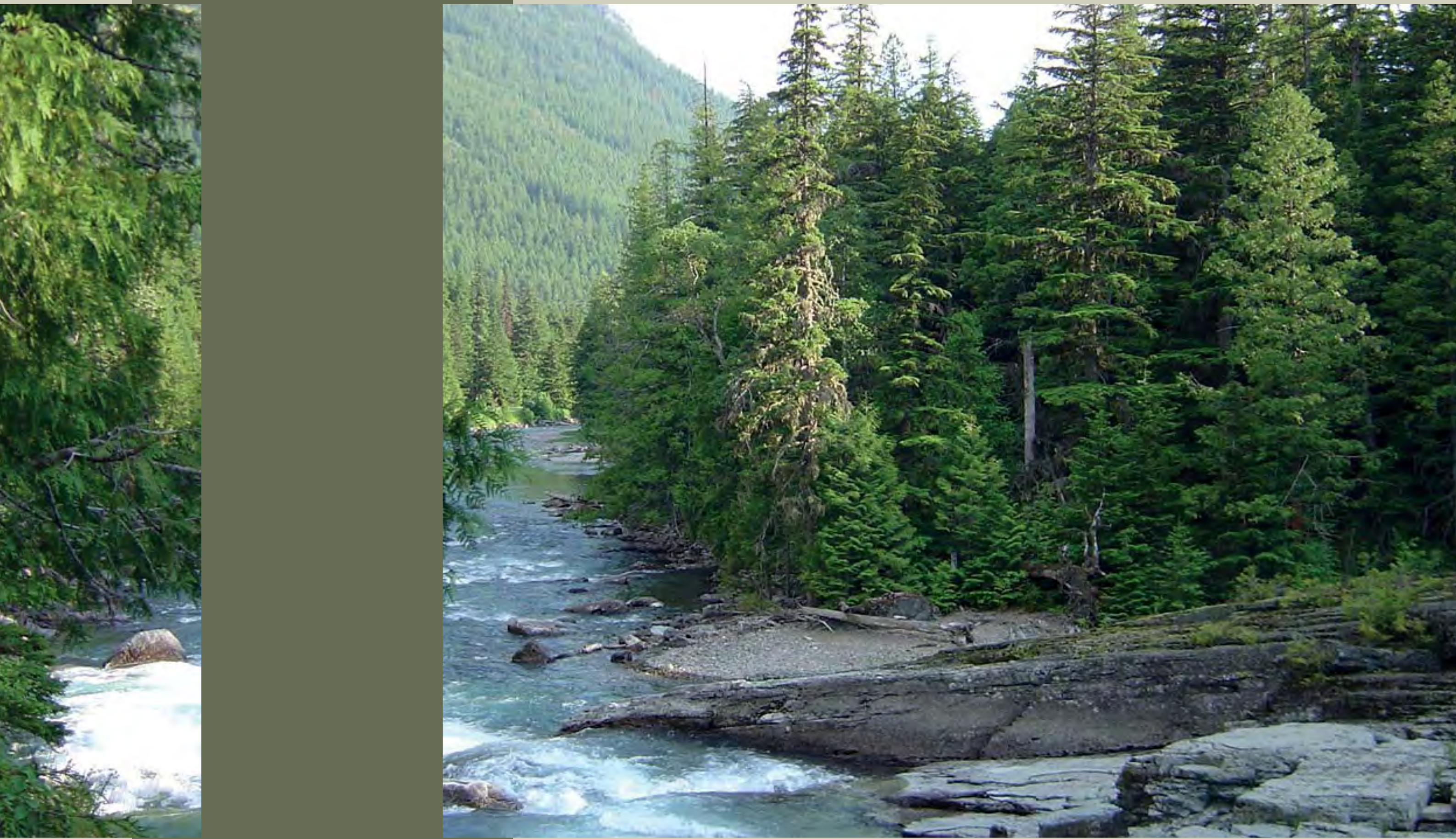

The North American Forest Sector Outlook Study

2006-2030

UNITED NATIONS

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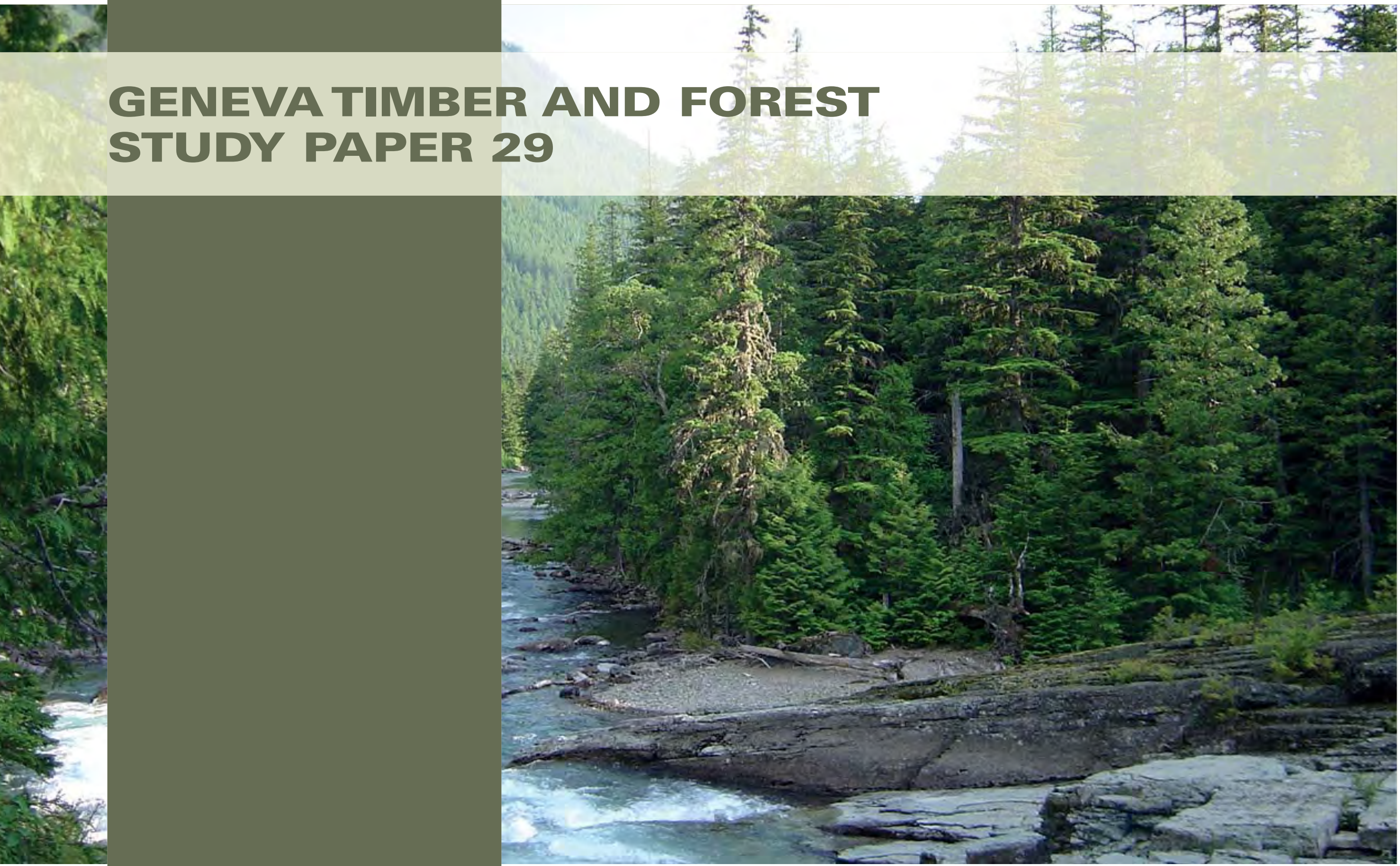
of the United Nations

GENEVA TIMBER AND FOREST STUDY PAPER 29



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Note

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Abstract

Projections for the United States and Canada to 2030 have been made with a global model to account for concurrent changes in other countries. Three future scenarios were investigated: two IPCC-based scenarios assuming the rapid growth of wood-based energy, and one IPCC-based scenario without this assumption. The model, under the IPCC scenarios, accounted for trends in population, income and land use along with emerging technology and predicted changes to consumption patterns for wood products and bioenergy. Markets for wood products, which mainly are destined for the construction sector in North America, are projected to recover by 2015 under all three scenarios examined. Projections suggest that, in spite of declining use of paper for media, other paper and paperboard for packaging and miscellaneous uses will continue to enjoy strong global demand.

Keywords

Bioenergy, biomass, Canada, carbon sequestration, climate change, consumption, demand, econometric, EFSOS, export, fellings, forest products, forest resources, future, GDP, globalization, import, increment, IPCC, markets, modelling, North America, policy, pulp and paper, roundwood, sawnwood, supply, sustainable, United States of America, wood energy.

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Foreword

Studies reviewing the outlook for the forest and forest products sector in Europe have been produced by the UNECE/FAO Forestry and Timber Section since 1953, with the most recent example being the European Forest Sector Outlook Study II, published in 2011.

For North America, companion studies were issued in 1990 and 1996. These reports were based on regular forest sector assessments that have been carried out in the United States since the early 20th century. A new assessment, called the 2010 RPA Forest Assessment System, forms the basis for the North American Forest Sector Outlook Study.

The objective of the North American Forest Sector Outlook Study was to quantify the implications of projections of the region's and the world's growth in economic output, population, and the bioenergy sector for the forest sectors of Canada and the United States. This outlook study differs from previous studies of the region because it uses a global forest sector model which fully recognizes the interdependence between North America, Europe, and the rest of the world. The study also makes projections in a new scenario-based format. The scenarios are based on specific scenario-storylines outlined by the Intergovernmental Panel on Climate Change. Further, this outlook study closely mirrors the companion European Forest Sector Outlook Study II by adopting a common scenario–based approach. The study also presents new projections of the evolution of comparative advantage in forest products for Canada, the United States, and other regions. These results will help decision makers foresee the implications of policies favouring wood-energy, analysts develop better strategies for forest sector investment, and forest economists reach a deeper understanding of the linkages across countries and forest industries.

Andrey Vasilyev
Officer-in-Charge
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Executive Summary

Projections to 2030 for the United States and Canada timber product market, forest stocks (the volume of standing live timber inventory), and forest area were made with a global dynamic and spatial equilibrium model of the forest sector. They were scenario-based, drawing on the Intergovernmental Panel on Climate Change (IPCC) A1B and B2 Scenarios from the IPCC Fourth Assessment (Intergovernmental Panel on Climate Change, 2007). A1B projects stronger economic and population growth (but stronger growth per capita) than B2 in both countries.

Projections of income per capita were based on IPCC projections for the OECD group of countries, and on the assumption of long-term convergence in these incomes per capita. Woody biomass production for energy was projected to be consistent with these two IPCC scenarios, as well.

An alternative A1B scenario, not imposing the IPCC assumptions on woody biomass but instead based on econometric results and past trends, was also done to assess the impact of the IPCC assumptions. Projections of the forest productivity effects of climate change were explicitly accounted for only in the United States projections.

Projections show that forest area in both countries does not significantly change from 2006 to 2030, but that timber stocks accumulate in both countries, slightly for Canada (less than 2% increase to 2030) and more in the United States (9% and 10% under the A1B and the B2 scenarios, respectively).

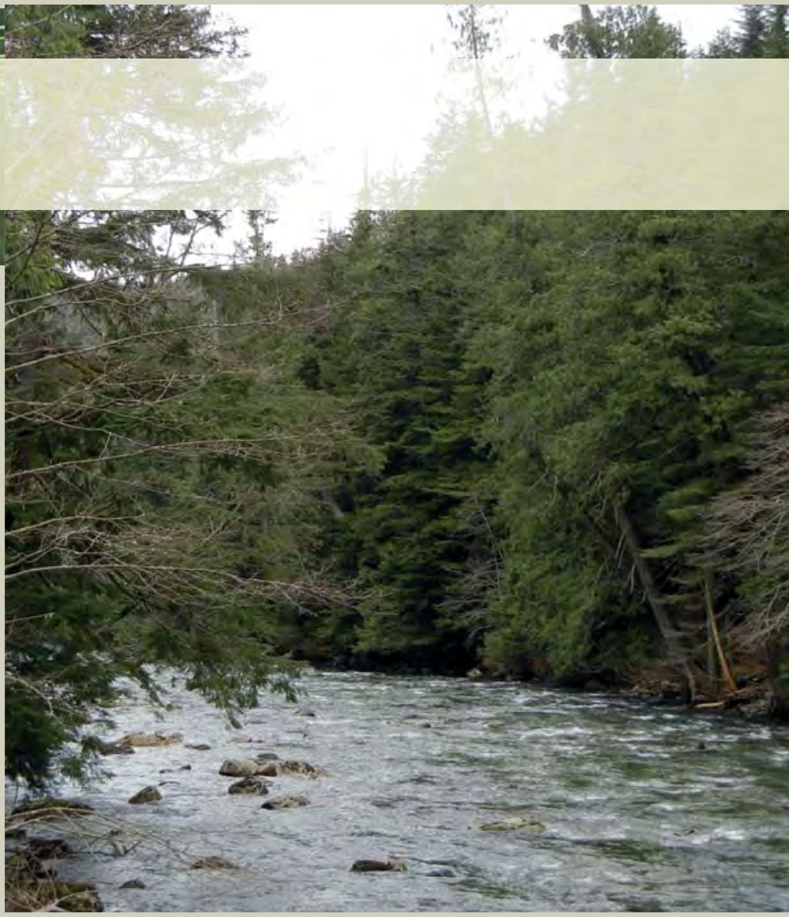
In terms of processed products, the results show that the growth in the use of woody biomass for energy significantly influences timber product markets only near the end of the projection period. Furthermore, with the exception of fuelwood, the market prices of most forest products, net of inflation, are projected to drop, regardless of assumptions about the woody biomass markets, although prices drop less with the woody biomass assumptions of the IPCC.

Production of woody biomass for fuel is projected to increase by 377% in Canada and 357% in the United States under the A1B scenario, and by 116% in Canada and 291% in the United States under the B2 scenario. An alternative A1B scenario without the IPCC woody biomass assumptions projects a more modest rise of 53% for the United States and 14% for Canada.

Industrial roundwood transformed in non-energy products is projected to decline under both the A1B and B2 scenarios and under an A1B scenario without the woody biomass assumptions. For Canada, sawnwood output is projected to decline by approximately 40%, from 2006 to 2030, under both the A1B and the B2 scenarios. The United States, on the other hand, is projected to increase its output of sawnwood products under A1B but to reduce it slightly under the B2 scenario.

