values	Recreation and ecotourism	

Source: Millennium Ecosystem Assessment, *Ecosystems and Human Well-being*: Synthesis (Washington DC: Island Press 2005).

benefit for consumers and net losses for producers while others show a net benefit for both. Table 4 summarizes recent research on these economic impacts on the industry. Overall, the world's timber supply is projected to rise moderately over the short to medium term, albeit with dramatic regional variability.[58]

In addition to the shift in harvest from natural forests to plantations, a global shift in the industrial wood supply is expected to accelerate from temperate to tropical zones and from the Northern to the Southern Hemisphere.[59] Producers in subtropical regions are predicted to be less vulnerable because of high growth rates and short rotation periods (which can provide opportunities for adaptation), but producers in native temperate and boreal forests may be vulnerable to less productivity because of shifts in climate zones.

Forests may also be affected by climate changes in other ecosystems or other economic, demographic, cultural, and political developments. In particular, forest productivity is tied to ecosystem services that are being degraded by factors outside forestry operations. The anthropogenic impact, particularly land-use change and deforestation in tropical zones, is likely to be extremely important to the future availability of forest resources.[60]

Experts found that 60 percent of the world's major ecosystem services have been degraded over the past fifty years,* and the Millennium Ecosystem Assessment projected that ecosystem services would become increasingly degraded over the first half of this century. Table 5 summarizes the study's findings.

* The Millennium Ecosystem Assessment was a four-year international scientific appraisal undertaken by nearly fourteen hundred experts from ninety-five countries who assessed the consequences of ecosystem change for human well-being and established the scientific basis for action needed to enhance the conservation and sustainable use of ecosystems.

These trends in ecosystem services are important to the forest products industry because companies and ecosystems are interrelated. Forest products companies may contribute to the enhancement or degradation of ecosystem services while at the same time they (as well as their suppliers and customers) depend on many of them. For instance, plantation forestry depends on nature to provide fresh water, climate regulation, and erosion control. The degradation of ecosystem services, therefore, could pose a number of operational, regulatory, and reputational risks to companies. At the same time, the degradation of ecosystem services could create opportunities for new products, services, and markets for businesses that respond to these trends.

Climate change and ecosystem degradation may affect the amount and timing of fresh water flows, with strategic effects on the plantation forestry.

The plantation forestry industry is dependent on the availability of fresh water and the regulation of water flow and climate. Regional climate change models indicate that plantation forestry could be at risk of diminishing water flows resulting from the deterioration of these three key ecosystem services.

Water Supply Threats to Latin American Plantation Forestry

Risks to water supply in Brazil include

- *Increasingly arid conditions in Brazil's northeast.* Competition for land in southern and southeastern Brazil is pushing forest products companies into a number of newer areas, including the northeast. Predictions based on regional models, however, suggest that annual rainfall will decrease in Brazil's northeast, a good part of which is already semiarid, as well as in the Amazon basin and the Pantanal.
- *Agricultural shift southward.* Climate change is expected to have a massive influence on agriculture and may make growing crops such as soybeans, corn, and coffee unfeasible in some areas. Brazil's Agricultural Research Corporation used climate change projections to ascertain the future for these crops and found that some of the plantations will have to move south as the heat rises. Such southward shifts in agriculture could put further pressure on land and water resources in areas where plantation forestry is concentrated and could drive land prices even higher.
- *Lower rainfall in southern Brazil as a result of deforestation of the Amazon.* While rains are predicted to increase by 5 percent in Brazil's southern and southeastern regions, where the majority of its forest plantations are currently located, deforestation and "savannization" of the Amazon (a process in which rainforest is replaced by savanna) could counterbalance and even overwhelm this effect. About half the Amazon region's rainfall is the product of reevaporation from the forests themselves, and deforestation reduces the amount of water vapor in the atmosphere. At least 30 percent of the rains in southeast Brazil currently come from the Amazon. The rainfall effects of savannization could also be felt in central-southern Brazil and parts of Argentina, Bolivia, and Paraguay, but the savannization of the Amazon is still uncertain.

Chile's forest plantations are concentrated in those regions that appear to be most susceptible to the impacts of climate change, including

- *Less rainfall.* The National Commission for the Environment (CONAMA) commissioned a research study of the climate outlook for Chile in 2070 to 2100. The study concluded that depending on the level of global greenhouse gas emissions, peak summer temperatures in Santiago could reach 40ºC, and rainfall would drop throughout most of the country. In the agricultural heartland from regions V to VIII, the shortfall in spring precipitation could be as much as 75 percent.
- *Alterations in stream flow resulting from less snow pack.* Most significantly for Chile's economic future, global warming would have its main impact on the Andes Mountains. The zero isotherm (the altitude above which the air temperature is below 0ºC) is expected to rise sharply and change snow-pack accumulations while swelling rivers in winter. Reductions in the snow pack would deprive Chile of an important store of water to carry it through the summer and autumn. This impact would be particularly marked in regions VII and VIII, an area that not only is important to agricultural production and the forestry industry but also is where Chile's main hydroelectric dams are currently located.

Sources: Helen Mendes, "Brazil Faces Forecast of Heat and Dust," *SciDev.Net*, February 8, 2007; IPCC, *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report* (Cambridge: Cambridge University Press, 2007); Eduardo Neira, Hernan Verscheure, and Carmen Revenga, "Chile's Frontier Forests: Conserving a Global Treasure" (Washington, DC: World Resources Institute, 2002); Ruth Bradley, "Warming to the Opportunities of Climate Change," *Business Chile*, August 2007.

FOREST ACCESS

International, national, and regional policies to prevent the deforestation of native forests may alter pulp and wood market dynamics by reducing illegal logging and access to native forests in developing countries. In theory, proper incentives and enforcing the protection of native forests should increase the demand for sustainable forestry alternatives and could create new opportunities for international forest products companies that practice sustainable forest management in tropical and subtropical markets.

Protecting existing forests is vital to mitigating the effects of, and increasing the resilience of communities to, climate change.

Forests contain 60 percent of all carbon stored in terrestrial ecosystems,[61] an enormous carbon reserve that can be released through natural and human events, including fires, extreme weather events, and land-use change. Carbon emissions from deforestation contribute 18 to 25 percent of the world's annual emissions of greenhouse gases.[62] Emissions from deforestation in Brazil and Indonesia alone are equivalent to the entire reduction commitments of the annex 1 countries during the first commitment period.[63] A recent study showed that the expected deforestation and degradation in the Amazon alone could cause a 0.3-degree Celsius change in global temperatures,[64] making even more clear the importance of addressing this issue.

According to the Intergovernmental Panel on Climate Change (IPCC), about 65 percent of forests' total mitigation potential is located in the tropics, and about 50 percent of this could be achieved by reducing emissions from deforestation. Policy measures could include positive incentives (national and international) to increase forest area, to reduce the deforestation and degradation of primary forests, and to maintain and manage working forests more sustainably, in addition to land-use regulation and enforcement.[65]

The forest products industry can provide deforestation solutions. As global production moves from native to managed forests, more products are coming from sustainable timber. It has been estimated that an area less than 10 percent of the world's current forested area could supply all of global industrial forest requirements if this transition continues.[66]

There is a strong international political impetus to reduce CO_2 emissions from deforestation. In December 2005, the UN Framework Convention on Climate Change began a two-year process to devise approaches to reducing greenhouse gas emissions from deforestation in developing countries (often referred to as "Reducing Emissions from Deforestation and Degradation," or REDD). Recommendations from this process were presented and debated at the international climate negotiations in Bali in December 2007. At these meetings, the "Bali Roadmap" was adopted in order to guide the process of reaching an agreement on the next climate policy regime after the Kyoto Protocol expires in 2012. REDD was formally included in the Bali Roadmap as a climate mitigation strategy.

At this stage, several coalitions have formed different approaches to REDD and are working to clarify and agree on implementation and methodological issues. For example, the World Bank announced the creation of the Forest Carbon Partnership Facility (FCPF) to help developing countries build the capacity needed to participate in a "national-level" REDD policy scheme and to test how a mechanism could work. Several donor countries have provided funding to the FCPF, and others have chosen to pursue alternative or parallel activities. Many policy negotiators feel that only a national-level REDD scheme would reduce emissions sufficiently.

Technical, political, and implementation hurdles remain, however. Both developing and developed country actors with expertise in deforestation and climate issues see significant risks in an approach in which money would flow to countries that have reduced their emissions from deforestation below an established baseline. Technically, quantifying the reduction in emissions from this sector is fraught with uncertainty. Some of the initial questions are how to monitor the forests, set a reasonable reference level/baseline, and quantify the likely shift of deforestation activities within the country and across its borders.

Equally challenging is the question of permanence. As the increase in the rate of deforestation in Brazil at the end of 2007 clearly shows, the ability of governments to reduce deforestation often is extremely complicated.[67] Even if Brazil's efforts could be improved, the creation of a price for emissions reductions alone may not be enough to overcome the strength of the economic reasons for deforestation. Some countries' institutional structures and confidence in government mechanisms and laws, such as land tenure and fund distribution, may present significant barriers to implementing the reduction of emissions, even with a high price for carbon.

Nevertheless, whether under REDD or other incentive structures to reduce deforestation on a national level, the growing concern about deforestation and the value of forests for climate change mitigation and adaptation has prompted new conversations about forest management. The question of forest governance and connection to market access, whether through REDD credits or timber, is a worthy investigation. Such inquiries may create the impetus and capacity to help level the playing field, in both supply and demand countries, for those forest companies previously competing with illegal logging operations. Creative thinking is needed to come up with possible synergies between industry and environmental goals.

In view of all these obstacles, ensuring that this mechanism produces the intended results is a daunting challenge facing the forest and climate communities for NGOs, governments, and business. An initial step would be to clarify the role of managed forests to provide wood and fiber in a national program to reduce deforestation, and how the industry can help. International climate policy mandates include sustainable development priorities that will consider the effects on forestry industries in emerging economies. One way to meet business, environmental, and social objectives would be to increase the number of certified forests and products coming from countries with high deforestation rates.

LAND USE COMPETITION

The future of biomass transport fuels and electricity production is uncertain, although current trends point to the expansion of bioenergy technologies in the major global markets, including the United States, Europe, Brazil, and China (for a discussion of the political and technological developments regarding the emerging bioenergy markets, see p. 49). Growing concerns about food prices and the greenhouse gas emissions from land use change for biofuels production could slow or reverse recent enthusiasm.

The availability of land for new plantations will be influenced by physical climate changes as well as competition from other land uses, including bioenergy crops.

A growing bioenergy sector will intensify the competition for land use and put pressures on native forests. The expansion of nonwood sources of biofuels (e.g., sugarcane, palm oil, and switchgrass) may create land-use conflicts with forestry. The most productive regions for plantation forestry, the tropics and subtropics, also are well suited to produce bioenergy feedstocks. The native forests in these regions are, as well, at high risk for conversion; for example, the World Bank estimates that Indonesia may convert 1.4 million hectares from wood production into palm oil production.[68] Some land use already has shifted from forestry to bioenergy in places such as Vietnam, which could raise wood prices owing to the smaller supply.

If the development of biofuels is poorly regulated, it could have devastating effects on ecosystems and greenhouse gas emissions. For example, the production of palm oil is rapidly becoming the single largest cause of deforestation in Indonesia, and in Brazil the intensive cultivation of soybeans and sugarcane for ethanol is having a similar impact on the Amazon and mid-Atlantic rainforests. Competition between food and fuel crops will likely lead to greater pressure on ecosystems, including water services.[69]

The European Commission mandated that a "sustainability scheme for biofuels" be developed by member states to meet its renewable energy mandates by 2020. It is likely that this sustainability scheme, as well as others being discussed in North America, will try not only to prevent the deforestation of native forests but also to ensure that forest bioenergy feedstocks (such as logging residues and fiber) are produced using sustainable practices (for a discussion of the role of forests resources to provide bioenergy feedstocks, see p. 53). As a result, companies with experience in sustainable forest management may be better positioned to benefit from evolving policy objectives on biofuel production.

MILLS

ENERGY PRICE RISK

Pulp and paper mills are highly energy intensive. A large portion of their energy needs is typically met through biomass heat and power, however, resulting in a lower carbon profile than other manufacturing sectors if biomass fuels are from sustainable sources. Because the forest products industry is one of the least carbon-intensive manufacturing sectors, it is not very exposed to direct constraints on carbon emissions. Over the first phase of the European Union Emissions Trading Scheme (2005–2007), the sector received many more emissions rights than actually needed, a situation that is likely to continue over the second phase of the trading period and beyond as the sectors face steep international competition from nonregulated competitors.[70]

Within the sector, mills vary dramatically with respect to efficiency and fuel mix. Those mills dependent on fossil fuels may face higher energy prices in a carbon-constrained economy. Consequently, many facilities are replacing aging boilers with ones with higher capacities for biomass heat and power generation. Although the industry still may be able to reduce its carbon profile by using more biomass heat and power, these changes will be carried out in the near to medium term. In the longer term, however, higher values for biomass resources (see Raw Materials Price Risk, p. 37) could limit the ability of on-site biomass heat and power generation to offset increasing energy prices.[71]

The manufacture of forest products requires significant energy and capital and is sensitive to price.

Pulp and paper production is one of the most energy-intensive industries in the manufacturing sector. Energy use typically represents the second- or third-largest cost for the industry,[72] though this varies greatly by mill type. Wood products mills, particularly dimensional lumber, require relatively little energy. Engineered wood products, however, require more energy, especially to treat wastewater. Pulp and paper mills are even more energy intensive, with chemical pulping requiring more energy than mechanical pulping. Overall, the most energy-intensive areas of forest products manufacturing are mechanical and chemical pulping, pulp and paper drying, and chemical recovery.

On average, fuel can account for 10 percent of U.S. papermakers' total production expenditures.[73] Globally, energy has cost from 3.5 to 4.5 percent of revenues, with an upward trend in recent years.[74]

Pulp and paper mills are also one of the most capital-intensive industries. The long-term nature of capital outlays, coupled with aging equipment, mean that some investment decisions must be made before climate change policies have been determined. Most of the biomass boilers used in pulp and paper mills in the United States will reach the end of their thirty- to forty-year lifetimes over the next ten to twenty years, and the technologies to replace them will greatly define the mills' exposure to future increases in energy price.

Climate change policy is likely to directly or indirectly raise the price of energy from fossil fuels, which will affect inefficient or fossil fuel dependent mills.

International, regional, national, and state climate change policies—such as the Kyoto Protocol, the European Union's Emissions Trading Scheme (EU ETS), and the Regional Greenhouse Gas Initiative in the U.S. Northeast—already create a cost for carbon dioxide and other greenhouse gas emissions. For example, in Nordic Europe, paper manufacturers reported that the introduction of the EU ETS contributed 70 to 75 percent of the increase in electricity prices.[75] Thus far, these costs have been absorbed by the higher price created by Europe's imbalance between supply and demand, but in 2008, the paper prices for these Nordic producers are expected to decline by 10 percent as a result of lower prices in North America.[76]

The momentum for a national climate change policy is building in the United States, although the implementation of greenhouse gas reductions still is likely to be at least several years away. Major future policy developments around the world could include a deepening of emission caps in Europe, Japan, and Canada; reengagement of the United States in international treaty negotiations; a new "post-2012" compliance period under the Kyoto Protocol; and new commitments for some developing countries.

Future climate change policies continue to be both uncertain and complicated, including the role of the United States and large industrializing countries such as China, India, and Brazil. Furthermore, a patchwork of local, national, and international climate policies are complicating the regulatory landscape for multinational corporations. Nonetheless, forest products manufacturers must make investment decisions regarding capital equipment that represent financial commitments to carbon dioxide emissions and that may become very costly under regulations that attach a price to carbon.

TABLE 6. Examples of Voluntary Climate Change Commitments in Forest Products Sector

Trade Associations	
American Forest & Paper Association	Reduce the forest products industry's greenhouse gas intensity by 12 percent by 2012 over that in 2000.
Confederation of European Paper Industries	Increase biomass share of on-site primary energy consumption by 25 percent to a total of 49 percent, or 56 percent of total energy consumption.
Forest Products Association of Canada	Implement agreement with government to reduce emissions intensity by 12 percent by 2010, from 2000 baseline, to contribute to commitment to Kyoto Protocol. Commit to becoming carbon neutral (without the purchase of offset credits) by 2015 and a net producer of renewable energy by 2020.
Japan Paper Association	Reduce CO_2 emissions by 10 percent by 2010 from 1990 baseline.
Integrated Forest Products	
Abitibi-Consolidated (merging with Bowater)	CCX[a]
Boise Cascade	Reduce total U.S. GHG emissions by 10 percent from 2004 to 2014.
International Paper	Reduce absolute greenhouse gas emissions by 15 percent by 2010 from 2000 baseline.
Stora Enso	CCX[a] (North American operations).
Temple-Inland	Reduce GHG emissions by 7 percent by 2007, from 2001 baseline.
Weyerhaeuser	Reduce absolute greenhouse gas emissions 40 percent by 2020, from 2000 baseline.
Integrated Pulp and Paper Products	
Aracruz Celulose S.A.	CCX[a]
Klabin S.A.	CCX[a]
Meadwestvaco	CCX[a]
Neenah Paper	CCX[a]
Smurfit Stone	CCX[a]
Suzano Papel E Celulose S.A.	CCX[a]
Integrated Wood Products	
Masisa S.A.	CCX[a]
Forest Products Manufacturing	
Louisiana Pacific	Reduce GHG emissions by 12 percent by 2012, from 2000 baseline.

Note: [a] All CCX members commit to annual reductions resulting in 2010 emissions 6 percent below 1998–2001 average or year 2000 emissions.
Source: World Resources Institute.

In addition to higher fossil fuel energy prices, petroleum products used as inputs will raise costs as well. For example, the adhesives and bonding products used in producing structural panels and laminated veneer lumber are tied to petroleum prices.

Mills can generate much of their own power needs by burning biomass wastes and by hosting combined heat and power (CHP) projects. The U.S. industry already generates up to 50 percent of its own energy needs.[77] In Europe, the Confederation of European Paper

Industries has set a target to increase its biomass share of on-site primary energy consumption by 25 percent, to a total of 49 to 56 percent of its energy consumption. The Forest Products Association of Canada has created a forest industry competitiveness task force that has created the goal of becoming not only carbon neutral by 2015 but also a net source of renewable energy by 2020.

Pulp and paper mills use large amounts of steam, making them ideal hosts for CHP projects. Such projects greatly reduce energy consumption by using the steam from nearby electricity generation in manufacturing processes. The number of CHP projects at pulp and paper mills is rising, especially in Europe.

Several major forest products manufacturers have made commitments to reduce energy consumption and greenhouse gas emissions. A number of companies have devised climate change strategies and commitments (see table 6). In 2006 Weyerhaeuser committed to reducing its greenhouse gas emissions by 40 percent by 2020 from its 2000 emissions. The company plans to achieve this goal by using more biomass to meet its energy needs for its pulp and paper operations, essentially becoming energy self-sufficient and reducing by 50 percent the cost of energy purchased from the grid. Such a commitment benefits both the environment and shareholders by lowering energy costs and reducing dependence on the grid.

Greater energy efficiency has not, however, been sufficient to keep up with the increasing production of pulp and paper. In Europe, absolute greenhouse gas emissions from the manufacture of paper products have risen 9 percent since 1990.

RAW MATERIALS PRICE RISK

The creation of new markets for forest resources faces many uncertainties in a bioenergy future. Any increase in wood and fiber prices from competing bioenergy demands could hurt forest products companies, as raw fibers normally represent 16 to 20 percent of the total cost of paper production (for a discussion of the political and technical trends and hurdles regarding forest bioenergy, see pp. 49–55).[78]

If bioenergy markets raised the prices of raw materials, it would affect the competitiveness of forest products manufacturing.

Bioenergy markets are likely to increase the cost of manufacturing some forest products by raising the market price of low-value wood and fiber. Based on the cost structure of Stora Enso, a global integrated forest products company, the European equity broker Cheuvreux estimates that a 1 percent rise in fiber costs would, on average, result in a 3 percent decline in earnings for pulp and paper manufacturers.[79]

The effects on manufacturers of an increase in the price of raw materials would be determined by the dynamics of the bioenergy market as well as how dependent the mill is on market pulp or chips for supplies. Sawmills, the panel industry, and the pulp and paper industry are likely to be the most affected by the increased use of wood for energy production, as raw wood comprises a substantial, and generally the largest, part of their total variable production costs. In Europe wood represents 70 percent of sawmills' costs, 25 to 50

CIBC's Bioenergy Winners and Losers in the Forest Products Industry

Winners	Losers
• Landowners • Feedstock producers • Key technology patent holders • Transport infrastructure providers • Existing users of feedstock that have a competitive advantage in producing a "joint product" (e.g., paper and ethanol, see p. 58)	• Existing users of bioenergy feedstocks, including producers of nonstructural panels (MDF, particleboard) • Energy-inefficient pulp/paper/solid wood mills dependent on bioenergy • Sawdust-based pulp

Source: Don Roberts, "Five Reasons Wood Is Going to Become Increasingly Scarce," CIBC World Markets client presentation, June 2007, Toronto.

percent of the panel industry's costs, and 40 percent of pulp and paper manufacturers' costs.[80]

Sawmills are likely to profit from bioenergy. Sawmills have benefited, and will probably continue to benefit, from the development of wood-based bioenergy markets because saw logs have a high value and no competition from energy uses and will obtain a higher price for the secondary products (slabs, chips, and sawdust) demanded by bioenergy markets. But secondary products also used for internal heat production and bioenergy may require new sources of energy, possibly increasing greenhouse gas emissions.[81]

The panel industry would suffer as a result of wood-based energy production. The panel industry will face more competition for all its raw materials, including slabs, chips, and sawdust from the sawmills, as well as for roundwood, and it has no secondary products to be fed into the energy markets.[82]

Pulp and paper could be both hurt and helped by the development of bioenergy. Although pulp and paper mills will face increasing competition for fiber, chemical pulp mills will be helped because they can manufacture new, high-value products at an integrated biorefinery (see p. 58). Mechanical pulping cannot do this, however, and therefore will be hurt by higher prices for raw materials and electricity.[83]

Robust bioenergy markets could also threaten the security of energy supplies for manufacturers dependent on biomass fuel for production.

Pulp and paper mills powered by biomass could face a drop in the energy supply if they require feedstocks beyond what is available from their own harvesting and manufacturing residues. Because market prices and interactions of bioenergy feedstocks are likely to change over time, mills investing in biomass to become energy self-sufficient will need to secure their biomass supply over the long term. (This risk also is noted in the Energy Price Risk section on p. 34.).

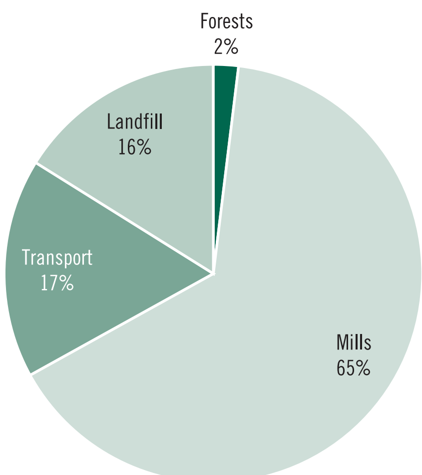
GREEN PROCUREMENT AND FINANCING

The end users of forest products are looking upstream to the environmental attributes of their raw materials. Lenders are also creating environmental standards to improve the environmental impacts of their loan portfolios.

Improved energy efficiency and biomass power could give mills a supply chain advantage over competitors.

Certification programs, designed to ensure that forests are harvested sustainably, are well established in the industry and can play an important role in purchasing decisions by downstream customers. Procurement policies for recycled content are relatively common as well, although many of the companies with sustainable wood- and paper-purchasing policies are also making commitments to reduce their own climate change emissions (for examples, see table 7). As a result, the demand from downstream manufacturers and retailers for less carbon-intensive raw materials and products is growing. In the future, it is likely that more downstream users will look to their suppliers to improve the carbon profile of their raw materials and products.

FIGURE 6. LIFE-CYCLE CARBON EMISSIONS OF *TIME* MAGAZINE



Source: Stith T. Gower et al., "Following the Paper Trail: The Impact of Magazine and Dimensional Lumber Production on Greenhouse Gas Emissions: A Case Study" (Washington, DC: Heinz Center, 2006)

Time Inc.'s climate change commitment requires its paper suppliers to have their own greenhouse gas reduction goals and gives preference to low-emission producers. This procurement policy is based in large part on Time's finding that paper manufacturing accounts for most of its products' life-cycle greenhouse gas emissions (see figure 6). Time Inc. is the world's largest magazine publisher, purchasing 600,000 tons of paper per year. As a result, its procurement policy creates a competitive advantage for those pulp and paper manufacturers that have set goals and taken action to reduce their greenhouse gas emissions. In addition, Rupert Murdoch recently announced that the News Corporation is drawing up a plan to become entirely carbon neutral.[84]

Wal-Mart, the world's largest retailer, recently revealed its commitment to climate change with its use of a "scorecard" to rank the greenhouse gas emissions of suppliers of certain products. The "scorecard" is a first step toward Wal-Mart's long-term goal to reach a 5 percent packaging reduction across its supply chain by 2013.