The production of wood-based panels is projected to rise by 77% in Canada and 17% in the United States from 2006 to 2030 under scenario A1B. But this production is projected to rise by 45% in Canada and drop by 16% for the United States under scenario B2. Plywood production is projected to rise in Canada under both scenarios, by 127% under A1B and by 110% under B2. Production of plywood in the United States increases only 2% under A1B and drops by 35% under B2.

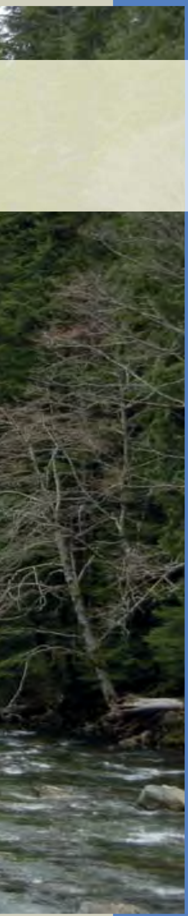
In the paper and paperboard sector, production increases are projected for both Canada and the United States, by 89% for Canada and 13% for the United States from 2006 to 2030 under A1B, and by 65% for Canada and 4% for the United States under B2. These increases in aggregate paper production hide a projected decline



in production of newsprint and printing and writing paper in the United States. For example, US newsprint production is projected to decline by 52% under the A1B scenario and by 62% under B2 from 2006 to 2030.

An analysis of aggregate and product-specific competitiveness using a revealed comparative advantage index indicates that Canada would retain its comparative advantage in processed forest products—sawnwood, wood-based panels, and paper—into the foreseeable future under all three scenarios.

The United States, on the other hand, is projected to remain at a comparative disadvantage, in all scenarios. However, a slight improvement towards a balanced trade, notably in sawnwood and paper and paperboard, would occur over the coming decades, especially in a future that does not involve a rapid growth of wood-based energy.



1 Introduction

The future of North America's forests and the forest products sector is important to policy makers, investors, manufacturers, and consumers. Policy makers are seeking information about the long-term effects of the development of a wood-based bioenergy sector on forest conditions and markets and the effects of altered domestic and international markets on the levels of goods and services that might be expected from forests in the coming years.

Investors and forest product manufacturers need information that can aid in decisions about the prospective profitability of forest product manufacturing investments and the likely emergence of regional and global competitors with a Canadian or US-based forest product manufacturing enterprise. Consumers of forest products, for example in the construction and paper-consuming sector need good information on the likely trends in their input costs (building materials, paper for printing, publishing, and packaging), so that informed decisions can be made regarding their investments.

1.1 Objectives of the outlook study

The North American Forest Sector Outlook Study (NAFSOS) was designed to examine possible futures of the forest sectors in the United States and Canada. In recognition of the importance of the international context in this assessment, a global forest sector model was used for the study. With this model and alternative scenarios, NAFSOS seeks to describe the recent history and projected futures of forest area, timber stocks (the volume of standing live timber inventory), production, consumption, trade, and prices across multiple categories of forest products. A special scenario, without an exogenous assumption on the development of wood-based energy, seeks to identify the North American and global consequences of this expanded role of energy wood. A measure of comparative advantage for the entire forest industry and its main components is used to describe how the United States and Canada would fare in the context of growing global populations and economies, evolving technologies, demand for energy wood, and limited forest resources.

1.2 Modelling approach

NAFSOS is based in part on the Global Forest Products Model (GFPM, Buongiorno et al., 2003; updated in Buongiorno and Zhu, 2011b). This peer-reviewed, published model makes projections of forest area, timber stock volume, and output, trade, and prices of 14 categories of forest products in 180 countries. The model takes into account changes in aggregate economic activity, human population, manufacturing efficiency, industry profits, and trends in the uses of forest products. An overview of the model is provided in Annex 1.

The GFPM makes projections from a base year, which for the purpose of NAFSOS is 2006, to a last year set here at 2030. While the last year of NAFSOS projection is the same as in the 2011 European Forest Sector Outlook Study II (EFSOS II), NAFSOS reports the projections only for 2015 and at five-year intervals after that, in recognition that the GFPM is best viewed as a descriptor of long-term trends, and not short-run fluctuations tied to year to year economic changes.

NAFSOS is based on the same GFPM modelling framework used in the US 2010 Resources Planning Act (RPA) Assessment. The 2010 RPA Assessment (see Annex 1) has a domestic US focus, with multiple regions and more detailed product categories than those for Canada and the United States used in this NAFSOS, and it makes some different assumptions about the functioning of the US and global forest product markets.

1.3 Acknowledgements

NAFSOS benefited from the contributions of members of the UNECE/FAO Forest Sector Outlook Team of Specialists; a Core Team of experts in modelling, led by Mart-Jan Schelhaas; and specific individuals from Canada and the United States.

From the United States, these included Joseph Buongiorno and Shushuai Zhu, of the University of Wisconsin-Madison, and Jeffrey Prestemon, of the USDA Forest Service's Southern Research Station and Vice Chair of the UNECE/FAO Forest Sector Outlook Core Group, who were the drafters of the study itself. Also contributing, especially in the earliest phases of study development, were, from the United States, Linda Langner (USDA Forest Service, RPA Assessment Leader and UNECE Timber Committee Chair), David Wear (Project Leader and RPA Forest Assessment Lead), and Peter Ince (USDA Forest Service Forest Products Laboratory). From Canada, we thank experts from the Canadian Forest Service of Natural Resources Canada for their review.

We would like to thank in particular Kit Prins and from the UNECE/FAO Forestry and Timber Section, Franziska Hirsch and David Ellul, who coordinated the development of the study in close cooperation with the Core Group of experts. We also gratefully acknowledge the infinite assistance in countless aspects of this work by Matthew Fonseca and Alex McCusker. Further, we highlight the broad support of Karen Taylor, Douglas Clark, and Paola Deda.

Finally, we acknowledge the broad contributions of the UNECE/FAO Forest Sector Outlook Team of Specialists and national correspondents who contributed in many ways to the successful design and completion of NAFSOS, particularly in the context of the three meetings held in Geneva in the period 2009-2011 (Box 1).

Source: adapted from SoEF 2011

Box 1: UNECE/FAO Team of Specialists and correspondents on Forest Sector Outlook.

Ramazan Balı, General Directorate of Forestry, Turkey
Pero Balotic, Ministry of Agriculture, Water Management and Forestry, Bosnia and Herzegovina
Paolo Camin, Federal Office for the Environment, Switzerland
Francisco Manuel Cardoso de Castro Rego, Technical University of Lisbon, Portugal
Taivo Denks, Ministry of the Environment, Estonia
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Christoph Dürr, Federal Office for the Environment, Switzerland
Karl Duvemo, Swedish Forest Agency, Sweden
António Emídio Santos, Autoridade Florestal Nacional, Portugal
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Aleksander Golob, Ministry of Agriculture, Forestry and Food, Slovenia
Piotr Grygier, Regional Directorate of State Forests - Poznań, Poland
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Michel Hubert, Ministère de l'Agriculture, de l'Alimentation, de la Pêche, de la Ruralité et de l'Aménagement du territoire, France
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Srećko Juričić, Ministry of Regional Development, Forestry and Water Management, Croatia
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Victor Kornienko, State Forestry Committee, Ukraine
Andrius Kuliesis, State Forest Survey Service, Lithuania
Jan-Olof Loman, Swedish Forest Agency, Sweden
Milan Oravec, National Forest Centre - Forest Research Intitute Zvolen, Slovakia
Leena Paavilainen, Finnish Forest Research Institute, Finland
Denitsa Pandeva, State Forestry Agency, Bulgaria
Tatiana Pasi, Federal Office for the Environment, Switzerland
João Pinho Rocha, Autoridade Florestal Nacional, Portugal
Sergei Lvovich Rodionov, Republican Forest Industry Association, Belarus
Raoul Romano, National Institute of Agricultural Economy, Italy
Patrick Snowdon, Forestry Commission, United Kingdom
Birger Solberg, Norwegian University of Life Sciences, Norway
Vlado Soldo, Ministry of Agriculture, Water Management and Forestry, Bosnia and Herzegovina
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Władysław Strykowski, Wood Technology Institute, Poland
Michal Synek, Forest Management Institute - Olomouc, Czech Republic
Alain Thivolle-Cazat, Institut Technologique Forêt Cellulose Bois-construction Ameublement (FCBA), France
Viktor Tkach, Ukrainian Research Institute of Forestry and Forest Melioration, Ukraine
Mati Valgepea, Centre of Forest Protection and Silviculture, Estonia
Roberto Vallejo Bombin, Ministry of Environment, Rural and Marine Affairs, Spain
Cristina Viejo Téllez, Ministry of Environment, Rural and Marine Affairs, Spain
Marc Wagner, Administration de la nature et des forêts, Luxembourg
Sheila Ward, Forestry Commission, United Kingdom
Frank Wolter, Administration de la nature et des forêts, Luxembourg
Tatyana Yakusheva, Federal Forest Agency, Russian Federation
Claudiu Zaharescu, Ministry of Agriculture and Rural Development, Romania.

2 Past studies of the forest sectors of the United States and Canada

Concerns about the future have driven efforts in the United States and Canada to understand the nature and extent of forest resources and their likely futures. In the earliest days of North American settlement by Europeans, forests were considered nearly infinite suppliers of wood. But intensive cutting as these immigrant populations moved west across the continent revealed the limits of this abundance.

In the United States, the perception of an impending timber shortage, the occurrence of widespread natural disasters in the form of wildfires and floods, and the advocacy of nineteenth century preservationists and conservationists such as Theodore Roosevelt and Gifford Pinchot, all contributed to the creation of government agencies that would help to manage the public lands. In 1881, the Division of Forestry was created within the Department of Agriculture, which was later elevated to the status of a Bureau (1901) and then a Service. Since 1905, the Forest Service has been the steward of the nation's federally owned forests.

In response to uncertainties about future raw materials for the forest sector, the United States Forest Service initiated a series of forest sector assessments. In 1909, a study of the timber supply situation in the United States was published (Kellogg, 1909), with subsequent reports issued in 1920, 1933, 1948, 1958, 1965, 1974, 1976, 1981, 1991, 1996, 2002, and 2007. The Forest Service's latest report, the 2010 Resources Planning Act Assessment, is expected to be published in 2012. All of these reports covered issues of timber supply, demand, current resource situations, current issues with respect to forest protection and, at times, perceived timber shortages.

For example, the 1952 assessment (USDA Forest Service, 1958) was a 713-page compendium of timber inventory volumes and species mixes, the historical timber utilization, forest protection, timber productivity, tree planting, forest ownership, and the projected future timber supply and demand of the United States. This assessment included a description of forest resources in Canada, Mexico and the world, an early recognition of the interdependence of the United States and Canada (and Mexico, along with the rest of the world).

These studies were originally mandated by the 1928 McSweeney-McNary Forest Research Act, directing the Secretary of Agriculture to work with States to develop periodic assessments of the timber situation in the United States. In 1976, details of the parameters of these assessments were issued in an amendment to the National Forest Management Act of 1976 and the 1974 Forest and Rangeland Renewable Resources Planning Act. These laws require periodic assessments, not just of timber, but all of the many goods and services provided by forests. The timber assessment portion provides the backdrop for the current study, focusing especially on timber resources and product supply and demand futures.

Although no similar legislative requirement to assess the long-term future of the country's forest sector exists in Canada, the federal *Department of Forestry Act*, passed in 1989, required that Forestry Canada and its successor, Natural Resources Canada, Canadian Forest Service, annually report to Parliament on the condition

of Canada's forest resources and their contribution to the economy. These *State of Canada's Forests* reports provide a combination of factual and analytical information about Canada's forests, and address topics and issues important to the future development of the Canadian forest sector. In 2007, the reports were complemented by a website offering a more detailed statistical and analytical view of the sector[1].

While domestic studies are important to understand especially the likely futures of forests and related forest output and supply-demand conditions, international organizations have provided a higher level, global perspective of status, trends, and likely futures. The Food and Agriculture Organization of the United Nations (FAO) and the United Nations Economic Commission for Europe (UNECE) have, through joint and separate efforts, often sought to assess the future of forests globally.

These efforts include world forest assessments and continent-wide assessments that answer particular questions about markets, trade, and forest conditions especially related to forest area trends, forest degradation, and the possible policy solutions needed to address particular, acute and chronic problems. Below, we briefly describe some recent efforts by the UNECE and FAO to assess the North American forest sector, in particular. Following this, we outline the current study and provide our projections for the US and Canadian forest sectors to 2030.

2.1 UNECE/FAO studies

2.1.1 North American Timber Trends Study (1996)

The UNECE and the FAO have produced studies of the long-term outlook for wood product markets and other forest based goods and services since 1953. Notable recent studies include the European Forest Sector Outlook Study (United Nations, 2005), the European Timber Trends and Prospects study (United Nations, 1996a), and the 1999 Global Forest Products Outlook Study, which used an early version of the GFPM (Zhang et al. 1997; Zhu et al., 1998). Regarding North America, the UNECE has commissioned two reports, a study of Timber Trends and Prospects for North America (United Nations, 1990) and a North American Timber Trends Study (NATTS) (United Nations, 1996b), covering Canada and the United States. In 2008, the FAO commissioned a North American Outlook Study, which remained in draft form.

The 1996 NATTS report provided projections of the United States and Canadian timber sector to 2015. The US component of the study was based on a set of forest inventory and timber product market models used in the 1989 RPA Timber Assessment. The timber product models of the RPA were focused especially on the United States and Canada and had only broad conceptualization of international developments that could affect the US forest sector. The RPA models were based on the Timber Assessment Market Model (Adams and Haynes, 1996), the North American Pulp and Paper Model (Ince and Buongiorno, 2007) and ATLAS (a timber inventory projection model) (Mills and Adams, 2007). This multi-model projection framework formed the basis of RPA timber assessments for 1979, 1989, the 1993 Update to the 1989 RPA Assessment, 2000, and the 2005 Update to the 2000 Assessment. After the 2005 Update to the 2000 Assessment, the RPA timber assessment process changed course. The new assessment, called the RPA Forest Assessment System, forms the basis for the North American Assessment in this report, producing projections for the United States and Canada with a detailed description of their relations with the rest of the world.

The Canadian portion of NATTS was based on simpler econometric models of nationwide consumption, production, imports and exports, by product category, with most of the trade focused on the bilateral US-Canada forest products flows that dominated both countries' external markets.