The numerous efforts to improve the environmental footprint of paper include cutting the industry's greenhouse gas emissions. The Paper Working Group, convened by the nonprofit Metafore, is an industry/public-sector collaboration to change paper-buying practices that includes Time Inc., McDonalds, Starbucks, and Bank of America. Environmental organizations in the Environmental Paper Network have named greenhouse gas emissions from manufacturing as one of the most important indicators to monitor the industry's environmental performance.[85]

The Sustainable Advertising Partnership is a newly formed collaboration of advertising, publishing, and printing industries to discuss steps to address climate change and supply chain sustainability. Some retailers are looking to reduce the greenhouse gas emissions of their print advertisements. For example, John Hardy, a luxury jewelry company based in Bali, has formed a partnership with the Institute for Sustainable Communications to request that publishers release information about their paper and printing sources. Aveda, a beauty products company owned by Estée Lauder, sends sustainability surveys with questions about greenhouse gas emissions to publications to help decide where to place its ads. Table 8 lists additional resources addressing climate change in forest products procurement.

TABLE 7. Examples of Companies with Green Procurement and Climate Change Policies

Company	Sustainable Forest Products Procurement: Certified Forestry	Sustainable Forest Products Procurement: Recycled Wood and Fiber	Climate Change Policy
CONSTRUCTION AND HOME IMPROVEMENT			
Andersen Corporation	X	X	X
B & Q PLC	X	—	—
Eagle Window & Door	X	—	—
Golden State Lumber	X	—	X
Hayward Lumber	X	—	X
Home Depot	X	—	—
KB Home	X	—	X
Lanoga Corporation	X	—	—
Lowes	X	X	—
CONSUMER SERVICES AND PRODUCTS			
The Body Shop	X	X	X
Estée Lauder	X	—	—
Federal Express	—	X	—
IKEA	X	—	X
Johnson & Johnson	X	X	X
Kinko's	—	X	X
Limited Brands	X	X	X
McDonald's	—	X	X
Nike	X	X	X
Office Depot	X	X	—
Patagonia	X	X	—
Staples	X	X	X
Starbucks Coffee Company	X	X	X
United Stationers Supply	X	X	X
ELECTRONICS			
Apple Computer	X	X	X
Hewlett-Packard	—	X	—
Quantum Corporation	X	X	X
PUBLISHING			
McGraw-Hill	—	X	—
RR Donnelley	X	—	—
Time Inc.	X	X	X
Wal-Mart	—	X	X
Williams-Sonoma	X	X	—

Source: ForestEthics website (accessed July 2007) and World Resources Institute.

TABLE 8. Resources for Forest Products Procurement and Climate Change

Paper Profile	Includes information about total amount of energy procured, possible energy surplus, and CO_2 emissions from burning fossil fuels and peat.
WWF GFTN	Supports efficient use of energy to minimize direct/indirect impacts on climate change, management to improve levels of carbon sequestration.
EPAT®	Rates the total amount of CO_2 emitted to the air per unit of product as well as efforts to reduce CO_2 emissions.
WWF Tissue Scorecard	Rates whether a company has set a vision and targets for maximizing use of biomass and other renewable energy and reducing CO_2 emissions, as well as ongoing research on and development of cleaner production and transportation technologies.
WWF Paper Scorecard	Rates fossil fuels' contributions to climate change and global warming through emissions of CO_2.
WWF Guide to Buying Paper	Provides background information; promotes reduction of CO_2 emissions and showcases companies reducing CO_2 emissions.

Source: World Resources Institute and the World Council on Sustainable Development, Sustainable Procurement of Wood and Paper-Based Products: Guide and Resource Kit.

Energy-efficient and low-carbon producers could attract better investment opportunities as a result of many financial institutions' sustainable lending standards.

The International Finance Corporation (IFC), along with the world's largest financial institutions, have committed to environmental standards in their lending policies to limit the negative environmental and social consequences of their investments. Over the last four years, the IFC has invested more than $1 billion in new projects spanning the entire forest products supply chain that are subject to the IFC's sustainability guidelines. In particular, the IFC has industry-specific environmental, health and safety (EHS) guidelines for board- and particle-based products, sawmilling and wood-based products, forest harvesting operations, and pulp and paper mills. One IFC project has offered $300 million in financing to Stora Enso for a sustainable forestry project in China.

The Equator Principles, a voluntary commitment by the majority of large financial institutions, is based on the IFC's EHS guidelines and applies to new projects with capital costs of more than $10 million. In 2006, the Equator Principles were estimated to apply to more than 80 percent of the world's project lending.[86] The IFC's adherence to its EHS guidelines, along with the majority of the financial community's acceptance of the Equator Principles, increases the likelihood that climate change implications will be considered in the development of capital-intensive forest products manufacturing projects. As a result, renewable and energy efficient operations should contribute to a project's ability to receive high-quality funding.

MARKETS AND PRODUCTS

CARBON MARKETS

The creation of incentives to increase the rate of carbon captured and the volume of carbon stored in forest ecosystems has attracted considerable interest. Expanding forest coverage by planting new, fast-growing trees is a way of increasing the rate of carbon dioxide sequestration. Protecting and maintaining older forests prevents stored carbon from being released into the atmosphere. Furthermore, carbon continues to be stored during the useful life of forest products. But because the carbon stored in forests and products is vulnerable to release through combustion or decomposition, its permanence cannot be guaranteed.

New financial products, such as tradable carbon dioxide credits, could create new revenue streams for the industry by managing forests for carbon capture and storage instead of, or in addition to, wood and fiber production. To date, however, many political and technical obstacles have prevented forest-based carbon credits from being included in regulated carbon markets. Given the heightened attention to issues of deforestation and land-use change in current climate policy debates, as well as progress in methods of assessing and monitoring carbon in forest ecosystems and products, forestry-based carbon credits may well be able to provide low-cost offsets in future carbon markets, particularly in North America. The scale of greenhouse gas emissions offset markets is likely to remain small in the foreseeable future, though, and other policy opportunities, such as relative price advantages from carbon constraints (see p. 61), may ultimately provide more transformative benefits to the industry.

If the price is right, forests can be managed for carbon capture and storage.

A forest's carbon density can be increased through various management techniques, including planting genetically improved trees, managing fires, controlling insects, changing rotation lengths, changing harvest techniques, and preparing sites.[87] Canada is considering such practices, called *forest carbon management*, as a long-term strategy to reduce emissions. Forest carbon management is currently allowed under the California Climate Action registry to generate carbon credits in that state.

Studies have shown that even small incentives to store additional carbon can benefit foresters. To demonstrate the value of carbon forest management offset projects in Canada, a group convened by the World Resources Institute worked with the Canadian Forest Service to create a "test case" performance standard in a pilot region. The analysis found that significant quantities of carbon could be stored, thereby increasing the carbon stock between 3.0 and 5.2 tons per hectare for an average management unit. Over twenty-five years, this amounts to between 32 million and 34 million tons of carbon that could be claimed. Even given a modest price for carbon—for example, $5 per ton of carbon, or about $18 per ton of CO_2—this would amount to between $161 million and $170 million in revenues over twenty-five years.[88]

A case study by the Consortium for Research on Renewable Industrial Materials (CORIMM), a collaboration among government, industry, and academia, shows the carbon sequestration contribution of a forest in the Pacific Northwest with a price of $10 per ton for carbon would increase the forest's value by $230 to $250 per acre.[89] For perspective, timberlands in the U.S. Southeast are valued between $600 and $1,500 per acre, depending on age class and species composition.[90] Similar results were obtained in an analysis conducted by the University of Alberta, which concluded that a price on carbon would increase forest values in Canada under every scenario it used.[91]

CORIMM's analysis found that substituting wood for other products is the most effective way for forest products to reduce greenhouse gas emissions. According to its research, intensive forest management that can grow more wood on shorter rotations sequesters and stores more carbon over time than does forest management with longer intervals between harvesting. This finding, however, is based on the premise that frequently trapping carbon in wood products creates more opportunities to replace fossil fuel–intensive building materials. As a result, substitution plus intensive short-rotation forestry ultimately stores the most carbon over time. Short rotations increase the number of products in use and allow for more substitutions with other materials, which more than offset the decline in forest carbon storage from this practice.[92]

The feasibility of forest carbon management is largely influenced by the price of carbon sequestration relative to the price of wood, the ownership of carbon rights, harvest constraints, and the forest's age. In regard to forest carbon management, sequestered and stored carbon is considered a forest product, whereas carbon emissions are viewed as a cost. This means that when creating a desirable forest management regime, changes in carbon sequestration and emissions must be balanced against other objectives, such as the production of forest products and services.

TABLE 9. Emerging Markets for Forestry Offsets

Market	Volume Traded (MMT CO_2e, 2006)	Transaction Value (billions 2006 US$)	Role of Forest Offsets
EU ETS	1,100	25	
Climate Development Mechanism (CDM)	450	5	• Afforestation and reforestation • Low penetration to date
Joint Implementation (JI)	16	0.14	
New South Wales Greenhouse Gas Reduction Scheme (NSW GGAS)	20	0.23	
Voluntary Offsets	20 to 50	0.1 to 0.25	• Afforestation, reforestation, conservation, conservation-based forest management • Approximately 50% forest-based \$5 to \$10/MTCO_2e
Chicago Climate Exchange (CCX)	10	0.04	• Afforestation and reforestation, conservation, conservation-based forest management • \$3.70/ton CO_2e early 2007 • Overseas offsets allowed

Source: World Bank, "State and Trends of the Carbon Market 2007"; the Climate Group; World Resources Institute interviews.

Further study is needed of the intricacies of the carbon cycle, better forest management methods, and silvicultural techniques for carbon sequestration; the impacts of managing carbon on other forest values; the risks and uncertainties associated with carbon management; and the long-term effects and economics of carbon management.[93]

The scale of forestry CO_2 offset projects currently is limited, although this could change if the rules or incentives change.

Companies, individuals, and countries are now more willing to pay for projects that will reduce greenhouse gas concentrations in the atmosphere. CO_2 credit markets facilitate transactions that could include payment for carbon stored in forests. Such forestry projects might focus on sequestering carbon from the creation of new forests (afforestation or reforestation), storing additionals carbon through the carbon forest management of productive forests (see previous section), and avoiding carbon emissions by preventing deforestation (see p. 31, and for an overview of carbon markets and forestry offsets, see table 9).

The European Union Emissions Trading Scheme (EU ETS) is the largest regulated carbon market in the world. Under this scheme, companies can reduce their emissions or purchase additional allowances or carbon credits that were created through approved carbon projects to meet their nationally mandated emissions reductions targets.* New energy finance estimates that \$33.8 billion of carbon credits will be needed by 2012 to meet targets under the Kyoto Accord and the European Emissions Trading Scheme.[94]

The EU ETS, however, specifically excludes all forest-based credits. Consequently, companies regulated under the European Emissions Trading Scheme cannot buy forestry project credits developed under the Clean Development Mechanism of the Kyoto Protocol to offset their greenhouse gas emissions, although these same companies are allowed to buy credits

* Under the Kyoto Protocol, carbon projects include the Clean Development Mechanism and Joint Implementation. The Clean Development Mechanism (CDM) allows industrialized countries with commitments to reduce greenhouse gases to invest in projects that reduce emissions in developing countries. Joint Implementation (JI) allows industrialized countries to invest in carbon reduction projects in other countries with commitments to reduce emissions.

TABLE 10. Selected Proposed Federal U.S. Greenhouse Gas Policies and Forest Offsets

Proponent	Type	Scope	Mid-Term Greenhouse Gas Targets	Forestry Offsets
Warner / Lieberman	Cap and trade	Electricity, industry, transport	Stabilization at 1990 levels by 2020	Up to 5% Int'l allowed
Bingaman	Intensity target w/ trading	Fuel producers, importers, large non-fuel GHGs	2.6% reduction per year 2012 to 2021	Int'l allowed
Feinstein	Cap and trade	Electricity (25 MW+)	2001 levels by 2015	Up to 5% forest Up to 25 % int'l
Waxman	Cap and trade	Economywide	1990 levels by 2020	Yes
Alexander	Cap and Trade	Electricity (25 MW+)		Afforestation and reforestation
Carper	Cap and trade	Electricity (25 MW+)	2001 levels by 2015	Yes
Kerry / Snowe	Cap and trade	Large emitters	1990 levels by 2020	Biosequestration

Source: World Resources Institute.

from any other Clean Development Mechanism projects. It is unclear whether these rules or more specific technical/risk difficulties have limited the overall development of forestry projects in the Clean Development Mechanism.[95] To date, forestry-related projects have accounted for less than 1 percent of all Clean Development Mechanism projects.

The EU ETS rules that benefited the forestry industry are not likely to be changed in the near term, as recent proposals regarding the future of the European Union's Emission Trading Scheme have resisted the inclusion of forest-based credits.[96] The prospects are more promising in North America, where future climate change regulations in the United States and Canada could include provisions for forestry carbon offset projects. Many of the recent proposals in the U.S. Congress to regulate greenhouse gases would allow regulated entities to offset their emissions through various forestry projects (for examples, see table 10).

Many companies not directly regulated under the Kyoto Protocol are trading on voluntary markets, such as the Chicago Climate Exchange (CCX), or are developing their own voluntary carbon offset projects. While significantly smaller than the regulated markets, voluntary markets are growing rapidly, with $91 million in carbon credits traded in 2006.[97]

Voluntary carbon markets have many fewer restrictions, less bureaucratic oversight, and lower transaction costs than do their regulated counterparts. For these reasons, forestry projects have had a much larger presence in voluntary markets than in regulated markets, accounting for 36 percent of all voluntary credits.[98] But the market for carbon credits from forestry projects will remain small if forestry projects are excluded from future national and international greenhouse gas offset programs.

Forestry carbon sequestration projects have received mixed reviews and remain controversial in policy debates. On one hand, forestry projects are relatively easy to describe, have the potential to spur economic development in rural and impoverished regions, and offer ecosystem services values beyond the project's carbon benefits. On the other hand, many have expressed serious doubts about the true carbon, sustainable development, and ecosystem services benefits of the projects actually developed, and they are skeptical of the capacity for "good" forestry projects to be developed consistently.[99]

From the project developers' perspective, experience with forestry carbon offset projects has been mixed. Forestry projects have not been as easy and inexpensive to implement as had originally been suggested. First, the timing of the payments for carbon credits compared with the upfront payments required to set up the forestry project means that many project financers may decide that forestry projects are too risky to fund.[100]

Second, putting together a forestry offset project requires a difficult balance of both silvicultural and carbon accounting expertise, along with significant interactions with local communities and other stakeholders. In the last four years, many project developers who submitted forestry offset proposals to the methodologies panel of the United National Framework Convention on Climate Change (UNFCCC) were rejected, in many cases after spending a great amount of money putting together the documentation to apply to the program.[101]

Third, because the permanence of forest credits cannot be guaranteed (e.g., pests or fires could jeopardize carbon storage), these credits often sell at a discount. At one extreme, the prevailing price for credits was only 25 cents per ton of carbon when the projects could not ensure the long-term storage of carbon. But approaches to deal with issues regarding permanence have been proposed, including (1) using temporary credits in a manner similar to CDM afforestation/reforestation projects, (2) reducing future financial incentives to take account of deforestation emissions above the agreed level, (3) carrying over credits and debits from one period to another, and (4) mandating the banking of a share of the emissions reductions.[102]

In addition, forest-based credits are seen as low-cost CO_2 offsets, which raises concerns about the impact of a flood of such credits on the price of carbon in the carbon markets. Beyond fears of undermining the stability of the carbon markets, some policymakers argue that these low-cost offsets would discourage more expensive investments in energy and other important infrastructure offset projects necessary for a transition to a low-carbon economy.

Advocates of forest-based credits argue that the setbacks are primarily political, not scientific or technical. In particular, the procedures governing land use, land-use change, and forestry projects were decided in only 2003 (at COP 9 in Milan), and the methodology was approved in 2005. The slow bureaucratic process has meant considerable policy uncertainty compared with that of other sectors. Moreover, the exclusion from the EU ETS markets has been a disincentive for investors and has not helped lead to further policy developments.[103]

Forest products companies may have opportunities to provide contracted silvicultural services or to trade in voluntary markets. Forest products companies already have the silvicultural expertise needed to develop forestry carbon offset projects. Given the constraints just discussed, forestry companies face many challenges as the primary developers of afforestation and reforestation carbon offset projects under the Kyoto Protocol. But forest products companies may be able to offer third-party forest management services in regulated markets or to participate in voluntary markets.

Forest products companies must overcome several challenges in order to participate in carbon-offset projects, including:

- *Funding*. How could financing be mobilized?
- *Mind-set.* Foresters understand tree planting in general but may have difficulty appreciating the management of industrial fiber that is not intensive.
- *Will to Replicate*. Projects may require spinning off a separate tree-planting operation.
- *Land Availability*. How can issues regarding the social acceptance of trees on previously open land, as well as competition for other uses, be resolved?
- *Carbon Permanence*. Successful tree planting is difficult, as the forest must be kept stocked and managed for fires and insect infestations.
- *A Suitable Business Model.* How can providing expertise be profitable?

The accounting of carbon stored in forest products will remain controversial in most climate change policy debates.

In a review of corporate responses to a climate change questionnaire,* forest products companies repeatedly cited as a risk of climate change the possibility that the policy would not recognize the potential of their products to contribute to a solution. These statements reflect the current narrow policy focus of many in the industry on the issue of accounting for carbon stored in forest products.

The amount of carbon stored in forest products is small compared with the amount of carbon stored in forests, although it is not insignificant. According to the Second Assessment Report of the Intergovernmental Panel on Climate Change, the current global stock of carbon in forest products is about 4.2 gigatons of carbon (GtC). Other studies have suggested much higher rates, ranging from 10 to 20 GtC.[104] The IPCC calculates that forest products annually sequester 0.026 GtC/yr, and others estimate that this rate is five times larger, at 0.139 GtC/yr.[105] Although the estimates are quite uncertain, even at the high end, the sequestration in forest products is small compared with the rates of the world's forests that store 1.2 GtC/yr.

International accounting guidelines developed for the Kyoto Protocol do not allow countries to claim carbon sequestered in forest products. The UNFCC's and the Kyoto Protocol's reporting requirements for the first commitment period assume that the carbon contained in harvested wood products is at steady state and that additions merely replace the losses from existing carbon stocks. For the first commitment period, and in accordance with the reporting guidelines, it is assumed that carbon in harvested biomass is released when the trees are removed from the ecosystem.[106]

These rules classify harvested forest products as emissions, rather than stored carbon, as soon as they leave the forest site. This classification is based on difficulties in tracking car-

* Response to the Carbon Disclosure Project, see http://www.cdproject.net/.

bon stored in products between countries as well as measuring postconsumer releases of greenhouse gases during landfilling or combustion. This rule has the perverse effect, however, of reducing opportunities for forest products to contribute to a lower carbon-emitting economy.[107]

Technical issues with tracking carbon stored in forest products and the emissions releases at the end of life were seen as intractable several years ago when initial greenhouse gas accounting methodologies were established. But since that time, forest products accounting protocols have been refined[108] and incorporated into the U.S. Department of Energy's Voluntary Greenhouse Gas Emissions Reporting Program.

Larger political and ideological issues persist nonetheless and make it unlikely that forest products carbon credits will become a priority for policymakers. At a global level, the potential reduction of greenhouse gas emissions by avoiding deforestation dwarfs the increasing consumption and substitution of forest products for other materials. In addition to climate change, the societal objectives of promoting sustainable development have been included in the Kyoto Protocol's CDM rules as well as in ongoing international REDD debates. Some people see a program allowing credits for forest products as industry welfare. But other stakeholders argue that sustainable forestry can help overcome some deforestation challenges by encouraging investment in forest economies and using incentives to increase the consumption of forest products.

Another political challenge is the concept of *additionality*, as defined in programs such as the Kyoto Protocol's Climate Development Mechanism. *Additionality* is the criterion used to define a carbon offset by limiting emission reductions to those that occur *in addition* to business-as-usual, therefore precluding forest products from receiving carbon credits. The purpose of additionality is to encourage new carbon reductions that otherwise would not have been realized, making it difficult to justify carbon credits for forest products that are currently produced and consumed regardless of climate incentives. Even with additionality, though, forest products industries could find other ways of increasing carbon storage beyond their usual practices.

The status of forest products is probably not likely to change at the international level. It is more probable that national, regional, and voluntary carbon reduction commitments and trading schemes will consider how the carbon stored in forest products could help in the accounting of greenhouse gases. Furthermore, credits for forest products may be a way to bring in industry and help mitigate some of the concerns about whether cap-and-trade policies might have an adverse economic impact, particularly in the short and intermediate terms. This debate may be helped by several factors, such as the following:

- Industry's increasingly successful efforts to gain endorsement of a simple, workable method of quantifying the long-term carbon benefit from wood products.[109]
- The potential for carbon stored in products to help manage the supply and costs of "carbon credits."
- The growing awareness of the synergistic benefits of enhancing the value of forests and forest products in order to address climate change concerns and halt deforestation in many regions of the world.

BIOENERGY MARKETS

Biomass electricity generation and transport biofuels are creating new and important markets for forest resources. In particular, the demand could rise for sustainably produced forest and manufacturing residues such as branches, bark, and sawdust, as well as dedicated short-rotation woody crops, including willow and poplar, and recovered wood and fiber. As forests are recognized as providing the second-largest and second most efficient resource for bioenergy markets (behind agriculture), up to 20 percent of global forestlands could be devoted to bioenergy markets in the future (for a discussion of market effects on the manufacturing sector, see p. 37).[110] Competition for land use with non-forest bioenergy feedstocks may increase with implications for forest owners (see p. 33). Yet many technical and political obstacles still exist, while environmental concerns are growing, with the potential to dampen or even halt recent momentum for bioenergy development.

Many alternative energy technologies are competing to replace fossil fuels. Concerns about economic security and the rising real price of oil, global climate change, national security, and dependence on Middle Eastern and Russian oil, as well as political support from rural and agricultural constituents, are piquing interest in alternative energy sources. New sources of fuel are already affecting energy market dynamics, and food, fuel, and fiber markets already are beginning to converge, with the prices of all three rising in recent years.[111]

Many of the alternative energy technologies are fueled by biomass, which may include forest feedstocks. On one hand, the forest products industry could provide primary resources for new electricity and transportation technologies. But on the other hand, the competition for forest resources may drive up the costs of wood and fiber and detract from the competitiveness of forest products.

Public policy and oil prices are paramount to the outcome of the race to find alternative fuels and energy sources.

Energy security is already at the forefront of political debate in the world's largest economies, a debate that is likely only to intensify. Instability in major oil-producing regions, combined with diminishing and more costly reserves in other parts of the world, essentially ensure that oil will only become more expensive and difficult to obtain.

The issue of global climate change is one of the most serious challenges of recent times, resulting in growing calls for action and ensuring that public policy responses will increase in the future. Trends affecting climate change also are expected to worsen as the emerging economies with growing populations consume more fossil fuels. The electric power and transportation sectors, which are heavily dependent on fossil fuels and oil imports, are the fastest-growing sources of emissions, contributing 40 percent of global climate change emissions in 2004.[112] Consequently, policymakers are likely to look to domestic renewable energy alternatives to lower greenhouse gas emissions. To meet this objective, however, total lifecycle greenhouse gas emissions must be carefully considered. In the case of biofuels, there is particular concern over greenhouse gas emissions from land use changes, such as deforestation, driven by demand for bioenergy feedstocks.

Public policy may well influence the commercialization of a new energy technology. Policymakers are supporting the development of alternative energy sources in a complex patchwork of local, national, and international mandates, subsidies, and incentives. A study of the future international biomass trade found that a majority of experts believe that a policy promoting biomass will be the greatest factor in determining the future potential of biomass energy development.[113] The other major factor will be the market price of oil and other fuel options.

Over the last decade, governments in Europe and North America have set ambitious targets for bioenergy consumption, which have created demand and encouraged investment in that sector, as shown in table 11. A recent report from the International Institute for Sustainable Development estimated that biofuels in the United States receive \$5.5 billion to \$7.3 billion in subsidies every year and that this support will rise as high as \$11 billion per year by 2012.[114] Most of these subsidies are linked to output, not to market demand. Short term biofuel technology development is heavily dependant on public policy support to reach commercialization over the long term.