In NATTS, several conclusions were reached about the evolution of the North American forest sector:

- Canadian harvests were projected to steadily grow;
- US harvests were expected to increase, especially in natural hardwood and plantation grown softwood from the eastern and southern US;
- Consumption was projected to grow steadily with populations and the economy;
- Prices for forest products were projected to rise, including for roundwood, in spite of projected healthy increases in overall timber inventory volumes;
- Forest product market export opportunities were seen primarily as lying in Europe or Japan but not China or other less wealthy Asian countries;
- Major competitors were viewed in countries with new plantations (Chile, New Zealand, Brazil) or extensive natural coniferous resources (Siberia);

[1] *Interested readers should look to canadaforests.nrcan.gc.ca for up-to-date statistics and information on topics of interest.*

- Per capita consumption of all forest products was projected to increase (for both the United States and Canada) over time;
- The outlook for Japan was characterized as "upbeat";
- Coniferous and non-coniferous sawnwood production and trade were projected to steadily rise to 2015, although perhaps at a slower rate compared to the 20 years before the early 1990s;
- Plywood production and consumption and trade opportunities were projected to stagnate at early 1990s levels;
- Structural panels were projected to be areas of strong production and consumption growth, with few trade opportunities;
- Particleboard was projected to have steady growth in production and consumption with few trade opportunities;
- Paper and paperboard production and consumption and exports were projected to steadily grow to 2015;
- Industrial coniferous roundwood production was projected to stabilize at early 1990s levels, due to increased efficiency in production and higher rates of recycling, while production of non-coniferous roundwood was expected to rise to 2015; and
- Demands for building products were expected to steadily rise to 2015, generally, forcing up prices.

2.1.2 FAO Forestry Sector Outlook Study—United States (2008)

The US report for the 2008 FAO forest sector outlook study for North America (Anonymous, 2008a) was primarily descriptive of the history and most recent trends in the US sector. It discussed changes in forest area, developments in the forest products industry, including employment, trade, production and consumption. It also had a discussion about the future—mainly factors expected to affect the evolution of the US forest sector. These include changes in demographics (rising population, an ageing and diversifying population with unequal growth rates across regions), the most recent economic downturn, which became a deep US recession by 2009, the collapsing housing market, rising unemployment, etc. The report also contained an outlook to 2020, based on the 2000 RPA Timber Assessment.

The major highlights of the projections to 2020 include the following: (1) forest area in conifers was projected to increase 8%, particularly because of large increases in planted areas, while that of non-coniferous species was a decline by 5%; (2) US imports, especially from Canada, were projected to decline because Canada's allowable cut was projected to decline due to insect infestations; (3) domestic harvests were projected to grow by 3 million m^3 annually, between 2002 and 2020; (4) imports of total forest products were projected to decline as a share of production, while consumption was projected to grow; (5) prices were expected to increase for sawnwood and oriented strand board (OSB), while prices were projected to remain steady or fall for plywood and paper; and (6) outputs of the pulp and paper sector were expected to rise in the coming decades.

2.1.3 FAO Forestry Sector Outlook Study—Canada (2008)

The 2008 FAO outlook study for Canada (Anonymous, 2008b) was, like the US study, mainly descriptive. It outlined the conditions and character of the Canadian forest inventory, uses of forests, and the contributions of the forest sector to the Canadian economy. With respect to the latter, there is a tight historical relationship between the United States and Canada; the two countries have the largest bilateral trade flow in the world in all forest products.

The study highlighted some unique and important aspects of Canada's forests. For example, nearly 93% of Canada's forests are publicly owned. But there are wide regional variations, from 9% public ownership in Prince Edward Island on the east coast to 96% public ownership in British Columbia on the Pacific coast. By federal law, the ten provinces and three territories of Canada are the stewards of the public forests within their jurisdictions. The federal role in forest management is limited, focusing primarily on national initiatives, international trade, parks, and aboriginal affairs.

The study indicated a relatively low rate of forest area change, estimated then at between 54 700 ha and 80 500 ha annually lost to other uses, nationwide, between 1990 and 1998.

National harvest totals were described as steady in the decades of the 1980s and 1990s to the early 2000s. The study noted a slight drop in the rate of tree planting nationwide, dropping by about 2% from the mid-1990s to the mid-2000s.

Substantial attention was given to the role of the forest sector in generating employment and economic output. Canada's forest sector is strongly cyclical, linked closely with the construction market in the United States and elsewhere; in 2006, 78% of Canada's exports went to the United States. The country is strongly export oriented, with over half of production

exported, although the nation had experienced a slow decline in its export competitiveness, attributable at least partially to a strengthening of the Canadian dollar, especially in the period 2003-2008. The report noted that there has been a decline in forest sector jobs in Canada, consistent with shrinking output. These declines have affected rural communities that depend on the sector for jobs and economic growth.

The forest sector was noted as in the midst of some significant structural changes. These include investments in new and more efficient forest product plants and the development by the mid-2000s of a significant bioenergy production capacity (especially power cogeneration).

The 2008 report also described the widespread timber mortality in western provinces resulting from the mountain pine beetle (*Dendroctonus ponderosae*) epidemic. The epidemic has created a glut of salvageable timber that generates some administrative and legal challenges, due to allowable cut limitations. The beetle has spread eastward from British Columbia into Alberta and the northern boreal forests of Saskatchewan, affecting especially lodgepole pine (*Pinus contorta*). There is concern that the epidemic could spread to jack pine (*Pinus banksiana*), a major component of the boreal forests of north-eastern Canada.

Policies and programmes in Canada directed at the forest sector's competitiveness received specific attention. The report describes three federal and various provincial programmes and industry-led initiatives designed to enhance the competitiveness of the sector in the face of growing production and export capacity being developed abroad. They include encouraging the use of wood in construction and energy, enhancing market access of Canadian products, making new investments in more efficient product processing capacity, and stimulating research and development.

According to the report, Canada's forest sector faces some serious challenges in the coming decades. These include arresting the shrinkage of the number of jobs and production levels of some product categories, addressing a growing rural-urban divide in the kinds of goods and services Canadians desire from their forests, continuing to advance forest sustainability through certification and other initiatives, and increasing the role that forests and wood products play in mitigating climate change. Employment in the forest sector workforce will need to accommodate and attract a progressively changing mix of younger workers who are more educated and more urban than previous generations.

Canada has long been the world's largest forest products exporter, with a comparative advantage unchallenged globally. The domestic forest sector indeed has grown in importance over the previous few decades, especially as a robust secondary forest product manufacturing capacity emerged. But concerns exist about maintaining that growth and sustaining the competitiveness of the sector over the long term, especially in light of growing efficient, new production capacity abroad and a strengthening currency. Finally, the influence of global warming, and its effects on forest productivity, disturbances, and the values that emerge from forests of Canada, is likely to be of great importance in the development of the sector over the coming decades.

2.2 RPA Timber and Forest Assessments

The *Forest and Rangeland Renewable Resources Planning Act* (P.L. 93-378, 88 Stat 475, as amended) was enacted in 1974. Section 3 of the Act requires a national renewable resource assessment to provide reliable information on the status and trends of the nation's renewable resources on a 10-year cycle. The requirements for the RPA Assessment include analyses of historical trends and anticipated uses of forest and rangeland resources, as well as an inventory of current resources. Part of the Assessment includes an examination of the timber sector—forest inventory and wood products. The RPA Timber Assessment has evolved over the years, consistent with advancing understanding of how the forest sector functions within an increasingly globalizing economy.

In most RPA timber assessments in recent decades, the timber sector was projected to grow—in inventory, in production, and even in product prices. The 2005 Timber Assessment Update (Haynes et al., 2007) discussed a sector that was likely to continue a then-recently observed growth path over a 45-year period from 2005 to 2050. Issues of a so-called "timber famine" that emerged in the 1970s had given way to a timber abundance, as harvest levels declined, especially on the federally owned forests of the National Forest System due to policy changes at the federal level. In this projected future, outputs held steady to rising due primarily to shifted investment and growing activity on high productivity southern (i.e., south-eastern US) forests. Softwood plantations, especially in the South, were rapidly increasing in area and in growth rates. This trend was foreseen as continuing into the future, although different trends were projected for different manufacturing subsectors. The intensification of timber management in the South was projected to lead to

a steady loss in some broad forest types (e.g., oak-pine and natural pine) and a shift to planted pine, while there would be a gradual ageing and increased species diversification of the forests on federal lands.

The 2005 Update also projected a one-third rise in total forest product consumption in the United States to 2050. Although prices of solid wood products were also projected to rise, their rate of growth, at 0.3% per year, is slower than in previous decades. The paper sector, however, should see a larger rise in prices. Much of the rise in output was expected to occur in the pulp and paper sector, on par with price increases, although softwood lumber and engineered wood products were expected to rise quickly, at a rate faster than paper, due to robust housing growth and advancing technology.

Canada's share of the domestic US market was expected to rise over time, although the importance of western Canada as a supplier of wood products was projected to decline due to the mountain pine beetle epidemic related inventory losses.

Losses were projected to occur in forest area, primarily due to conversion to built-up uses nationwide, a decline of about 3% between 2005 and 2050. Simultaneously, the 2005 Update foresaw a decline in industrial timberland but a steady rise in intensively managed plantations, particularly in the South. Timber stocks, also in contrast with the forest area loss, were projected to rise by one-third between 2005 and 2050, much of that growth concentrated in federal lands with lower harvest rates, especially in the West.

The current 2010 Assessment, now nearing completion, is the basis for the projections for the US and Canada for this study. The 2010 Assessment is scenario-based, without a central projection of the future evolution of policies, climate, or society. Instead, these projections derive from three of the four IPCC Emissions Scenarios: A1B, A2, and B2, with the B1 family of scenarios omitted. Part of the 2010 Assessment involves an overview of the most recent trends in important aspects of production, consumption, and trade in forest products.

3

Recent trends in the forest sector of North America

3.1 Forest inventory

North American forest stock (standing live timber inventory) volumes, in aggregate, have risen by 3% from 1992 to 2006. Although this stock growth combines forests from Central America to Canada, they do illustrate a trend of general increase, which is true for both the United States and Canada.

Smith et al. (2009) describe the forest resources of the United States for four broad regions: The North (north-eastern quarter), the South (south-eastern quarter), the Rocky Mountains, and the Pacific (Alaska, Hawaii, California, Oregon, and Washington). Although the South has one-fifth of its forests in plantations, most forests (92%) in the United States are of natural origin.

It has been estimated that in 1630, before widespread European settlement of the land occupied by the United States today, forests covered about 420 million hectares (ha), or 72% of the land area. By 1907, that share had declined substantially, but the changes varied considerably across regions. Since 1907, the area of forest has risen in the North but remained fairly steady in other regions. As of the mid-2000s, forests covered approximately 280 million ha, 72% of what existed in 1630. Forest area has remained relatively stable since the mid-1950s, with fairly minor fluctuations; today's forest area is nearly the same as in 1953.

About 10% of all forestland is in so-called "reserved" or roadless status. Reserved and roadless forestland area varies across regions, with the highest amounts found in the western US (Pacific and Rocky Mountains), where 53% is in reserved status.

Ownership of domestic US forests is mainly private, at 56% of all forests, although the amounts vary widely from region to region. About 20% of forests are National Forests (managed by the Forest Service), 38% are private non-corporate, 18% private corporate, 13% other federal, 9% state, and 2% are county and municipal forests. Private ownership dominates in the South and North, while public ownership is the majority in the Pacific and Rocky Mountains.

A notable change in forest ownership has taken place over the past 15 years or so in the United States: a nearly total divestiture of forests by the timber industry, placing most of this corporate timberland in the hands of timber investment management organizations and real estate investment trusts. The effects of this transfer, which is nearly complete today (only a few large timber industry ownerships remain), on forest management and the production of timber and other forest values, are not yet clear.

Forest density and the composition of forests have evolved over the past 150 years. According to Smith et al. (2009), forests in some regions have become much denser as a result of fire exclusion and harvest reductions on federal forestlands; this is especially true in fire prone parts of the West. Another aspect of fire exclusion and harvest reductions has been ecological succession from seral forest types to later stages, nearing climax. At the same time, so-called old growth forests have nearly disappeared; for example, only 5% of old growth coastal forests in the Pacific remain compared to what grew prior to the European settlement in the second half of the nineteenth century and early twentieth century.

Forest health is an ongoing concern throughout much of the United States. Areas burned by wildfire have risen dramatically from the 1980s, to levels in the 2000s not seen since the first half of the twentieth century. Various causes have been suggested: climate change, harvest reductions, overly successful fire exclusion, and growing human populations. Invasive and endemic pest epidemics are also a current concern. These include epidemics of endemic pine beetles (the mountain pine beetle in the West and the southern pine beetle) (*Dendroctonus frontalis*) in the South, exotic gypsy moths (*Lymantria dispar*) (in the North), the hemlock woolly adelgid (*Adelges tsugae*) in the North and South, the emerald ash borer (*Agrilus planipennis*), and, earlier, diseases such as the chestnut blight (*Cryphonectria parasitica*) and Dutch elm disease (*Ophiostoma ulmi and O. novo-ulmi*).

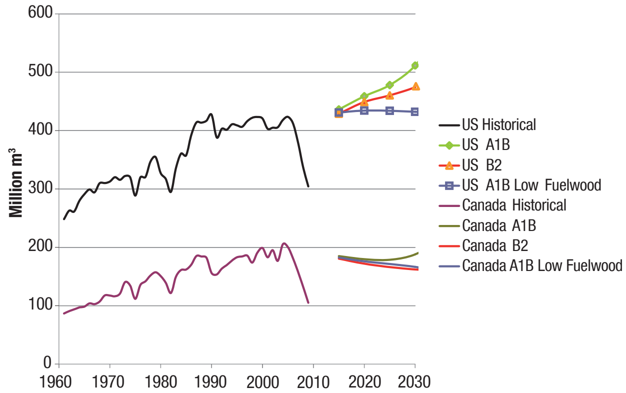
Such insect and disease outbreaks can change forests from older to younger age classes, eliminate entire species or genera, and thereby alter the mixes and amounts of goods and services provided by these forests. Furthermore, exotic invasive tree species and herbaceous plants alter ecosystem functions.

Insects, diseases, exotic species, and wildfire are further influenced by climate change. Climate change in the United States, caused largely by human-induced increases in greenhouse gases that themselves sometimes directly alter forest growth, has meant overall higher temperatures, altered precipitation patterns, and probably changed rates and severities of catastrophic events (droughts, floods, hurricanes, ice storms, etc.). These effects of climate change, both directly (through temperature and precipitation) and indirectly (through altered disturbances) are likely bringing changes to future forest growth, composition, and mortality.

3.2 Aggregate production, consumption, and prices of forest products

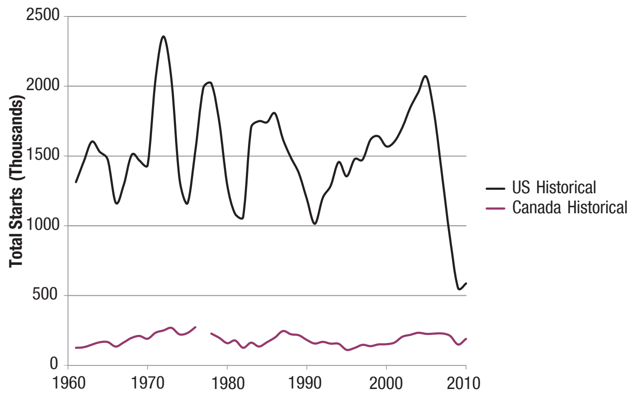
The simplest way to describe the recent past of the forest products market in Canada and the United States is to evaluate a consistent data set of production and consumption of major inputs and outputs of the market: industrial roundwood, fuelwood, and derived products. Figure 1 shows that Canada and the United States' total timber harvests move more or less in tandem. In 1961, at the beginning of this FAO data series compiled in early 2011, Canada's total production of industrial roundwood was 87 million cubic metres (m^3) and US production was 248 million m^3. Unsteady growth occurred in both countries, with rises and falls mainly consistent with the United States' housing market (Figure 2); the Canadian housing market demonstrates less cyclicality throughout the 50-year period shown. By 2009, however, overall industrial roundwood production for both countries dropped to levels not observed in over 30 years.

Figure 1: Total industrial roundwood production, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

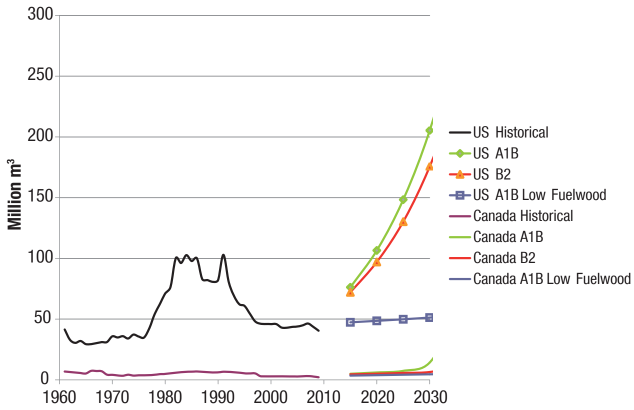
Figure 2: Total housing starts in the US and Canada, 1961-2010.



Source: US Bureau of the Census (2011), Canada Mortgage and Housing Corporation (2011), Statistics Canada (2011a).

Data on the quantity of fuelwood produced in both countries document little net change from 1961 to 2009. In the United States, production dropped by a mere 1 million m^3 over that 49-year span (Figure 3). The 1980s in the United States and Canada was a period of rapid growth in the use of wood stoves in housing, as well as increased use of wood as an energy source for wood products manufacture. The overall trend in Canada was negative over the same time span, dropping from 6.5 million m^3 to 2.7 million m^3 by 2009. The aggregate data on fuelwood production show no evidence of increased novel uses of wood fibre in energy production.

Figure 3: Wood fuel production, 1961-2009, and projections to 2030.

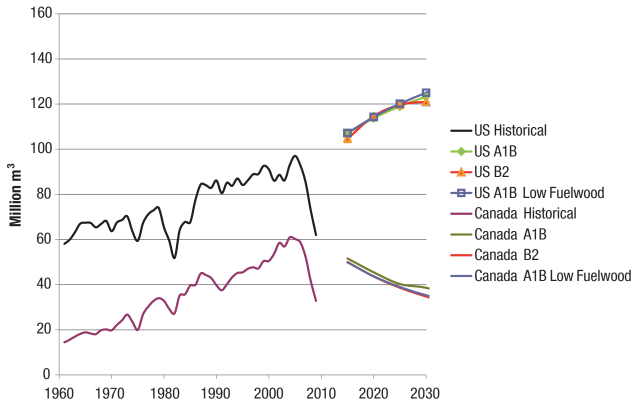


Source: FAO (2011), GFPM.

Sawnwood production in Canada and the United States (Figure 4) follow very similar trends. The similarity of trends can be appreciated by observing the net export quantities of both countries (Figure 5); the mirror images of net exports (Canada has positive net exports, the United States negative) are the result of the fact that nearly all of the US imports of sawnwood come from Canada and nearly all of Canada's exports go to the United States. The volatility of both production and net exports over the 1961 to 2009 span reflect the housing market (Figure 2) primarily in the United States.

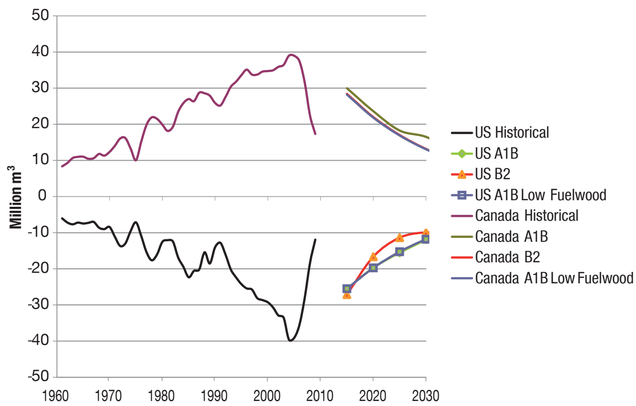
Sawnwood production increased strongly through the end of the last housing peak but has since fallen in the United States from 97 million m^3 to 62 million m^3 (a 22% drop) between 2005 and 2009. Canada's production dropped from 61 million m^3 to 33 million m^3 (a 46% drop) from the 2004 peak to the 2009 likely trough. The data from 1961 to 2009, however, indicate an overall positive trend in both series, somewhat steeper in Canada than in the United States, mainly due to higher overall export growth in Canada compared to the United States. The strong reduction in net exports for both countries derive partly from the housing market contraction, but other factors, such as a weakened US dollar compared to the Canadian dollar, have made the Canadian product less competitive in the United States.

Figure 4: Sawnwood production, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

Figure 5: Sawnwood net exports, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

Panel production (Figure 6) grew robustly in both the United States and Canada from 1961 to 2009. Trade between the United States and Canada, on the other hand, was modest until the advent of the US-Canada Free Trade Agreement, in the late 1980s, when panel tariffs were progressively lowered. The net export trend (Figure 7) shows these changes, with net exports from the United States falling from -0.6 million m^3 in 1991 to -18.6 million m^3 in 2005 before the strong housing market contraction, while Canadian net exports rose from 1.4 million m^3 to 11.8 million m^3.

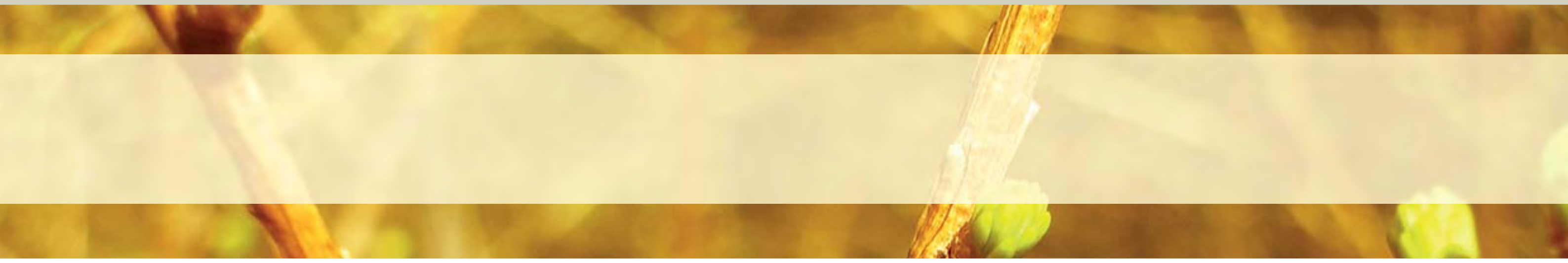
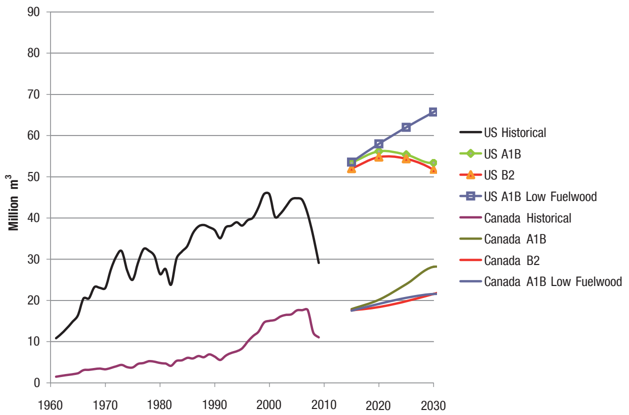
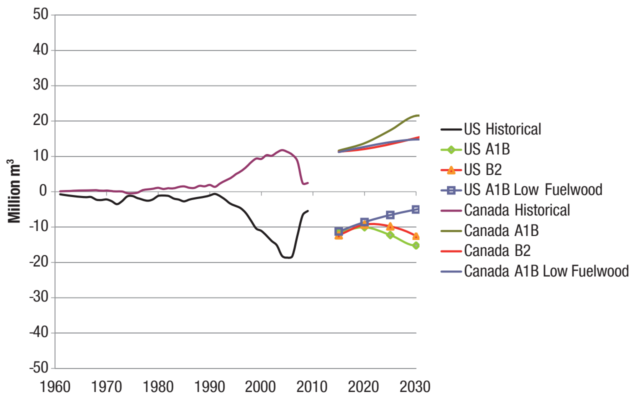


Figure 6: Wood-based panel production, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

Figure 7: Wood-based panel net exports, 1961-2009, and projections to 2030.



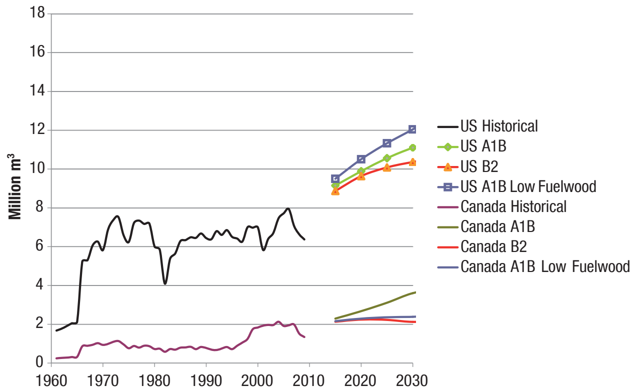
Source: FAO (2011), GFPM.

The housing market contraction of the late 2000s had a large impact on panel production, which fell by 35% in the United States between 2005 and 2009 and by 37% in Canada. The overall growth from 1961 to 2007 in Canada was steadier, with other export markets being able to soften some of the wide drops of exports to the United States created by the volatile US housing market. This overall trend obscures slightly more dynamic behaviour observed in panel subcategories (Figures 8-10). Fibreboard production underwent rapid acceleration in the 1960s, slowed or fell to the mid-1980s, and then recovered to higher levels by the 2000s. Fibreboard output (Figure 8) did not decline much in either country in the late 2000s, in spite of the housing market contraction.

Particleboard underwent rapid growth, especially with the explosion in the use of OSB in construction, which however also caused the drop of production in 2007-2009 (Figure 9).

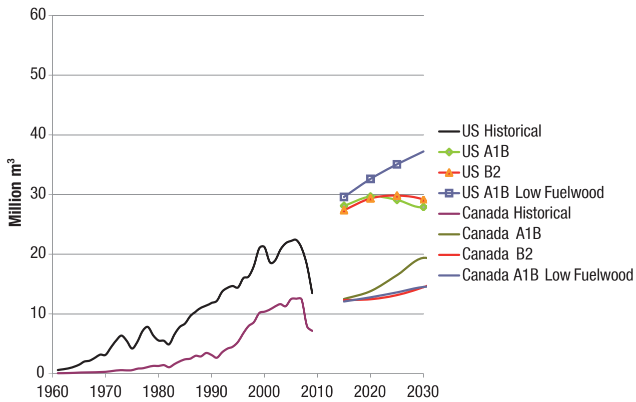
Production of the aggregate category veneer + plywood (Figure 10), has stagnated in both countries since the 1970s, and wider cycles have been observed in the United States than in Canada. Production began a rapid slide in about 2000 in the United States, to levels by 2009 not observed since the early 1960s. In Canada, the production also decreased in the late 2000s, but the drop was modest. The net export data for veneer and plywood (Figure 11) show erratic falls and rises. Since the late 1980s, US net exports have become more negative, although some recovery was evident after the housing market contraction in the late 2000s. In 2008 Canada changed from being a net exporter to a net importer as its US export market practically disappeared.

Figure 8: Fiberboard production, 1961-2009, and projections to 2030.



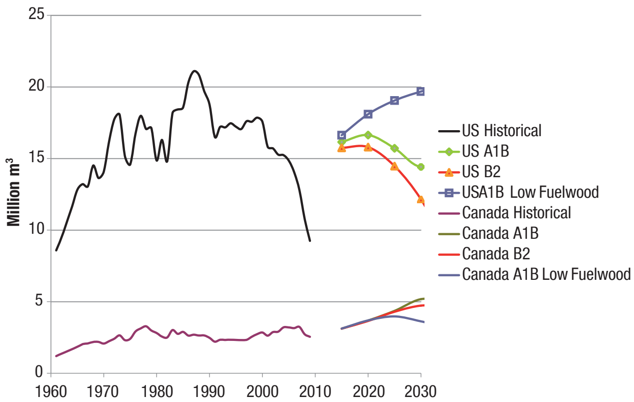
Source: FAO (2011), GFPM.

Figure 9: Particleboard production, 1961-2009, and projections to 2030.



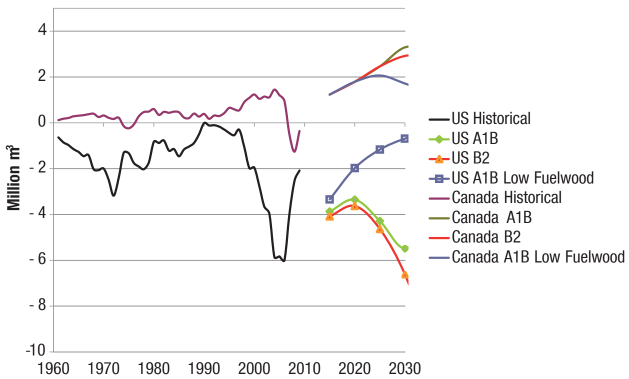
Source: FAO (2011), GFPM.

Figure 10: Veneer + plywood production, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

Figure 11: Veneer + plywood net exports, 1961-2009, and projections to 2030.