The price of oil may influence the development of bioenergy independently of public policy. Assuming that oil prices remain high, many transportation fuels will be competing against biofuels, as well as other electricity technologies choices over biomass. In addition, biofuels will be competing with other mobility options such as increases in energy efficiency and/or new vehicle technologies that could significantly reduce energy consumption and greenhouse gas emissions, possibly postponing or eliminating a transition to alternative

TABLE 11. Renewable Energy and Biofuels Targets by Region

Region	Biomass Power	Biofuels
European Union	• 12 percent renewable energy sources by 2010 (for which 130 Mtoe of biomass must be produced). • 20 percent renewable energy sources by 2020 to be shared appropriately among member states. • 10 percent biofuels in petrol and diesel in each member state by 2020, to be accompanied by a sustainability scheme for biofuels.	• 5.75 percent of transport fuel consumption by 2010 (about 27 billion L of ethanol and 24 billion L of biodiesel). • 10 percent transport fuel consumption by 2020.
United States	• Alternative energy production tax credit of \$0.019/kWh for closed-loop biomass and \$0.01/kWh for open-loop biomass. • 24 states have renewable portfolio standards that include biomass electricity. – Recently North Carolina adopted a RPS including biomass (August 20, 2007). Other southeastern states may follow.	• 7 percent of transport fuel consumption by 2012 (7.5 billion gallons). – Each gallon of cellulosic ethanol counts as 2.5 gallons toward the target. • 36 billion gallons of ethanol production per year by 2022. • California will have a 10 percent ethanol blend rate by 2010. • Minnesota will have a 25 percent renewable fuel target by 2020.
Canada	• Ontario's Standard Offer program offers biomass generators \$0.11/kWh for electricity fed back onto the grid. Generators can earn an additional \$0.0352 during peak demand. Payments last for 20 years and accommodate generators up to 10 MW.	• 5 percent average renewable energy standard for both diesel and gasoline by 2010 • Ontario's fuel to contain 5 percent ethanol by 2007.
China	• 15 percent renewable energy by 2020. – 5 gigawatts of biomass by 2010. – 30 gigawatts of biomass by 2020.	• 2 million tons of bioethanol from nongrain feedstocks by 2010. • 200,000 tons a year of biodiesel by 2010.

Source: World Resources Institute.

energy. For example, future vehicles could be powered by electricity instead of liquid fuels, in which biofuels would not have a significant role (although this could increase the use of biomass electricity).

A bioenergy future is by no means certain.

Energy security, climate change, and political interests are not always aligned. Alternative fuel technologies such as coal-to-liquids or hydrogen manufactured with coal electricity are derived from domestic resources in coal-rich nations. But these fuels do not reduce emissions of greenhouse gases and, in most cases, would increase emissions. Although most of the emerging alternative energy technologies serve energy security objectives, only those fuels derived and powered from sustainable renewable sources that cut total lifecycle greenhouse gas emissions will contribute to climate change mitigation (see figure 7).

Besides energy security and greenhouse gas reduction objectives, political constituencies such as agriculture, mining, and rural populations can greatly influence policy outcomes. Accordingly, a combination of policy objectives and political dynamics will greatly influence which, if any, alternative energy technologies will be used on a commercial scale.

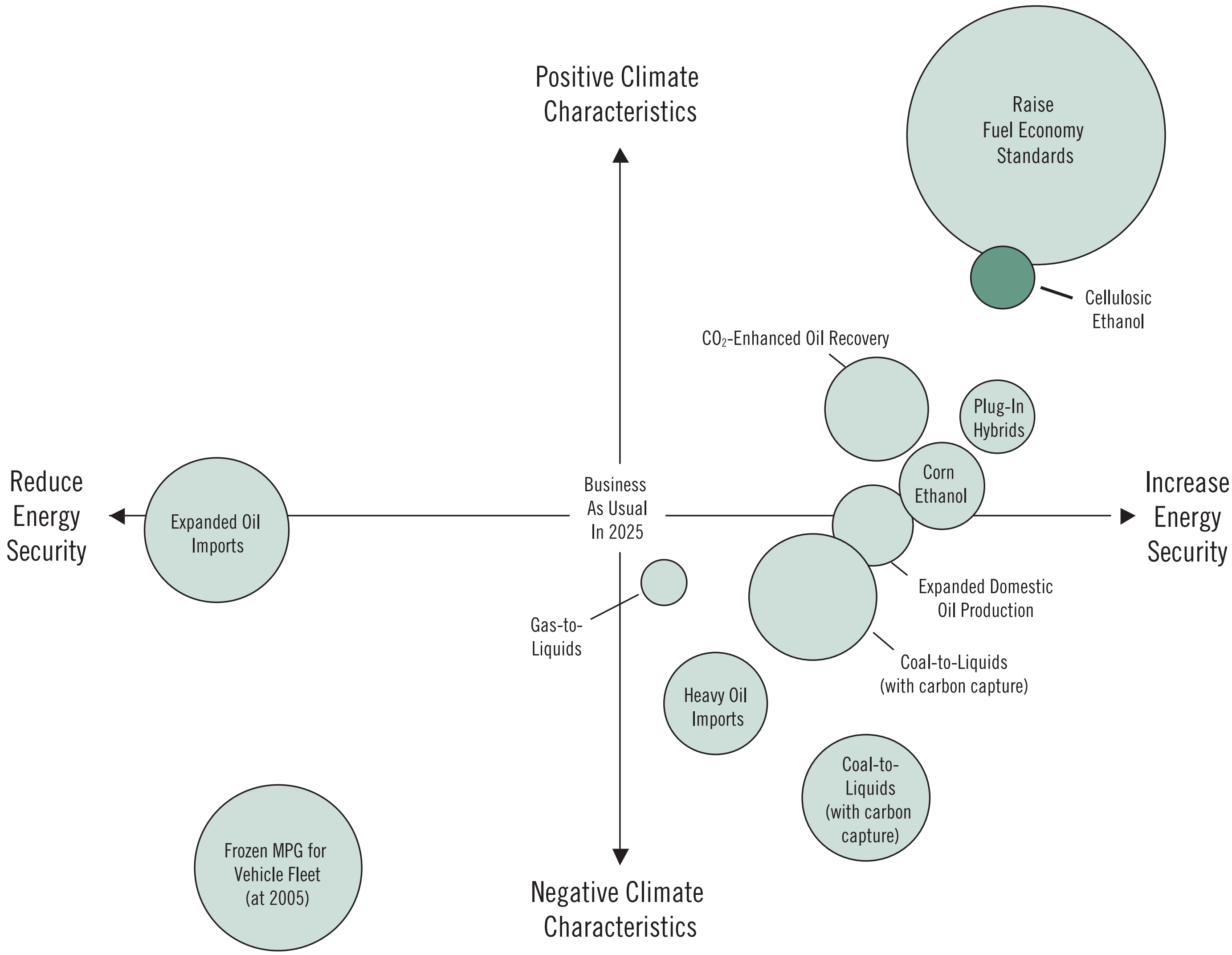
Technologies such as starch ethanol and biodiesel have already been proven and are cost-effective in view of rising oil prices, especially with policy support from the United States and the EU. But the competing coal-to-liquids also is a proven technology and is likely to become cost-effective with increased scale. In addition, coal-rich countries such as the United States, China, and Australia appear likely to place a greater value on energy security than climate change, and therefore such fuels may win over biofuels.

There are major drawbacks to today's biofuels, which are derived from starches including corn, soy, and sugarcane. Ethanol would require its own distribution infrastructure because it is water-soluble and the existing pipelines and filling station equipment for gasoline are not completely watertight. Indeed, logistics were cited as the single largest factor inhibiting bioenergy development by a poll of international bioenergy experts. [115]

In addition, there will not be enough starch crops available to meet both increasing energy and food demands. The Department of Energy's National Renewable Energy Laboratory said corn could only supply about 12 to 18 billion gallons of ethanol a year, or about 10 percent of the 140 billion gallon/year consumed in the U.S. After that, ethanol would start to impact the price of corn, raising the cost of everything from meat to manufactured food products around the globe. There are serious concerns over impacts of increased food prices in impoverished regions that depend on food imports. The rising price of corn in the U.S. due to ethanol production has already increased tortilla prices in Mexico, a diet staple for much of the population.[116]

The sustainability of bioenergy is raising serious and growing environmental concerns. Starch ethanol is very energy intensive to produce. Not only does the production of corn require fossil fuel-based fertilizers and machinery, the process to manufacture ethanol also requires energy inputs that are likely to come from the grid. Furthermore, increasing corn cultivation will have major environmental impacts including soil erosion, water quality issues from fertilizer and pesticides runoff, and management of wastes.

FIGURE 7. ENERGY SECURITY AND CLIMATE CHANGE TRADE-OFFS OF TRANSPORT ENERGY OPTIONS FOR THE UNITED STATES IN 2025



Note: Size indicates the relative scale of oil displacement in 2025. The future potential volume of cellulosic ethanol is believed to be greater than that of corn ethanol, although the bubble is smaller in 2025 due to the expected time required to bring production to scale.
Source: World Resources Institute, 2007.

Furthermore, the growing bioenergy sector will intensify land-use competition and put pressures on native forests. Native forests in tropical regions are at high risk for deforestation when the prices for agricultural bioenergy feedstocks such as palm oil, soy, and sugarcane rise.

If the development of biofuels is poorly regulated, the effects on ecosystems could be devastating. The production of palm oil is rapidly becoming the single largest cause of deforestation in Indonesia, and in Brazil the intensive cultivation of soybeans and sugarcane to make ethanol is having similar impacts on the Amazon and mid-Atlantic rainforests.

Recent research has further questioned the efficacy of biofuels as a climate change mitigation strategy. One analysis in *Science* magazine found that if the equivalent area of land needed for large-scale biofuels production was instead converted to forests, two to nine times more carbon would be sequestered over a thirty-year period than the amount of emissions that would be avoided by using biofuels.[117] Another, published in early 2008, shows that conversion of forests and grasslands to cropland for bioenergy feedstocks doubles greenhouse gas emissions over gasoline in the case of corn, while switchgrass results in a 50 percent increase.[118]

Because bioenergy production is driven primarily by public policy, any evidence of negative environmental consequences may slow or even change the course of bioenergy policy. The European Commission recently ruled that a "sustainability scheme for biofuels" must be developed to meet its renewable energy mandates in 2020. Therefore, if certification or other sustainability programs for biofuels prove to be too cumbersome or are ineffective, as argued by a growing number of scientists, policymakers, and environmental advocates, the support for bioenergy could disappear. This has been evidenced by calls for delays in the United Kingdom's biofuel policy until the results of a sustainability inquiry are released.[119]

There are many unanswered questions about the sustainability of forest-based bioenergy. The availability of marginal and degraded lands to support commercial scale production without driving deforestation of native forests is unknown. Another uncertain issue is the greenhouse gas impacts of trade flows, particularly as production shifts to fast-growing regions in the southern hemisphere for consumption in the north. These issues will need further investigation to better understand the sustainability implications of forest bioenergy development. More information on sustainability impacts will be necessary to persuade governments and environmental advocates to support policies in favor of forest bioenergy.

The billion-dollar question: To what extent will forest biomass fuel alternative energy technologies?

Initial estimates show that the use of cellulosic ethanol will be necessary to meet the United States' biofuel targets. The U.S. Congress is debating a target of 35 billion gallons of ethanol production per year by 2017 and 60 billion by 2030. At current production levels of about 6 billion gallons, roughly 20 percent of corn crop is already being used for biofuels. Many believe the maximum output of corn-based ethanol in the United States is around 15 billion gallons.[120] Beyond that amount, it is generally agreed that the growth of biofuels will depend on new cellulosic feedstocks to increase the consumption of biofuels.

A 2005 study by the U.S. Departments of Energy and Agriculture, nicknamed the "Billion-Ton Study," concludes that with the right policies, the United States could generate more than 1.3 billion tons of biomass a year by midcentury, when large-scale bioenergy plants are likely to be in operation.[121] These feedstocks would be enough to produce 100 billion gallons of ethanol a year, which is more than seven times today's ethanol output.

About one-fourth of the feedstocks would come from forestry products, including fast-growing trees, logging and forest residues, and pulping waste. The rest would come from agricultural products, primarily crop residues and perennial crops (notably switchgrass). While not all the one billion tons identified in the study could be collected, it is not unreasonable to expect ethanol to replace 40 billion gallons of gasoline in the near future.[122]

Cellulosic ethanol technology is being developed outside the United States as well. In China, cellulosic ethanol is being promoted over starch ethanol. In December 2006, the Chinese government announced that it no longer would approve the construction of starch-based ethanol plants and is encouraging cellulosic ethanol production with a ten-year, $5-billion capital investment. Europe, with relatively few established ethanol refineries, may jump straight to cellulosic ethanol, leapfrogging past starch-based ethanol as a first-generation biofuel.

Cellulosic feedstocks may be regional. Because cellulosic ethanol can be produced from any biomass, crops and crop residues that are well suited for a particular region and wastes from existing industries are good candidates for feedstocks. A number of projects around the world are developing enzymes for local feedstocks, such as wheat straw in the UK, woodchips in Scandinavia, and cornstalks in the U.S. corn belt.

In the United States, native prairie grass, or switchgrass, is a promising dedicated crop for cellulosic ethanol, as it requires no plowing, fertilizer, or pesticides and can be grown on marginal and degraded agricultural lands. Furthermore, switchgrass could restore some ecosystem benefits to agricultural lands, including erosion control, habitat, and soil quality. Given the low-energy and agricultural inputs and the large quantity of suitable land, many see switchgrass as an ideal dedicated crop for large-scale ethanol production in the United States.

Besides switchgrass, wood enjoys advantages relative to those of most other cellulosic biomass. As described in the "Billion Ton Study," large-scale ethanol production will require a combination of many feedstocks. Wood is a suitable feedstock due to its high sugar content, high bulk density (thus lower transport costs), long storage life and low storage costs, less-intensive use of water and fertilizers, as well as established collection systems. Of the dedicated crops, switchgrass and poplar have the highest ethanol yields per hectare,[123] and wood feedstock production has the lowest net greenhouse gas emissions of any bioenergy crop.[124]

Sustainably produced dedicated short-rotation woody crops like poplar and willow may provide a significant source of bioenergy feedstocks over the medium to long term. More readily available are forest residues that are considered by many to be a viable raw material for biofuel production. Forest products manufacturer Potlatch claims that 30 to 50 percent of the tree is left in the woods after logging, much of which can be harvested for bioenergy markets.[125] In addition to available volumes, the economic viability of harvesting forest residues will be contingent on stumpage, extraction, transport, and processing costs. Environmental costs need to be included in harvesting decisions as well, although how much and what type of forest residues can be cost-effectively and sustainably harvested is largely unknown.

Bioenergy markets for forest residuals may provide fire management and prevention benefits for native forests. Currently, landowners often must pay to have their forests thinned, so the demand for woody debris could create new income for landowners while preventing these materials from going into landfill.[126] Bioenergy could also provide markets for the damaged and dead wood left over from insect infestations. In British Columbia, Canada, infestations of the mountain pine beetle have already killed large areas of trees, creating an accumulating surplus of deadwood that increases the risk of fire. According to one report, if only 25 percent of the wood killed by mountain pine beetles were converted to ethanol, it could supply between five and ten years' worth of British Columbia's gasoline requirements.[127]

The technology to manufacture cellulosic ethanol is not yet commercially viable. Even though cellulosic feedstocks are much more abundant and cheaper than starches, the processing technologies continue to be more expensive. According to the U.S. Department of Energy, the cost dropped from $5.66/gallon in 2001 to $2.26/gallon in 2005, but the 2005 costs still are one-third to one-half more expensive than starch ethanol.[128]

The main disadvantage of cellulosic biomass is that the enzymatic breakdown of the hemicellulose and cellulose into fermentable sugars is not very efficient. The cost-effectiveness of production thus is dependent on technology that is not yet commercially viable, whereas starch-based ethanol already is a proven, available, and cost-effective technology. While the industry claims that cost-effective production will come within the next five years, World Resource Institute experts believe that the development of a large-scale industry is at least ten to fifteen years away.

Large economies of scale will be needed to bring down costs. Fueling large-scale production will create enormous challenges regarding materials handling and land use. For example, a world-scale 100-million-gallon plant would consume roughly 2.4 million green tons/year of wood (or 1.2 million dry tons/year).[129] For comparison, a large-scale wood products mill consumes approximately half this amount.

Georgia will be the likely site of the first larger-scale wood cellulosic ethanol plant. Forest residues from the state's millions of acres of indigenous Georgia pine will be the main source of biomass for the world's largest cellulosic ethanol plant, owned by Range Fuels. Range Fuels asserts that by using wastes and unmarketable timber, its feedstocks will not compete with traditional wood and fiber markets, although low-value timber markets are likely to be affected if cellulosic production expands beyond the initial projects.

Other projects using wood chips to manufacture cellulosic ethanol are planned for New York and Canada. In upstate New York, an industry/government/academic demonstration project will use forests residues and plantation willows to produce electricity, cellulosic ethanol, and other bioenergy products.

Biomass electricity is another potential consumer of forest resources.

Biomass power has greatest momentum in Europe. Europe is the world's principal user of wood biomass as it strives to meet its renewable fuels mandates. As a result of Europe's demand, wood pellet production has increased in North America, Russia, and Africa. The consumption of wood pellets in Europe has increased tenfold since 2000, to about 5 million tons per year, and is expected to rise to almost 13 million tons per year by 2010.[130]

In the United States, biomass power has not received the same support as have other renewable energy technologies, but if this policy changes, biomass could take off. For example, the Alternative Energy Production Tax Credit for open-loop biomass* is $0.009 kWh less

* Open-loop biomass is solid, nonhazardous, cellulosic waste material; lignin material; or agricultural livestock waste nutrients as defined in IRC Section 45(c)(3).

than for other renewable energy technologies, including closed-loop biomass.* The discrepancy in support between open and closed-loop biomass subsidies is primarily driven in part by environmental concerns, especially air quality. In addition, several states with renewable portfolio standards have placed restrictions on biomass power technologies or do not include them as qualifying energy sources due to the same environmental considerations. But regions such as the Southeast, which are rich in forest biomass resources, may adopt renewable portfolio standards that are favorable to the industry and technological advances may assuage environmental concerns.

New sources of raw materials will be needed to meet the increasing demand. The current wood pellet feedstocks consist primarily of sawmill residues, because sawdust and shavings are the cheapest and most suitable raw material. In most parts of North America, the price of sawdust and shavings doubled between 2005 and early 2007 owing to the demand for bioenergy. Therefore, to expand production in North America, the pellet industry needs to use fiber sources other than sawdust and shavings. Because wood pellet feedstocks are cheap, if fiber costs rise, other costs will need to be lowered through economies of scale. In the U.S. South, two wood pellet plants are being constructed that will produce twenty-five times more pellets than the current plant capacity.[131]

Other biomass electricity generation technologies are being developed that could improve the efficiency and scale of biomass power. *Co-firing* refers to combusting biomass with coal to produce electricity. It is a near-term, low-cost option that has been demonstrated, tested, and proved in all boiler types commonly used by electric utilities. There is little or no loss in total boiler efficiency after adjusting the combustion output for the new mixtures, and the environmental benefits of co-firing include lower emissions of carbon dioxide, sulfur dioxide, and oxides of nitrogen.

Wood gasification is a more sophisticated technology option currently being developed. To date, one of the biggest problems with gasifying biomass is producing a consistent gas. Nonetheless, the world's first commercial wood gasification plant is starting up in Germany, controlled by Shell and a strategic partnership between Daimler Chrysler and VW. Technology advancements in wood gasification will have synergies with biomass-to-liquids fuels.

The demand for forest resources for bioenergy could have a dramatic effect on the market.

The development of the bioenergy sector is expected both to increase the world demand and decrease the world's supply of wood fiber, especially in the tropical regions. CIBC World Markets predicts that the global cost curve for wood fiber will move upward but that the increase will tend to be greater at the lower end of the curve where the Southern Hemisphere producers reside. Although the Southern Hemisphere is expected to maintain its absolute advantage in growing wood fiber, at the margin the comparative advantage may start to shift back to the traditional producers in the north.[132]

An international biomass commodity market should be considered to increase the global use of bioenergy, because in many areas, the supply of and demand for biomass are not aligned to enable trade. To fulfill the increasing demand, biomass must be transported over larger

* Closed-loop biomass is generally defined as any organic material from a plant that is produced exclusively for use at a qualified facility to produce electricity.

distances and imported across continents. Trading currently represents about 5 percent of the total use of biofuels in industrialized countries.[133] Greenhouse gases will increase with longer transport distances, a factor than may influence the environmental appeal of biomass technologies. Regulations or certifications of bioenergy production, particularly for sustainability criteria, may also influence trade flows to regions such as Europe.

Some in the forest industry view the emerging bioenergy sector as a threat, which may be real where there is direct competition for low-quality fiber. The industry's policy position is that wood and recovered paper should be used primarily as raw material, not as feedstocks. Its concern is that promoting wood only as a source of renewable energy will discriminate against its current uses as raw material, thereby raising the price and lowering the competitiveness of forest products in the market. Bioenergy already is a big issue for some segments hit by the increasing demand for wood pellets, especially the European pulp and paper and nonstructural panel industries.[134]

The industry's view is that the pulp and paper industry generates more employment and value than do the bioenergy industries.[135] Accordingly, they believe that the most efficient use of forest resources for bioenergy is after they have been recycled several times and no longer can be used in products.

The sustainable forestry value chain will benefit from new markets and the increased demand for forest resources. The sustainable forest sector already has an infrastructure and has demonstrated expertise in growing, harvesting, and delivering wood in a sustainable manner. Over time, this expertise can be applied to minimizing the cost of the supply chain for the emerging bioenergy sector, possibly lowering the average cost of fiber for all industrial users, while meeting environmental policy objectives.[136] Furthermore, the higher demand for forestry resources will likely increase landowners' investment in forest productivity, possibly increasing carbon capture as well as decreasing the risk of forest conversion to other uses with higher land rents.

Sustainable forestry companies also could grow dedicated cellulosic energy crops, such as hybrid-poplar, willow, and other fast-growing plants. This is most likely in tropical countries, where the crop yields are higher and the land and labor costs are lower. According to Steven Rogel, chairman, president, and CEO of Weyerhaeuser, "Crops created for and dedicated to fuel feedstocks offer the opportunity to augment value creation from our managed forestlands."

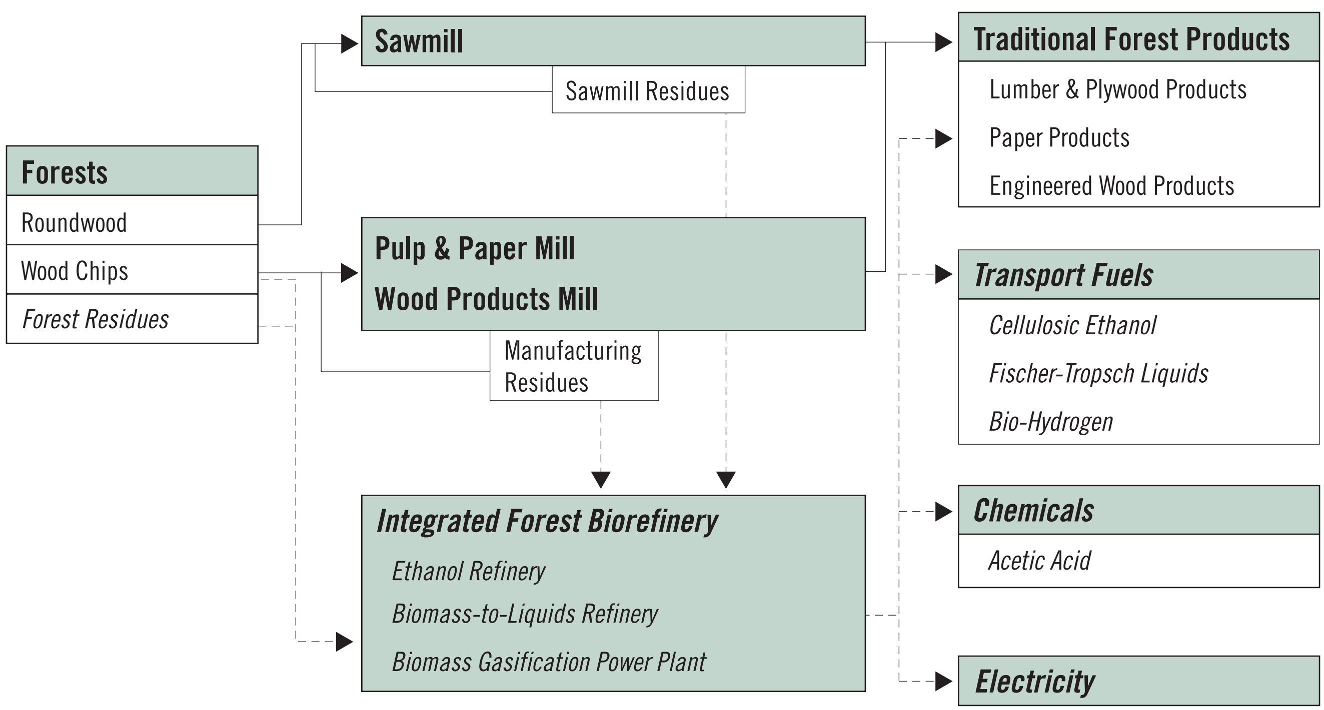
In the United States, the opportunity to converting land to dedicated energy crops is limited because the most productive arable land has already been converted to agricultural use and the marginal agricultural areas have reverted to grasslands or forests. Therefore it is more likely that the growing of energy feedstocks will be compatible with a wide range of other, more valuable, forestry products.