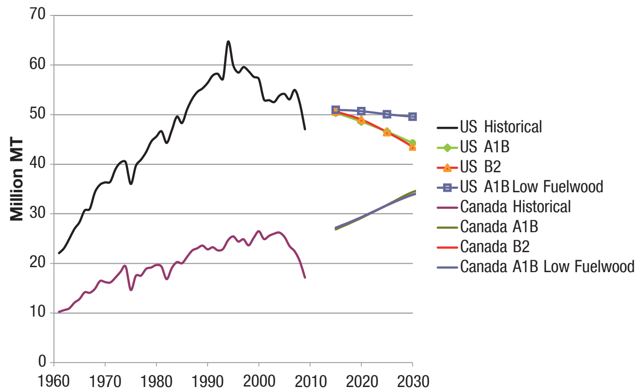


Source: FAO (2011), GFPM.

Wood pulp production in Canada and the United States has undergone a similar trajectory from 1961 to 2009. Strong growth was evident in both countries from 1961 through about the mid-1990s (Figure 12). The 1994 peak in production of wood pulp in the United States was followed by a steep decline, an arresting of that trend with some recovery in the first part of the 2000s, and then another sharp drop with the onset of the recession. Canada's peak came later, in 2004, but has since dropped rapidly. These trends parallel the decline in paper and paperboard production (Figure 13), and the increasing use of waste paper, which was less affected (Figure 14).

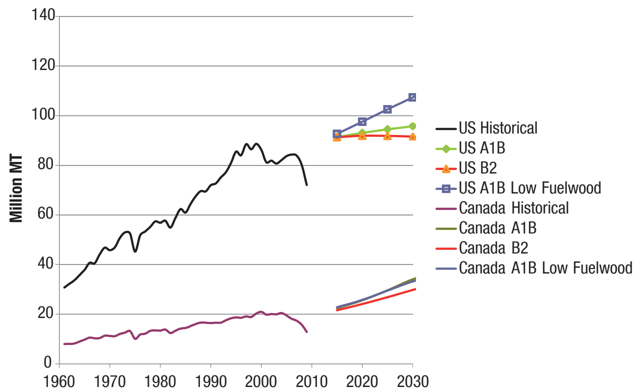
The strong interconnections of the US and Canadian paper markets is revealed by the net export data (Figure 15), exhibiting mirror-image fluctuations in production over nearly the entire 49-years of observation. The general trend of both countries' net exports, however, was positive, with the United States going from net importer to net exporter during the 1990s, falling and then recovering at the end of the last recession by 2009. In Canada, steady growth eroded in the 2000s, falling from a peak net export quantity of 10.8 million metric tonnes (MT) at its historical peak in 2002 to 6.6 million MT by 2009.

Figure 12: Wood pulp production, 1961-2009, and projections to 2030.



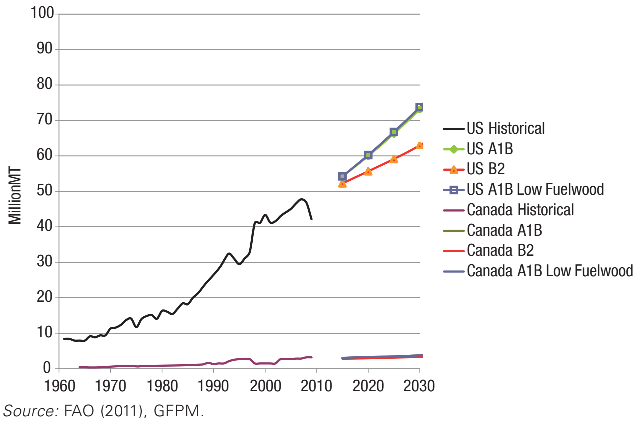
Source: FAO (2011), GFPM.

Figure 13: Total paper and paperboard production, 1961-2009, and projections to 2030.



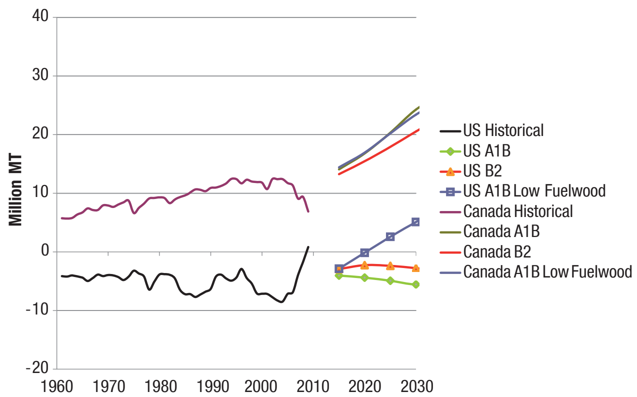
Source: FAO (2011), GFPM.

Figure 14: Recovered paper production, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

Figure 15: Total paper and paperboard net exports, 1961-2009, and projections to 2030.

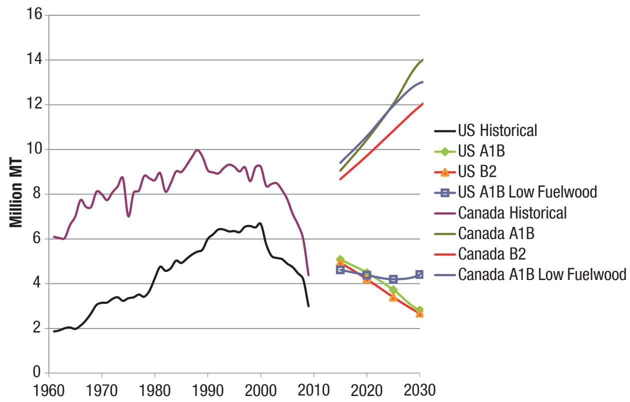


Source: FAO (2011), GFPM.

The main reason for the negative trend in the production of wood pulp during the last decade has been the decline in demand and thus in production of certain categories of paper. A definite negative trend in total paper and paperboard production is detectable after 1999 (Figure 13). This was due to a large fall in production of newsprint (Figure 16) and printing and writing paper (Figure 17). The reasons include the general economic stagnation during that period, shift from printed to electronic media, and the increase of production capacity in countries outside the United States and Canada. The decline has been particularly severe for newsprint.

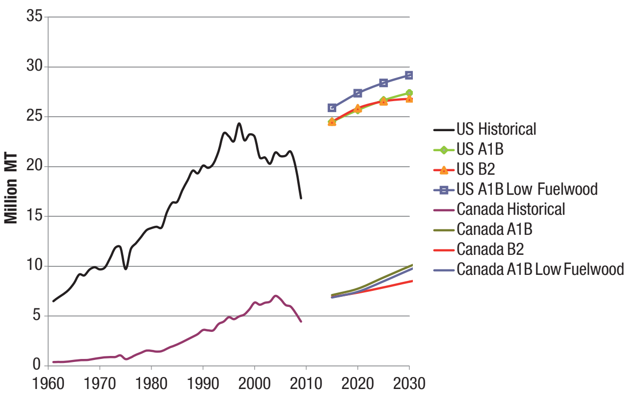
In Canada, which produces more than the United States, production peaked in 1988 (at 10.0 million MT), declined slowly through the 1990s and early 2000s, and then fell to 4.4 million MT by 2009. This decline is explained largely by a decrease of the United States' demand for newsprint, as shown by the pattern of net trade (Figure 18). In the United States, production peaked in 1999, at 6.5 million MT, and fell to 3.0 million MT by 2009. In printing and writing paper, the United States is the larger producer. Its peak production was in 1997 (at 24.3 million MT), falling by 31% (to 16.8 million MT) by 2009. In Canada, the historical peak was 7.0 million MT in 2004, and the 2009 level was 37% lower, at 4.4 million MT.

Figure 16: Newsprint production, 1961-2009, and projections to 2030.



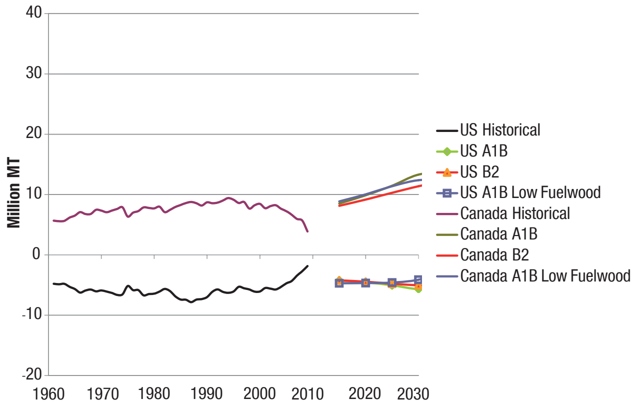
Source: FAO (2011), GFPM.

Figure 17: Printing and writing paper production, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

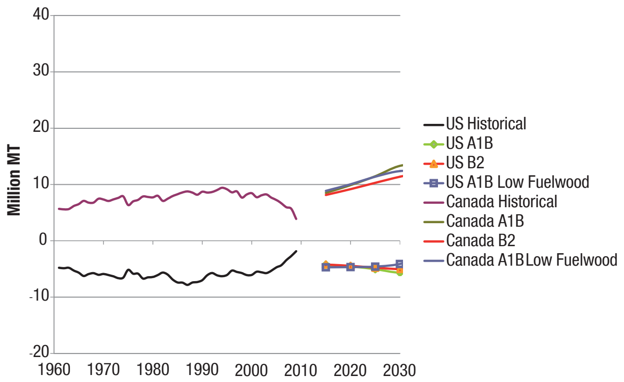
Figure 18: Newsprint net exports, 1961-2009, and projections to 2030.



Source: FAO (2011), GFPM.

Other paper and paperboard products, excluding newsprint and printing and writing paper, and including tissue and corrugated stock, have experienced fewer declines in production than other paper products (Figure 19). Most recently, the US and global recessions have caused a 10% drop in the United States' production, from a 2006 peak (58.5 million MT) to 2009 (52.3 million MT). In Canada, production shrank less in absolute value as other paper and paperboard is a smaller part of the industry in Canada than in the United States, but the percentage decline was greater, 25%, from 5.3 million MT at the 2004 peak to 4.0 million MT by 2009.

Figure 19: Other paper and paperboard production, 1961-2009, and projections to 2030.

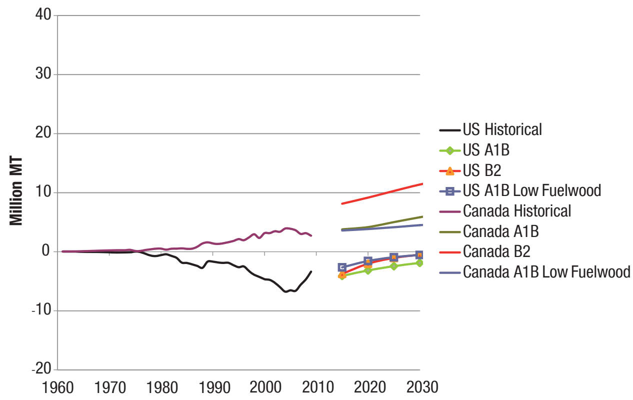


Source: FAO (2011), GFPM.

Net exports of total paper and paperboard (Figure 15), newsprint (Figure 18), and printing and writing paper (Figure 20) exhibit the same kind of mirror image trends and dynamics in the United States and Canada. In the aggregate and sub products, the United States has historically been mainly a net importer and Canada a net exporter. However, this has changed with the economic recession of the late 2000s, the decline in use of print media, and possibly a weakening US dollar relative to the Canadian currency making US products cheaper than Canadian products.

By 2009, the United States had positive net exports of total paper and paperboard (0.8 million MT), while Canada's net exports decreased from a 2002 peak of 12.4 million MT to a 2009 quantity of 6.9 million MT. In newsprint and printing and writing paper, the net exporter status of Canada and net importer status of the United States had both eroded, mainly due to the economic recession in the United States. Net exports of other paper and paperboard (excluding newsprint and printing and writing paper) for both countries have historically been positive. They have been larger and growing faster from the United States than from Canada. Canada's net exports have declined somewhat since 2000, reaching near balanced trade by 2009. Net exports were still growing rapidly in 2008-2009 for the United States.

Figure 20: Printing and writing paper net exports, 1961-2009, and projections to 2030.



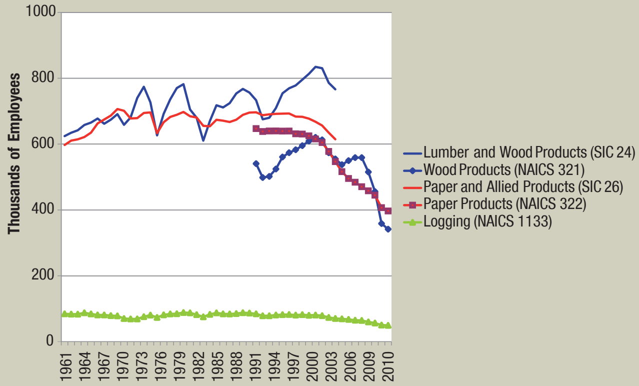
Source: FAO (2011), GFPM.

3.3 Employment changes over time

During the past 50 years, the North American forest sector has undergone rapid labour-saving technology changes. These changes occurred also in other parts of the economy, as capital-intensification reduced the demand for workers throughout a shrinking manufacturing sector, especially in the United States. The result for the forest sector was static to falling employment levels in both lumber and wood products and in paper and allied products (Figure 21). US lumber and wood products (SIC 24) employment has fluctuated in the past along with construction activity and a rising level of employment was evident through the mid-2000s.

However, with the housing market contraction that began in the late 2000s, SIC 24 employment has fallen from its 1999 peak of 834 000employees to an estimated 2010 level of 461 000 (US Department of Labor, Bureau of Labor Statistics, 2011). In US paper and allied products (SIC 26), the decline has been evident since the mid-1990s, when employment hovered around 690 000. By 2010, we estimate that employment in SIC 26 was about 431 000. In forestry and logging (NAICS 133, not shown in Figure 21), data available for the United States since 2001 show a decline from approximately 77 000 employees in 2001 to 37 000 by 2009. The logging subsector (NAICS 1133, shown in Figure 21) has exhibited a more gradual decline over the past several decades, but it had fallen 39% by 2010, compared to average employment level of experienced in 1990 to 1999. In total, by the late 2000s, we estimate that employment in the forest sector based on SIC 24 + SIC 26 approximations plus NAICS 113 was approximately 963 000 nationwide in 2009; based on NAICS categories, the total in 2009 was about 802 000.

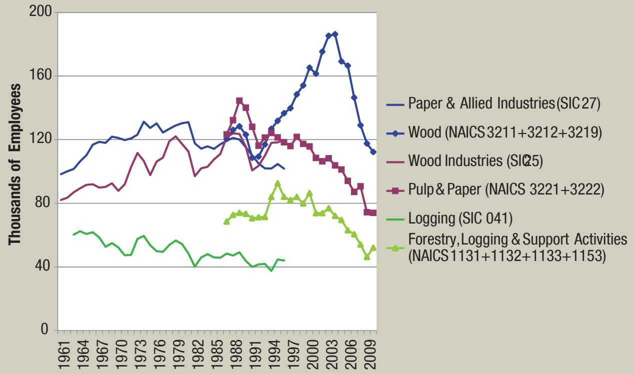
Figure 21: United States forest sector employment, 1961-2010.



Source: US Department of Labor, Bureau of Labor Statistics (2011).

Employment data from Canada (Figure 22) (Statistics Canada, 2011b; Natural Resources Canada, various issues) show that labour force levels in the nation's forest sector (all industries in logging and support, wood products, and paper and allied products) rose from about 249 000 in 1963 to a peak of 308 000 in 1979 according to data based on standard industrial classification (SIC) codes. Using the later NAICS codes, the nationwide total in 1987 was 312 000, peaking in 2003 at 370 000, and then dropping to 238 000 by 2010. These trends are consistent with the overall trends in the production levels described in Figures 1 and 3 to 10.

Figure 22: Canada forest sector employment, 1961-2010.



Source: Statistics Canada (2011b), Natural Resources Canada (various issues).

Labour productivity in forest industries has improved steadily in recent decades in Canada and the United States. In Canada, the quantity of labour input in the wood products sector (shown in Figure 22 for NAICS 3211+3212+3219) per unit quantity of lumber and wood panels output (FAO, 2011) has declined: the average employment per million m^3 produced during 1990-1992 was 2 512; by 2007-2009, it was 2 392, representing a 4.8% improvement in this productivity measure. For the paper sector (NAICS 322), labour input decreased as well, from 7 749 per million MT in 1990-1992 to 5 516 per million MT by 2007-2009, a 28.8% improvement in productivity. In forestry, logging and support industries combined, labour input changed from 455 per million m^3 of industrial roundwood produced during 1990-1992 to 411 per million m^3 during 2007-2009, a 9.7% improvement in productivity.

Combining the employment data exhibited in Figure 21 and data on output from FAO (2011), we observe similar changes in the United States. The number of jobs per million m^3 in NAICS 321 averaged 4 262 in the United States during 1990-1992 and then decreased to 4 073 in 2007-2009, a 4.4% improvement. In NAICS 322, there were 8 760 jobs per million MT of output in 1990-1992, but by 2007-2009 this had fallen to 5 550, improving this measure of productivity by 36.6%. In logging (NAICS 1133) labour input dropped from 199 jobs per million m^3 of industrial roundwood produced in 1990-1992, to 164 jobs per million m^3 in 2007-2009, a 17.4% improvement.

The improvements in labour productivity exhibited in both countries imply that, without output growth, employment would continue to decline. With just modest output growth, employment may not increase significantly. As we will see in the following section, however, depending on whether the decrease in labour intensity of forest product output continues or levels off, total employment in the sector could still recover to pre-recession levels in both countries and even exceed them by 2030.

4

Projections to 2030 for the United States and Canada

The GFPM (described in section 7.1.5) was used in NAFSOS to project forest area and stock, and consumption, production, trade and prices of 14 product categories in the United States and Canada connected to 178 other countries. Annex 1 describes the scenarios used to project forests and markets. Two scenarios were derived from IPCC Emissions Scenarios A1B and B2. They consisted of projections, by country, of income and population (Center for International Earth Science Information Network, 2009) and of bioenergy production including wood. Wood-based bioenergy production was assumed to be a constant share of total bioenergy production projected by the IPCC.

Annex 1 describes how the bioenergy assumptions were implemented in the GFPM. The two scenarios differ from those implemented in EFSOS II in one important way relevant to bioenergy: NAFSOS assumes the creation of an (unspecified) system of incentives for the use of wood in the bioenergy sector, modelled in the product category called “fuelwood”, without attempting to project energy prices and their effects on the amounts of wood entering the bioenergy sector as done in one scenario evaluated in EFSOS II.

Another difference between NAFSOS and EFSOS II is in the assumptions on the effects of climate change. The EFSOS II includes effects of such changes on forest productivity for all European nations. In NAFSOS, forest area and stock in the United States are influenced by projected climate change, and affect timber (roundwood) supply over time. Changes of forest area and stock in all other countries, including Canada, in the current version of the GFPM do not explicitly depend on climate, apart from the effects already embedded in past data on changes in forest stock and area. While ideally the effects of climate change on Canada’s forest resources would have been incorporated into this analysis, we leave this, including effects of climate change on all countries’ forests, to future assessments.[2]

In the description of the projection results, we report projections for the two scenarios, A1B and B2, and for a separate alternative scenario for A1B that drops the assumed growth in the use of wood in the bioenergy sector, and instead assumes (as is the typical modelling framework for GFPM) that fuelwood consumed is used in its historical mix—i.e., to generate heat in homes and electricity and other forms of power used in manufacturing in the forest sector. This special scenario, which we label “A1B-Low Fuelwood,” therefore quantifies, when compared to the A1B scenario, the net effect of assuming the high rate of growth in a wood-using bioenergy sector.

4.1 Projected forest conditions

4.1.1 Forest area

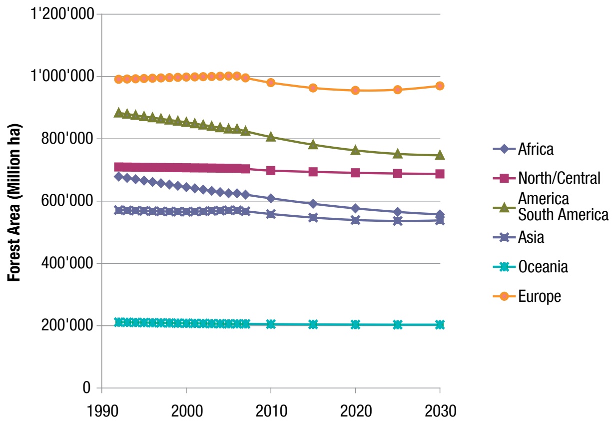
The world forest area is projected to decline between 2006 and 2030 under all three scenarios and across all regions in aggregate (Figures 23 and 24). Area changes are modelled in the GFPM as a quadratic function of a country’s income per capita—as an Environmental Kuznets Curve. This statistical relationship, based on data on

[2] *A strategic assessment of the effects of climate change on Canada’s forests is Williamson et al. (2009).*

forest area change and income per capita in 58 countries, describes falling forest area in poor to middle income nations and increasing forest area in nations with upper ranges of income per capita. Forest area growth peaks for middle income nations. Under both the A1B and B2 scenarios, incomes are projected to rise worldwide, pushing several countries into middle-income status and forest accumulation, but still keeping many countries at low incomes and forest depletion. Because income per capita is the driving variable determining area changes, the projection for forest area is the same for A1B and A1B-Low Fuelwood scenarios (Figure 23).

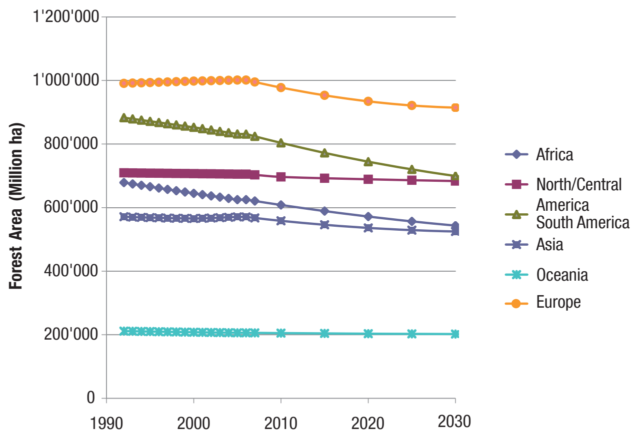
Worldwide, forest area is projected to decline between 2006 and 2030 by 6.0% under A1B and by 9.4% under B2. In the GFPM region "North and Central America" (see section 7.1.5) forest area is projected to decline less steeply, by about 2.6% under the A1B and A1B-Low Fuelwood scenarios, and by 3.1% under the B2 scenario. Europe's forest area, which includes Russia, is projected to decline by 3.1% under A1B and by 8.7% under B2. Africa's forest area is projected to decline by 10.8% under the A1B and A1B-Low Fuelwood scenarios and by 13.1% under the B2 scenario.

Figure 23: Forest area by region, historical and projected to 2030 under A1B.



Source: FAO (2011), GFPM.

Figure 24: Forest area by region, historical and projected to 2030 under B2.



Source: FAO (2011), GFPM.

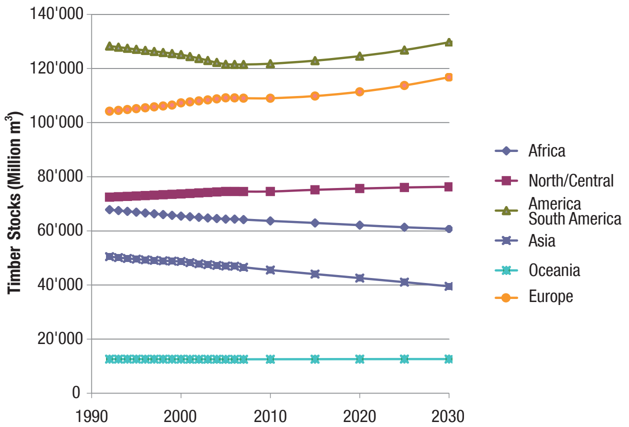
4.1.2 Timber stocks

The world level of forest stock is projected to change less in relative terms than the forest area (Figures 25-27). Stock levels change from year to year as the net result of growth, which in the GFPM depends in part on forest density, minus mortality and harvests. The extent to which stock levels change depends heavily on the rate of harvest. Timber stocks worldwide are projected to increase under the A1B scenario by 2% and under the A1B-Low Fuelwood scenario by 4% from 2006 to 2030. Under the B2 scenario, worldwide stocks are projected to decrease slightly, by 1%. Thus globally, net forest growth is projected to almost match, or exceed harvests, in spite of worldwide aggregate population and income growth and, in the case of the A1B scenario, the emergence of a large wood-using energy sector. However, the regional projections show marked differences.

In North/Central America, stocks are projected to rise by 2% between 2006 and 2030 under the A1B, 3% under B2 and by 4% under the A1B-Low Fuelwood scenario. The overall rise in stock in the region, in the face of falling forest area, indicates that forests are projected to have progressively higher stand densities. The largest increases of forest stock are projected for South America, as much as 8% from 2006 to 2030 under scenario A1B-Low Fuelwood. On the other hand, Asian forest stocks are projected to decline substantially under all three scenarios, by 16%, 13%, and 10% under A1B, B2, and A1B-Low Fuelwood, respectively. European stocks are projected to rise by 7%, 3%, and 9% under these three scenarios, respectively.[3]

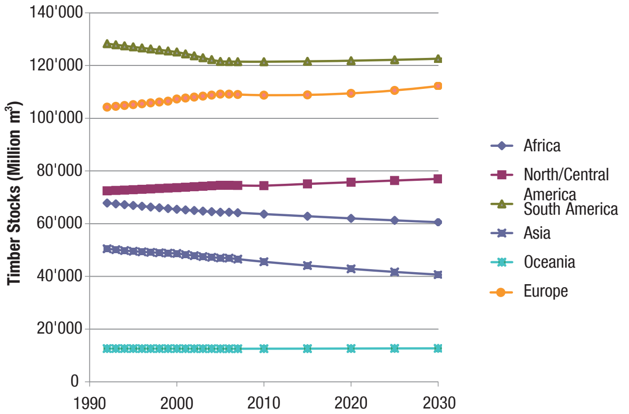
[3] *EFSOS II countries and those identified by the GFPM used in NAFSOS as comprising "Europe" (see section 7.1.5) do not perfectly coincide, so direct comparisons are not warranted.*

Figure 25: Timber stocks by region, historical and projected to 2030 under A1B.



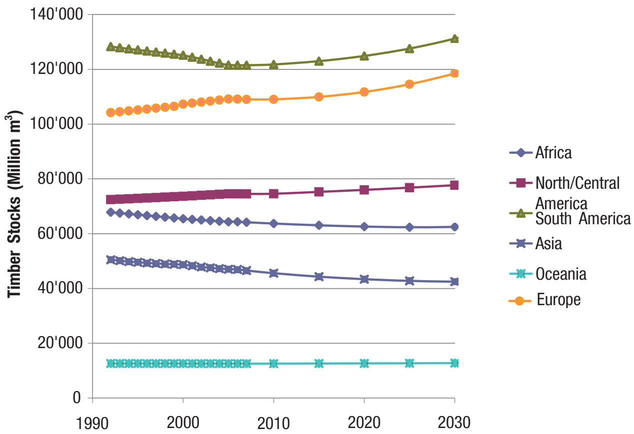
Source: FAO (2011), GFPM.

Figure 26: Timber stocks by region, historical and projected to 2030 under B2.



Source: FAO (2011), GFPM.

Figure 27: Timber stocks by region, historical and projected to 2030 under A1B-Low Fuelwood.



Source: FAO (2011), GFPM.

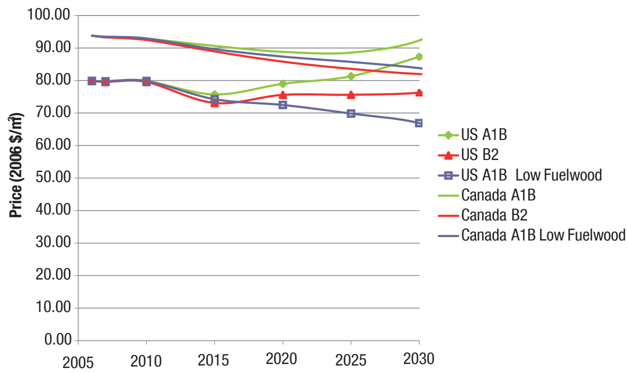
4.2 Projected forest outputs

4.2.1 Industrial roundwood

Industrial roundwood production is an indicator of the overall vibrancy of the domestic timber market. The GFPM projections (Figure 1) suggest that the United States and Canada would, under all three scenarios, return by 2015 near the peak production levels that were observed in the early 2000s. In the United States, industrial roundwood production would continue to increase until 2030 with scenarios A1B and B2, but would stagnate under A1B-Low Fuelwood. In Canada, projections suggest that output would continue to weaken, except at the end of the projection under A1B. The projections of A1B-Low Fuelwood scenario suggest that unless more wood is used for energy, the production of industrial roundwood in both countries would stagnate or even decline after a brief recovery.

These differences become clearer when observing the price projections in the two countries (Figure 28). Under the A1B-Low Fuelwood scenario, industrial roundwood prices are projected to fall from about USD 80/m^3 to about USD 67/m^3 by 2030, while under the A1B scenario they to rise to about USD 88/m^3 by 2030 (in constant 2006 dollars). In Canada, prices fall under all three scenarios, although the emergence of a large, wood-using bioenergy sector pulls up prices under the A1B scenario in the last ten years of the projection, returning them to near the level observed in 2006.

Figure 28: Industrial roundwood price, base year and projected to 2030.