Chemical pulp and paper mills could evolve into "biorefineries" that produce biomass-derived products, including traditional wood and paper products, wholesale electricity, fuels, and chemicals.

In addition to emerging bioenergy markets for forest resources, some manufacturing facilities may be well positioned to become integrated forest biorefineries, producing traditional forest products along with bioenergy fuels, electricity, and chemicals. Today's pulp and paper mills already operate as rudimentary biorefineries in that they collect and process biomass while at the same time generating a significant portion of their energy needs from biomass residuals and manufacturing by-products. The advanced forest biorefinery concept entails the development of technologies to support two novel processes at existing pulp mills: (1) the extraction of cellulose and hemicellulose to produce ethanol and (2) biomass gasification to produce biomass-to-liquids fuels and electrical power. These technologies will enable mills to better utilize the biomass resources already collected to produce a range of fuels and chemicals in addition to conventional products (see figure 8).

Integrated biofuels production could revitalize the pulp- and paper-manufacturing industry, particularly in North America and Nordic Europe, where increased competition from lower-cost producers has forced mill closures. The benefits of integrating pulp and paper and bioenergy production can be found in both the wood value chain and production processes. Pulp and paper companies can or already have set up an integrated harvesting chain for both pulpwood and forest residues for energy generation. In addition, paper mills are already equipped with many of the necessary components for biofuels production, including wastewater treatment facilities, boilers, heat, and power, and they have the necessary permits to operate them.

FIGURE 8. TRADITIONAL FOREST PRODUCTS MANUFACTURING VERSUS AN INTEGRATED FOREST PRODUCTS BIOREFINERY



Source: World Resources Institute.

The chemical pulping industries have natural synergies with cellulosic ethanol production. As cellulosic ethanol technology advances, some paper mills might choose to convert their existing facilities to produce ethanol from pulp. Installed at paper mills in the United States, biorefineries could produce 2.4 billion gallons of ethanol a year.[137]

Promising new technologies such as biomass gasification, along with innovations of existing processes such as Fischer-Tropsch synthesis, are being, and will be, developed further. Biomass-to-liquids concepts are attracting the most interest from industry, owing to the valuable secondary products (chemicals and electricity) as well as a choice of biofuels production (Fischer-Tropsch biodiesel, biohydrogen, and biomethanol). Studies have shown that the integration of a biomass-to-liquid plant with a pulp and paper mill would be economically attractive under many circumstances.[138] Nearer-term opportunities include biodiesel manufactured from tall oil, a by-product of softwood pulp mills.

Besides energy self-sufficiency, mills could generate new revenues by selling electricity to the grid. For instance, a biorefinery's power plant could displace the need for today's aging Tomlinson boilers and other biomass- or fossil fuel–based boilers that are used for energy production and chemical recovery. Wood gasification would produce syngas, which could be burned in gas turbines to produce steam for manufacturing and power for the grid.

Complex technical hurdles still exist. Cellulosic ethanol production, wood gasification, and biomass-to-liquids are promising technologies that are in various stages of research and development. Researchers are racing to develop effective and efficient enzymes to allow the commercialization of cellulosic ethanol, while wood biomass power and biomass-to-liquids technologies face obstacles in the way of gasifying wood. These technologies are currently in R&D and early demonstration stages.

The Agenda 2020 Alliance, a project of the American Forest & Paper Association, is an industry-led partnership with government and academia that collaborates on precompetitive research, development, and deployment of new technology-driven business models. In particular, this partnership is pursuing a research agenda to advance wood gasification and biomass-to-liquids technologies. Vision 2030 of the Forest-Based Sector Technology Platform is a similar partnership of major stakeholders in Europe. In addition, strategic research and development alliances on biofuels development are being formed across industries (for examples, see table 12).

The forest biorefinery is a highly "disruptive" technology, requiring a large capital investment to install and a new business model to operate. Policy or funding assistance from government sources thus will be required to bring the concept to commercial use.

Mills will need to optimize profits over new variables. Each mill must calculate which process variations, if any, would be most financially attractive. Analyzing the feasibility of an integrated forest biorefinery requires a complex case-specific evaluation and optimization study. Those variables to be optimized are the carbon consumed to produce pulp and paper, the production of bioenergy, chemicals, and wood products.

TABLE 12. Strategic Cross-Sector Biofuel Alliances

Date	Partners	Fuel	Primary Feedstock
May 2007	UPM and Andritz (Carbona)	Biomass-to-liquids	Wood
April 2007	ConocoPhillips and Tyson Foods	Biodiesel	Animal fats
April 2007	Weyerhaeuser and Chevron	Cellulosic ethanol	Wood and other cellulose
March 2007	Stora Enso and Neste Oil	Biomass-to-liquids	Wood residues
June 2006	British Petroleum and Dupont Chemicals	Biobutonal	Starch transitioning to cellulose
May 2006	Norske Skog and Norske Hydro	Biodiesel	Wood
2001 & 2002	Petro Canada, Royal Dutch Shell, and Iogen	Cellulosic ethanol	Agricultural residues

Sources: CIBC World Markets, Pöyry, and World Resources Institute.

In addition, many issues must be analyzed in order to test the business potential, including synergies arising from feedstock harvesting, the utilization of heat and power, and the existing infrastructure at mill sites. These benefits may be compromised by the negative impacts of bioenergy markets on wood costs and energy/fiber balances.

Preliminary calculations made by Pöyry, an industry consultant, indicate that wood-paying capability of paper production is still significantly higher than that of biofuel production.[139] But some assessments of economic performance indicate that the profit from the joint production of biomass-to-liquids could be similar to that from paper production.[140] The Agenda 2020 Alliance in the United States calculated potential new product revenue streams from a forest biorefinery, as shown in table 13.

Whether biomass resources will be sufficient to support extensive forest biorefining plans in addition to the projected growth in pulp and paper production is unknown. Furthermore, according to Pöyry, generating biomass power at manufacturing facilities is a more efficient method of reducing greenhouse gas emissions in the sector than manufacturing biofuels.[141]

TABLE 13. Potential New Products and Revenue Streams from a Forest Biorefinery Mill

New Products	Net Revenues ($US millions per year)
Hemicellulose extraction and conversion:	
19 million gallons ethanol	$53
6 million gallons acetic acid	
Additional pulp production capacity	$0.57
Biomass and black liquor gasification:	
additional electricity generation capacity (for use at the mill and export)	$32
or	
1.1 million barrels renewable Fischer-Tropsch liquid fuel	$63
Note: The model refinery is a kraft pulp mill with an input of 2,089 tons/day hardwood, 1,122 tons/day softwood, and 318 tons/day bark producing 1,580 tpd unbleached pulp.	

Source: AF&PA Agenda 2020 Technology Alliance, *Advancing the Forest Biorefinery: Technical Appendix to the Forest Products Industry Technology Roadmap*, 2005.

PRODUCT COMPETITIVENESS

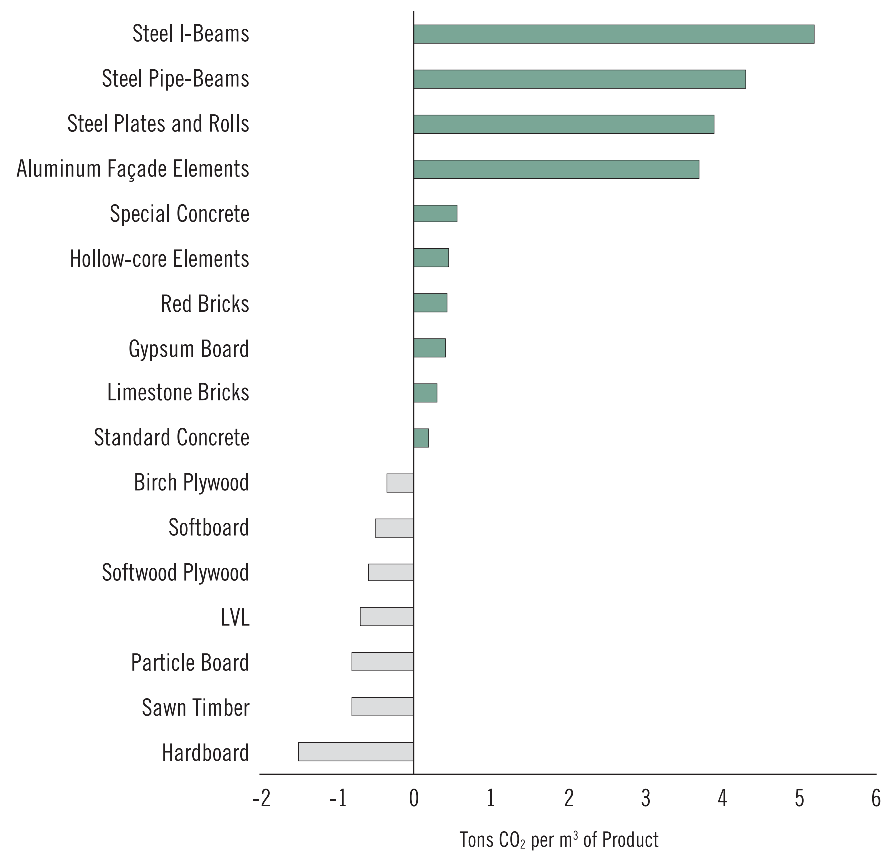
Many climate change policy approaches could provide incentives that directly or indirectly benefit the industry's low-carbon emitting products. A price for carbon emissions or "carbon-neutral" building mandates is likely to create incentives to substitute sustainably produced forest products for other materials, especially in the construction sector.

Climate change policies regarding low-carbon emission incentives and mandates may improve the competitiveness of forest products.

Paper and wood have the lowest energy consumption and the lowest carbon dioxide emissions of any commonly used packaging or building materials. In particular, wood building products have carbon advantages over substitutes such as steel, concrete, and bricks. Each cubic meter of wood used stores 0.75 to 1 ton of CO_2 emissions. Using wood as a substitute for other materials saves, on average, an additional 1.1 tons of CO_2 emissions that would have been produced, resulting in a total savings of approximately 2 tons CO_2 (see figure 9).[142]

A case study comparing homes framed in wood, steel, and concrete in Minneapolis and Atlanta found that wood-framed homes reduced greenhouse gas emissions by 26 percent

FIGURE 9. NET CO_2 EMISSIONS (IN TONS/M^3) OF BUILDING PRODUCTS



Source: RTS data (1998-2001).

versus steel and 31 percent versus concrete. These results were obtained from increasing the amount of wood from 7.8 percent to 10.1 percent of the mass of the Atlanta house and from 7.4 percent to 15.1 percent of the mass of the Minnesota house.[143]

Although wood building materials offer the greatest potential to reduce carbon emissions versus their substitutes, even the use of paper and board packaging can have a beneficial impact.[144] The most common substitutes for cardboard and paper packing is glass, polyvinyl chloride (PVC), polyethylene terephthalate (PET), steel, and aluminum. Figure 10 shows the CO_2 emissions benefits of using card instead of these materials.

The National Council for Air and Stream Improvement (NCASI) looked at the national U.S. effects of substituting wood-based products for other materials and found that the greenhouse gas benefits of using wood-based building systems amounted to 9.6 million tons of CO_2 equivalents per year. The corresponding energy benefit was approximately 132 million gigajoules per year. These figures represent approximately 22 percent of the energy and 27 percent of the greenhouse gas emissions associated with the preoccupancy stages of residential structures in the United States, although these estimates are very sensitive to assumptions about the rate of carbon accumulation in forest ecosystems.[145]

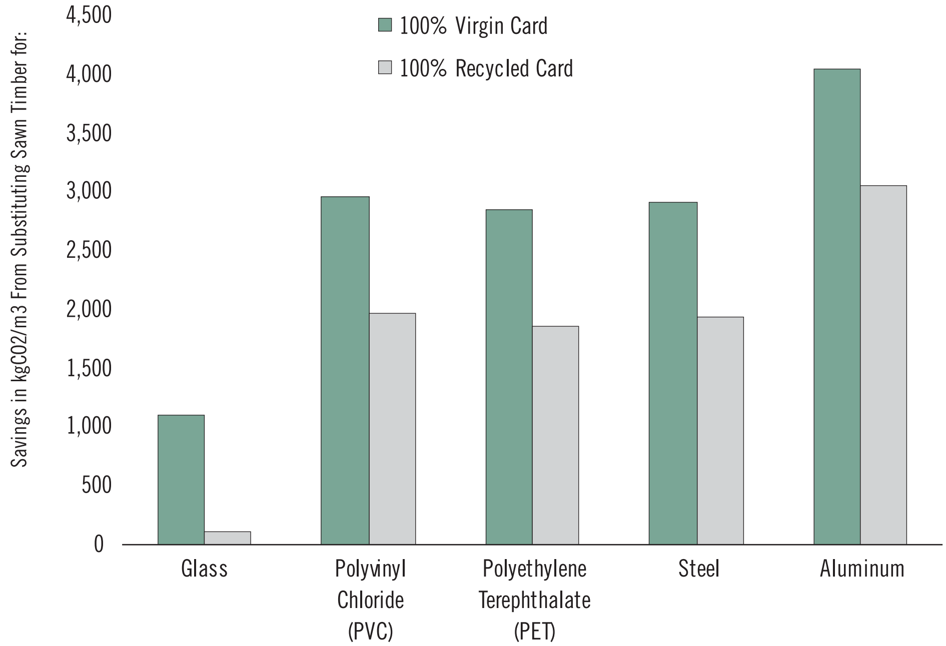
A price for carbon emissions might create cost advantages for forest products versus alternatives. In theory, because the manufacture of forest products can be powered by biomass, any price for carbon emissions should affect fossil energy–intensive industries such as steel, cement, and aluminum much more directly than their forest product substitutes.