Source: GFPM.

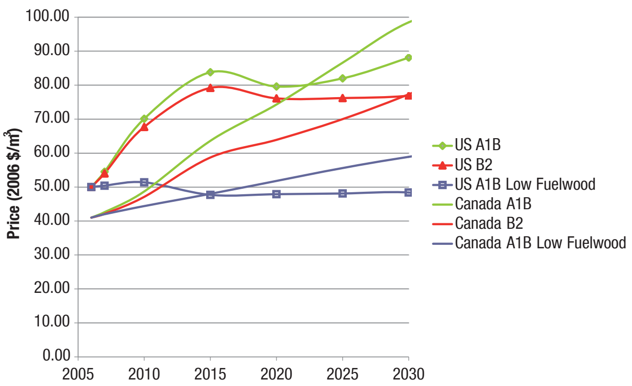
4.2.2 Fuelwood

Fuelwood is the means by which the NAFSOS projections accommodate the assumed rapid rise in the use of wood to produce energy in scenarios A1B and B2 as one way of mitigating carbon emissions from fossil fuel consumption. The

A1B scenario in both the United States and Canada leads to the highest increase in fuelwood production, rising by about 5-fold by 2030 compared to 2006 levels in the United States (from about 40 million to 205 million m^3) and by 7-fold in Canada (from 2.2 to 14.3 million m^3) (Figure 3). Under scenario B2, the rise is somewhat smaller in the United States, to 175 million (4.3 times higher) and Canada, to 6.5 million m^3 (3 times higher). Under the A1B-Low Fuelwood scenario, the US production level increases very little, to 51 million m^3 by 2030, and somewhat faster in Canada (to 4.6 million m^3).

Thus, the United States' production of fuelwood is highly dependent on the assumed emergence of a wood-based bioenergy sector. Fuelwood prices under the A1B and B2 scenarios are projected to rise in both countries from the 2006 levels of about USD 50/m^3 in the United States and USD 41/m^3 in Canada (Figure 29). Under scenario A1B, prices rise to about USD 88 in the United States and USD 98 in Canada, slightly surpassing the price of industrial roundwood. Under scenario B2, both countries' prices arrive at about USD 77. Under the A1B-Low Fuelwood scenario, where a wood-using bioenergy sector does not emerge to the degree projected by the IPCC, prices still rise in Canada, nearly doubling from 2006 levels to about USD 59 by 2030, but remain virtually constant in the United States.

Figure 29: Fuelwood price, base year and projected to 2030.



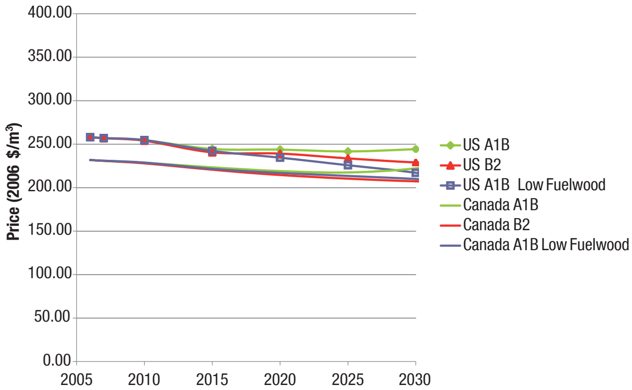
Source: GFPM.

4.2.3 Sawnwood

The effects of the housing market contraction in the United States have been evident in the recent data on sawnwood for both the United States and Canada. While there has been a strong positive correspondence between US and Canadian sawnwood production in the historical record (Figure 4), driven by US housing starts (Figure 2) and leading to increasing US imports and Canadian exports (Figure 5), the projections suggest a movement toward more balanced sawnwood trade in the coming decades for both the United States and Canada.

The more balanced trade is caused mainly by a projected reduction in the growth of demand for sawnwood in the United States. In all three scenarios shown in Figure 4, US production levels rise (presumably after recovery from the housing market contraction of the late 2000s evident in the historical data, although this contraction and recovery is not explicitly modelled in NAFSOS). In Canada, production achieves its early 2000s level by 2015 but declines from that point forward under all three scenarios. Under all three scenarios, prices for sawnwood are projected to decline (Figure 30). The price decreases the most in the United States under scenario A1B-Low Fuelwood, where little industrial roundwood is diverted to energy, thus keeping the price of industrial roundwood (Figure 28), the main cost in sawnwood production, down.

Figure 30: Sawnwood price, base year and projected to 2030.



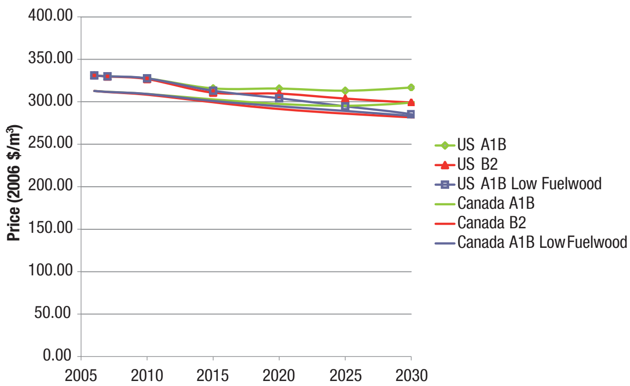
Source: GFPM.

4.2.4 Wood-based panels

All three scenarios suggest a recovery from the housing market contraction (observed but not explicitly modelled in this NAFSOS) by 2015, with rising overall output to 2030. The peak output of total wood panels occurs in 2020 under scenarios A1B and B2 for the United States (Figure 6). Production levels by 2015 are projected to match or exceed the highest observed (late 1990s or mid-2000s levels) in both countries from 2015 onward. Growth is strongest under the A1B scenario for Canada but under the A1B-Low Fuelwood scenario for the United States. Scenario B2 has the lowest overall growth rate compared to 2006 levels in both countries, reflecting the lower economic growth assumed under this scenario.

Without competition from the bioenergy sector under A1B-Low Fuelwood in the United States, the low price of industrial roundwood input (Figure 28) into the wood panels sector allows for the most rapid and steady expansion of this product aggregate in the United States. In Canada, however, under the A1B-Low Fuelwood scenario, the strong US production growth erodes Canada's export position relative to that of the United States, and so growth in its net exports is constrained (Figure 7), and US net exports become less negative. Price projections for wood panels (Figure 31) show declines under all scenarios, but less so under scenario A1B for both the United States and Canada. Starting from an average price of about USD 330 in the United States and USD 310 in Canada in 2006, prices decrease slightly, to about USD 320 under scenario A1B in the United States and to about USD 300 in Canada. Like for sawnwood, the largest price decline of wood-based panels occurs in the United States under scenario A1B-Low Fuelwood.

Figure 31: Wood-based panels price, base year and projected to 2030.



Source: GFPM.

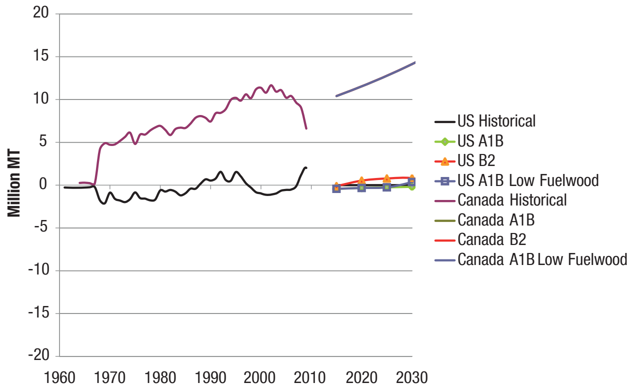
The results for the wood-based panels aggregate hide strong differences between its components. Fibreboard (Figure 8) and particleboard production (Figure 9) closely mimic the projection for the aggregate wood-based panel market, with rises under all three scenarios for both countries. The veneer + plywood category (Figure 10), however, exhibits different trends according to scenario. Under A1B and B2, after a recovery to late 1990s levels of output by 2015 and 2020, production declines. In contrast, without the use of wood for energy under the A1B-Low Fuelwood scenario, production reaches levels in the United States that were last observed in the 1980s.

In Canada, veneer + plywood reaches production levels by 2015 that match those of the 2000s, and then rise from there, to nearly 5 million m^3 by 2030 under scenarios A1 and B2. In trade, the United States almost eliminates its deficit by 2030 under scenario A1B-Low Fuelwood, but resumes a strong import dependence after 2015 under A1B and B2 (Figure 11). In accord with the tight connection between the two countries, Canadian exports behave almost symmetrically with respect to US imports, decreasing after 2015 under A1B-Low Fuelwood, and increasing under A1B and B2.

4.2.5 Wood pulp

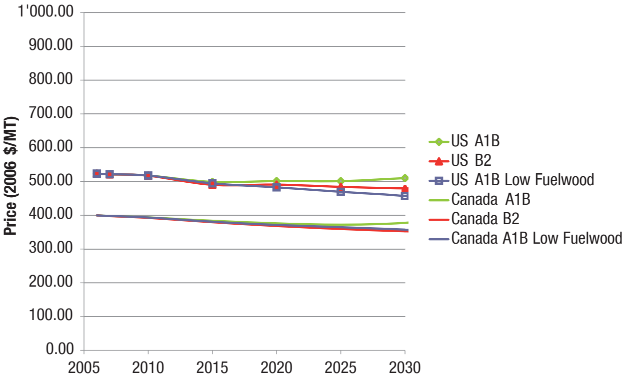
Projections for both scenarios, A1B and B2, show that, after recovery from the recent global economic downturn, total wood pulp production is projected to return by 2015 to levels observed in the early 2000s in both the United States and Canada (Figure 12). In Canada, there is a projected steady rise from 2015 (to over 34 million MT by 2030), while in the United States, after achieving about 51 million MT by 2015, output is projected to decrease or at best stagnate. Under scenarios A1B and B2, production falls to below even the 2009 level and by 2030 reaches levels last observed in the United States in the early 1980s (less than 45 million MT). Under the A1B-Low Fuelwood scenario, US output remains nearly constant between 2015 and 2030. Net exports do not change appreciably for the United States under any of the scenarios (Figure 32). In Canada, net exports return to the levels observed in the 2000s and then rising to 14 million MT by 2030. Throughout the projected period, Canada is able to produce cheaper wood pulp (Figure 33), and thus to stimulate its exports and production.

Figure 32: Wood pulp net exports, historical, 1961-2009, and projected to 2030.



Source: GFPM.

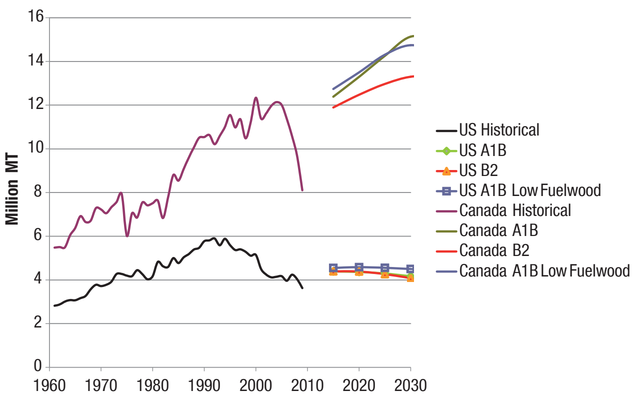
Figure 33: Wood pulp price, base year and projected to 2030.



Source: GFPM.

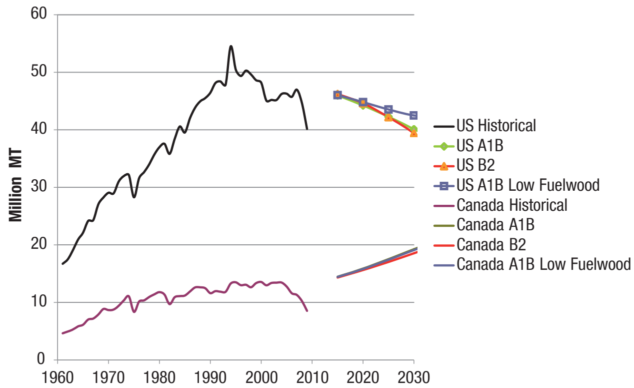
Projections of production of the two major subcategories of wood pulp, mechanical and chemical, are shown along with their historical amounts in Figures 34 and 35. Mechanical wood fibre pulp is used especially in the production of newsprint and paperboard, and hence its trends closely follow production of newsprint and the aggregate category of “other paper and paperboard”. Chemical wood pulp is destined for a variety of uses, including printing and writing paper and packaging, and so its historical and projected production follow all of the subcategories of paper outputs shown in Figures 16, 17, and 19.

Figure 34: Mechanical wood pulp net exports, historical, 1961-2009, and projected to 2030.



Source: FAO (2011), GFPM.

Figure 35: Chemical wood pulp net exports, historical, 1961-2009, and projected to 2030.



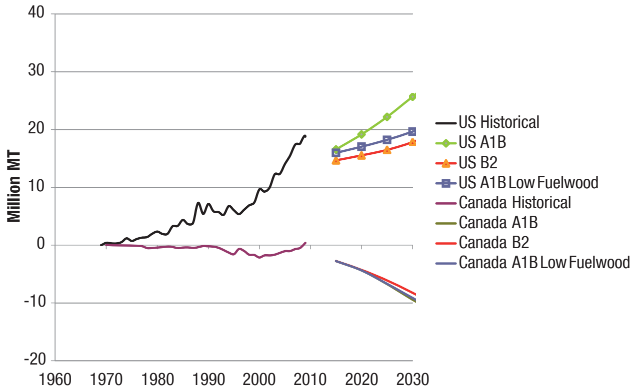
Source: FAO (2011), GFPM.

4.2.6 Recovered paper

The historical record for recovered paper has been one of steady rises in the United States. In percentage terms, the rises are similar in Canada (Figure 14). This steady rise in recovered paper production is projected to continue to 2030. The strongest rises in the projected future occur with the more rapid economic growth projected under scenarios A1B and A1B-Low Fuelwood. In the United States, output is projected to achieve levels by 2015 under all three scenarios that were never achieved in the historical record—to over 50 million MT, rising to nearly 63 million MT by 2030 under scenario B2 and 73 million MT under scenarios A1B and A1B-Low Fuelwood. In Canada, recovered paper production would rise by about 15 to 20% by 2030 compared to late 2000s levels. Net exports levels have been larger and positive for the United States since the beginning of the available record (1970) (Figure 36). These increased somewhat unsteadily to nearly 20 million MT by 2009.