Earlier this year, Canada's National Roundtable on the Environment and the Economy estimated that for Canada to reach its 2050 greenhouse gas emissions target, carbon prices would have to rise from $15 a ton in 2015 to $200 by 2030.[146] These targets are similar to those proposed in the Warner-Lieberman bill before the U.S. Senate, with both the Canadian and the prospective U.S. targets being arguably less ambitious than Europe's. With the wood products industry having an energy intensity 1/3000th that of the cement and steel sectors, a moderate or high price for carbon could have a significant impact on forest product substitution, especially with respect to building materials, in the important markets of North America and Europe.

At a lower carbon price, such energy cost advantages costs might be diluted by the forest products industry's generally higher raw materials costs, compared with those of other industries. In addition, considerations such as fire safety, durability, or hygiene might create barriers to forest product substitution. To what extent increases in carbon prices would encourage the substitution of forest products for other materials is an area needing more detailed economic modeling and analysis.

"Carbon-neutral" mandates create a preference for forest products over other materials. Climate change is placing pressure on governments to encourage and/or mandate green building standards for residential and commercial construction, a large source of greenhouse gas emissions. In North America, the building sector accounts for 37 percent of CO2 emissions. As pointed out earlier, on a life-cycle basis, wood-framed homes have 26

FIGURE 10. CO_2 SAVINGS FROM CARD SUBSTITUTION



Source: IIED, 2004. Based on Ministry for Environment (2001) data.

percent less greenhouse gas emissions than steel-framed homes do, and 31 percent less than concrete-constructed homes do. These figures may led to a greater demand for structure wood and panels as communities in the United States and elsewhere adopt policies to fulfill their publicized commitments to reduce greenhouse gas emissions.[147]

In 2001, France signed a charter promoting the use of wood in the construction sector, particularly targeting public buildings, road works, and social housing. The country's goal is to increase wood use by 2010 to 25 percent from a base of 10 percent. Prime Minister Gordon Brown of Great Britain announced in July 2007 that all new residential home construction would be carbon neutral by 2016, implemented by a series of ambitious targets in the nearer term to reach that goal. Home construction accounts for 25 percent of CO_2 emissions in the UK.[148] At a U.S. conference of mayors, local governments across the United States focused on buildings, setting a target of 2030 as the year that all new city structures would have no net greenhouse gas emissions.

Those mandates requiring the use of wood over other materials will have the most dramatic impact in regions that currently do not use wood as a large percentage of their construction material. Although nearly all homes are constructed with timber frames in North America, the situation is quite different in parts of Europe. In central Europe, for example, cement dominates the building market, with a share of 70 to 80 percent.[149]

GREEN BUILDINGS

Consumer preferences for "green" products, particularly in the construction sector, are growing.

The methodology governing green building standards and ratings will greatly influence the impact of green building markets on the forest products industry.

The green building market is the fastest-growing segment of the United States' residential construction industry. Historically, the green building market has occupied only a tiny niche in the construction industry. But now, rising energy prices and resurgent public concern about environmental sustainability have made buildings that use green materials and advanced energy technologies into a very fast-growing area. Indeed, the National Association of Homebuilders estimates that green buildings will rise from 2 percent of housing starts in 2005 to between 5 percent and 10 percent in 2010. An example is the new Bank of America headquarters in New York, which is one of a number of new office buildings that will meet the stringent standards set by the U.S. Green Building Council, known as Leadership in Energy and Environmental Design (LEED).

The most important green building standards do not currently favor less carbon intensive materials. As of 2006, the "Green Globes" building standard fully incorporated life-cycle greenhouse gas emissions into its assessments of building materials. The National Association of Home Builders' "Green Home Building Guidelines" also use a greenhouse gas life-cycle tool to determine environmentally-preferable building products. But the current version of LEED from the U.S. Green Building Council, which is the de facto industry standard, does not account for the carbon intensity of materials in its ratings. If LEED does decide to integrate life-cycle greenhouse gas assessments into future rating systems, it will surely have an impact on the growth of wood products in the green building market.

CONSUMER AND GOVERNMENT RELATIONS

The climate change benefits of forest products are not widely understood, creating an opportunity for the industry to improve its consumer and government relations.

The communication of climate change benefits may create opportunities to change consumers' preferences for forest products.

Environmental benefits are often attributed to forest product substitutes (such as the "plastic saves trees" mentality). Many people believe that the use of wood is detrimental to forests and biodiversity, partly because of campaigns to raise awareness about tropical deforestation as well as claims by other industries.[150] Although many of the major international forest products companies are not operating in native forests with high conservation value (such as the Amazon), the public often attributes deforestation and biodiversity loss to the industry as a whole. Sustainable certification schemes have increased public awareness of "bad" versus "good" products to some degree, but much more could be done. In addition, the lack of leadership on public policy issues and the minimal promotion of certification programs have resulted in the continuation of these environmental biases against forest products.

Several campaigns have been organized to educate consumers on the environmental profile of wood. In North America, the Wood Promotion Network has launched a consumer education campaign to promote the environmental and climate change benefits of wood over its substitutes. The "Be Constructive" campaign targets construction professionals as well as consumers.

The "wood for good" is a generic wood promotion campaign in the UK that was begun in 2000. Within "wood for good," the "Changing Attitudes Campaign" focused on changing beliefs about the environmental profile of wood through newspaper and magazine advertising. The industry consultant Pöyry conducted an analysis of the campaign and found that its audiences received the campaign positively and that members of the UK's industry reported increases in sales that they believe were a result of the campaign. The "wood for good" effort cost approximately $2 million in 2004.[151]

Unless education campaigns also address concerns about protecting forests through sustainable forestry, many consumers and policymakers will remain skeptical of "greenwashing": misleading environmental claims by companies about the positive environmental aspects of their products or operations. While the link between sustainable forestry and climate change may be intuitive to those familiar with the industry, these complex concepts may be difficult to convey to consumers who may already have been exposed to negative campaigning against the industry.

CONCLUSIONS

Climate change and policies to address it offer both wide-ranging challenges and opportunities for the forest products industry. While the impacts are likely to be felt in existing value chains, new products and markets could fundamentally transform the industry's business models. The role of forests in the global carbon cycle creates a unique position for the industry to provide a range of products, from sequestered carbon to alternative energy to lower-carbon construction materials that can contribute to climate change solutions while ensuring the health of the industry. Nonetheless, the industry also faces many risks that complicate the overall picture, so the outcomes differ from company to company.

Any serious attempt to mitigate climate change must shift away from energy produced by fossil fuels. The transition to a low-carbon economy will not be smooth, with regulations evolving along with the science and technology to create a complex and uncertain operating environment for years to come. As with the information technology revolution and advent of the digital age, new winners will emerge, and outdated industries will vanish. In many respects, the forest products industry is approaching a crossroads: How will companies and the sector as a whole respond to the new risks and opportunities they face?

The severity of the risks of climate change and the enormity of the challenge to address them ensure that the issue will receive greater interest and scrutiny in the future from CEOs, shareholders, and policymakers alike. Investors and managers will need to devise strategies to assess exposure, hedge their risk, and create value that progress with developments in policy, science, and technology. The industry also will need to take a more active role in shaping the rules and regulations governing its carbon-constrained future.

This report has presented a broad overview of the major risks and opportunities that may emerge for the sector, as summarized on the inside back cover.

NOTES

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Summary of Major Climate Change Risks and Opportunities

FORESTS

Physical Impacts on Forests

Forest resources, both native and managed, are heavily dependent on climate conditions for productivity. Evidence is mounting that forests will be profoundly affected by climate change, with overall increases in productivity and great regional variability resulting in part from increased disturbances caused by fires, pests, and diseases. In addition, the ability of nature to provide ecosystem services (e.g., pollination, water purification, and flood management) is severely degraded in many parts of the world, with implications for forests' health. Changes in forest productivity due to climate change and degraded ecosystem services will therefore require new strategies for management and adaptation. In particular, climate change could create water supply concerns in regions where tree plantations are most productive.

Access to Forestlands

International climate policy is likely to create incentives for developing countries to reduce deforestation and protect native forests. If such mechanisms are effective, the demand for sustainably harvested forest resources may increase to fulfill the growing need for wood and fiber in these regions. If properly designed, these deforestation programs may allow the industry to compete in regions where illegal logging has made sustainable practices uneconomic. Conversely, companies operating in regulated forests could be hurt by new rules.

Land Use Competition

Bioenergy production may lead to land-use competition in some areas of the world. The most productive regions for plantation forestry, namely, the tropics and subtropics, also are often well suited to producing bioenergy feedstock. The expansion of sugarcane, palm oil, and switchgrass agriculture may lead to deforestation and reduce available forestlands, presenting a serious issue for climate change mitigation that will likely be addressed through public policy.

MILLS

Energy Price Risk

While the forest products industry may or may not face regulations targeting its direct greenhouse gas emissions, carbon constraints could significantly raise the price of fuel and purchased electricity. Energy costs comprise a large proportion of paper and wood products manufacturers' overall production costs. As a result, reductions in mills' use of energy and greenhouse gas emissions benefit both the environment and their profit line.

Leading forest products manufacturers are already making commitments to reduce their greenhouse gas emissions by improving the energy efficiency of their mills and replacing fossil fuels with biomass power. These commitments are strategic investments by forest products manufacturers to reduce their consumption of fossil fuels, as future climate change policies are likely to indirectly or directly place a price on carbon.

Raw Materials Price Risk

A large-scale bioenergy industry may pose challenges to forest products manufacturers by increasing raw materials costs and thereby possibly reducing competitiveness with substitute materials. The bioenergy demand for forest and manufacturing residues may also threaten energy supplies for manufacturers dependent on biomass power for production. Companies with dedicated forest resources are best positioned to respond to increases in raw materials prices.

Green Procurement

Green procurement policies from downstream customers may create additional incentives to reduce the greenhouse gas emissions from manufacturing forest products.

Major investment banks and the International Finance Corporation have adopted lending guidelines which include energy efficiency and carbon emissions criteria. As a result, renewable and energy-efficient operations should contribute to a project's ability to receive high-quality funding.

MARKETS AND PRODUCTS

Carbon Markets

International, national, and regional climate change policies may create opportunities for companies to participate in carbon markets. Although the current policies allowing credits for forest carbon management and CO_2 sequestration projects are limited, forest product companies may yet be able to participate in current voluntary programs or future regulatory systems. Overall, the impact of carbon markets on the forest products sector is likely to remain limited in the foreseeable future.

Bioenergy Markets

Developments in cellulosic ethanol, biomass-to-liquids fuels, and wood biomass electricity technologies should create new markets for forest resources. If and how bioenergy markets affect forest companies will depend greatly on which alternative fuels reach the marketplace, as well as the vertical integration of a firm.

Some facilities may be well positioned to become integrated forest biorefineries, producing traditional forest products along with bioenergy fuels, electricity, and chemicals.

Product Competitiveness

Many climate change policy approaches could provide incentives that directly or indirectly benefit the industry's low-carbon emitting products. A price for carbon emissions or "carbon-neutral" building mandates is likely to create incentives to substitute forest products for other materials, especially in the construction sector.

Green Buildings

Consumer preferences for green products, particularly in the construction sector, are growing. However, the methodologies of major green building standards will greatly influence to what degree sustainable wood products will be preferred over competing materials based on lifecycle carbon emissions.

Consumer and Government Relations

The climate change benefits of sustainable forest products are not widely understood, creating an opportunity for the industry to improve its consumer and government relations.

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