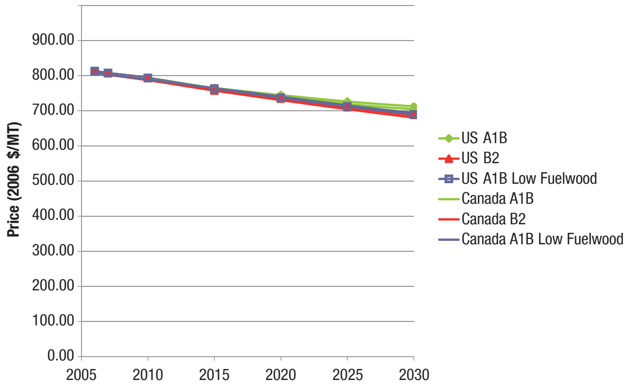
Projections indicate that following recovery from the current economic downturn, net exports from the United States will remain below 20 million MT but may rise somewhat. This expansion is fuelled in part by the projected increase in the recovery rate, which should reach 65% in North America according to scenario A1B, and 61% with scenario B2 (see Figure 59). In contrast, Canada, a small supplier of recycled fibre compared to the US, and which is projected to increase in its use of recycled fibre for paper manufacture, is projected to become a net importer and see its trade balance deteriorate from current levels of approximate parity.

Figure 36: Recovered paper net exports, historical, 1970-2009, and projected to 2030.



Source: FAO (2011), GFPM.

Figure 37: Total paper and paperboard price, base year and projected to 2030.



Source: GFPM.

4.2.7 Paper

Under all three scenarios, total paper and board output of the United States and Canada is projected to rise to historic levels by 2030 (Figure 13). The largest percentage increases are projected for Canada, under all three scenarios, with the lowest rate of increase projected under scenario B2. For the United States, after achieving record outputs in 2015, B2 is the only scenario with projected steady output. Production increases faster after 2015 under the A1B-Low Fuelwood scenario, partly because wood input prices remain lower (Figure 28). Up to 2009, the United States was a net importer of total paper and paperboard, mostly from Canada (Figure 15).

In the late 2000s, with the recession came a collapse of United States' paper imports and a slight positive trade balance. The projections suggest that this change is temporary and that the US will continue to be a net importer under scenarios A1B and B2. However, under scenario A1B-Low Fuelwood the US becomes a net exporter of paper and paperboard by 2030. For Canada, all three scenarios project a recovery to trade dominance for Canada's paper sector by 2015, with net exports rising to nearly 15 million MT by then and to more than 20 million by 2030. In all scenarios the real price of paper and paperboard is expected to decline throughout the projection period from slightly more than USD 800 per metric tonne to about USD 700 per metric tonne by 2030 (Figure 37).

The future trends of newsprint production are similar for all three scenarios, but the trajectory for the United States is very different from that of Canada, the dominant producer (Figure 16). Both Canada and the United States, historically producing mainly for the US market, have had a strong drop in production (and consumption) since the late 1990s. The projections indicate that for the US after an initial recovery, there would be continued erosion of production from 2015 to 2030, except for scenario A1B-Low Fuelwood. In Canada, production is projected to rise steadily after a more than full recovery from the 2000s decline, to output levels ranging from 12 million MT (B2 scenario) to 14 million (A1B scenario). This growth is due in part to an increase of Canadian exports to new markets outside the United States, especially in Asia, while US exports would hardly change from 2000s levels (Figure 18).

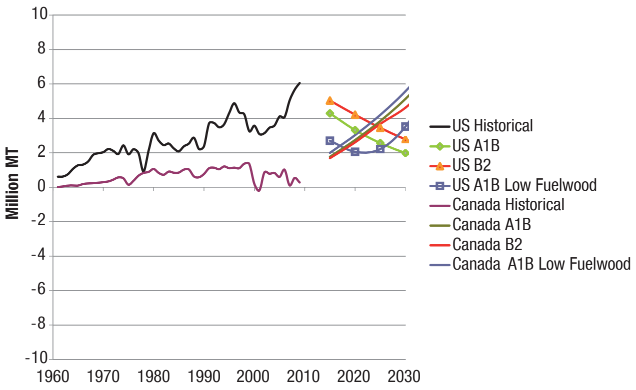
Printing and writing paper has also experienced a decline in production in the United States and Canada, especially during the recent economic crisis (Figure 17). Nevertheless, in accord with the positive assumptions of long-term gross domestic product (GDP) growth in the IPCC scenarios, the projections indicate recovery and growth of printing and writing paper production until 2030. The A1B and A1B-Low Fuelwood scenarios lead to the highest total outputs by 2030, to 29 million MT in the United States (A1B-Low Fuelwood scenario) and just over 27 million (A1B scenario), with the lowest projection for scenario B2 (almost 27 million). In Canada, production is projected to rise to nearly 10 million MT by 2030 under the A1B and A1B-Low Fuelwood scenarios; scenario B2 has output projected at about 8 million MT.

Although the United States and Canada have had mirror-image trade positions in the historical record to the late 2000s (Figure 20), projections indicate that both countries should see some

improvement in their trade positions to 2030. Due to the increasing demand outside of North America, the net trade of both countries is projected to improve. The net exports from the United States are projected to be less negative and achieve near balance, while those of Canada are projected to rise from around 3 million MT to over 10 million under scenario B2 by 2030, with lower increases projected under the A1B and A1B-Low Fuelwood scenarios.

The largest subcategory of the Total Paper and paperboard aggregate is "other paper and paperboard," for which historical data show rises in output for both the United States and Canada (Figure 19). There was a downturn in the late 2000s, due to the general economic recession, but projections indicate a recovery and then growth up to 2030, in most scenarios. The United States' production is projected to reach 68 million MT by 2030 under A1B, but production would hardly change under scenario B2. In Canada, production reaches over 9 million MT by 2030 under all three scenarios. Both the United States and Canada have been net exporters of other paper and paperboard in the past (Figure 38), and all three scenarios suggest that they will remain net exporters through 2030. However, in the United States, net exports are expected to decrease to less than 4 million MT by 2030. In Canada, on the other hand, net exports are projected to recover and increase steadily to between 4 and 6 million MT, depending on the scenario, by 2030.

Figure 38: Other paper and paperboard net exports, historical, 1970-2009, and projected to 2030.



Source: FAO (2011), GFPM.

4.3 Projected competitiveness

The projections of production, net trade, and prices reported above were elaborated further to measure the past and future competitiveness of the United States and Canada relative to other regions, in forest product industries. While the projections of competitiveness we provide here are intended to focus on changes expected for Canada and the United States vis-à-vis the rest of the world, data and illustrations provided for major reporting regions should not be considered in conflict from similar assessments offered in other Outlook studies for those regions (e.g., Europe).

Figures 39-41 show the revealed comparative advantage (RCA) in total forest products for the United States, Canada, Europe, South America, Africa, Asia, and Oceania under scenarios A1B, B2, and A1B-Low Fuelwood. The RCA index is the ratio of the country's (region's) value of net exports to the value of a country's (region's) total domestic production at local prices (see Annex 7.4.2).

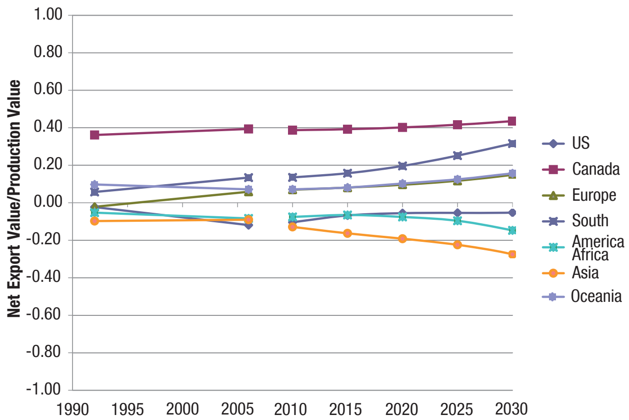
The three figures show that Canada, the world's largest exporter of forest products, has had in recent years the world's highest RCA, and that it is projected to retain that advantage to 2030 under all three scenarios. The recent experience of stability in Canada's RCA index reveals that net exports have remained a relatively stable share of its total production, in spite of Canada's most recent reductions in total forest product outputs. The United States, in contrast, has long been a net importer, resulting in a negative RCA index. By 2030, under each scenario, the RCA of the United States is projected to improve slightly under all three scenarios, even reaching zero (balanced trade) by 2030 under the A1B-Low Fuelwood scenario.

South America, Europe, and Oceania have had, like Canada, an RCA in forest products relative to other regions in the past (positive RCA indices), and projections indicate a continuation of this trend. Although we do not show the RCA indices for individual countries besides Canada and the United States, it is worth noting that South America's position derives from strong comparative advantage in Brazil and Chile and to a smaller extent Argentina. Europe's advantage stems mainly from Finland, Sweden, Norway, and Austria. Oceania's values are

aggregates of mainly Australia and New Zealand, and these two countries both demonstrate comparative advantages that are projected to be maintained to 2030.

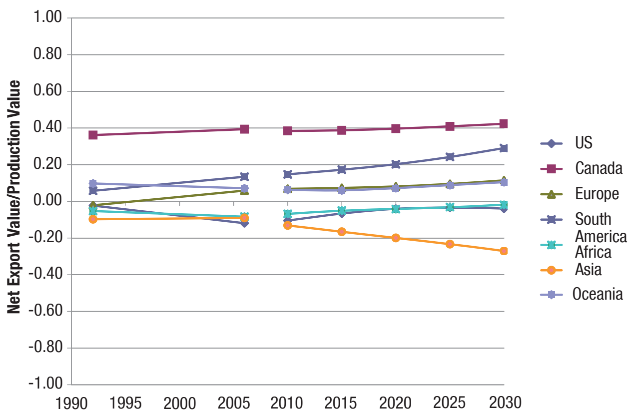
While Asia as a whole demonstrates a negative RCA throughout recent history and into the projected future under all three scenarios, countries with positive past and projected RCA indices include Indonesia and Malaysia.

Figure 39: Total forest products RCA, historical (1990, 2005), and projected to 2030 for scenario A1B.



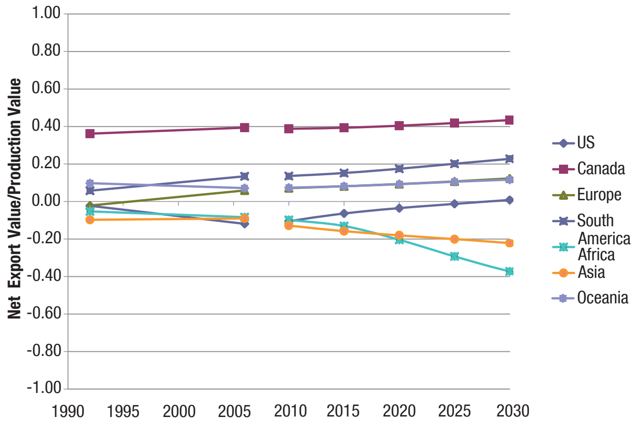
Source: FAO (2011), GFPM.

Figure 40: Total forest products RCA, historical (1990, 2005), and projected to 2030 for scenario B2.



Source: FAO (2011), GFPM.

Figure 41: Total forest products RCA, historical (1990, 2005), and projected to 2030 for scenario A1B-Low Fuelwood.



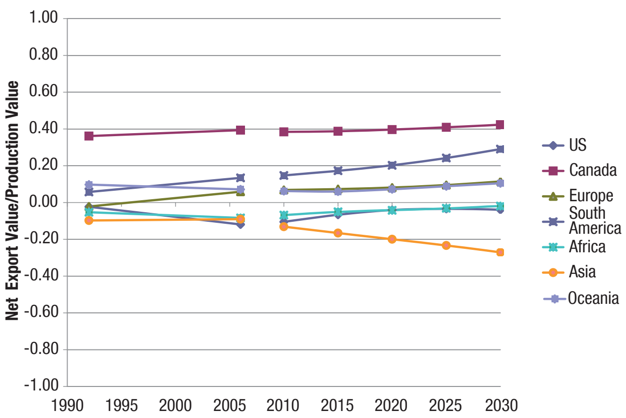
Source: FAO (2011), GFPM.

Figures 42-56 show more industry detail, with RCA indices for total roundwood, sawnwood, total wood panels, total wood pulp, and total paper.

The figures indicate that, as in the past, and under all three scenarios, Canada is projected to retain a large, positive comparative advantage in all product categories, except total roundwood, until 2030. Although similar patterns exist for other countries in Europe, South America, Asia, and Oceania, for the purpose of NAFSOS, the RCA projections for Canada document its future continuing dominant position in North America as the provider of forest products to meet the excess demands principally of the United States, but also of other emerging economies, especially in Asia.

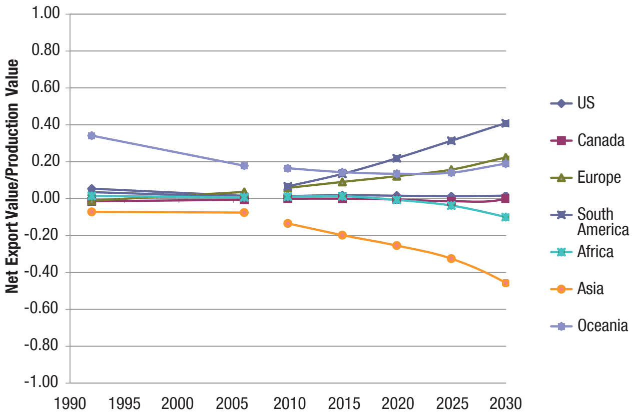
For the United States, the RCA indices suggest that the country remains at a disadvantage up to 2030 in sawnwood, wood panels, and paper industries, with more balanced positions in roundwood and wood pulp. However, the RCA is projected to improve over time for most product categories and scenarios, especially under scenario A1B-Low Fuelwood, as producers in the United States benefit from low wood prices.

Figure 42: Total roundwood RCA, historical (1990, 2005), and projected to 2030 for scenario A1B-Low Fuelwood.



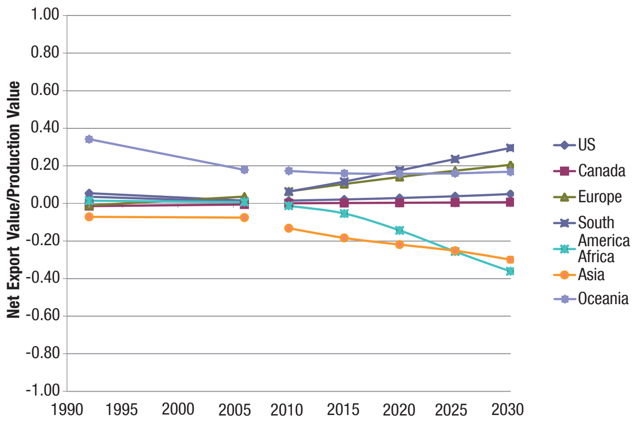
Source: FAO (2011), GFPM.

Figure 43: Total roundwood RCA, historical (1990, 2005), and projected to 2030 for scenario B2.



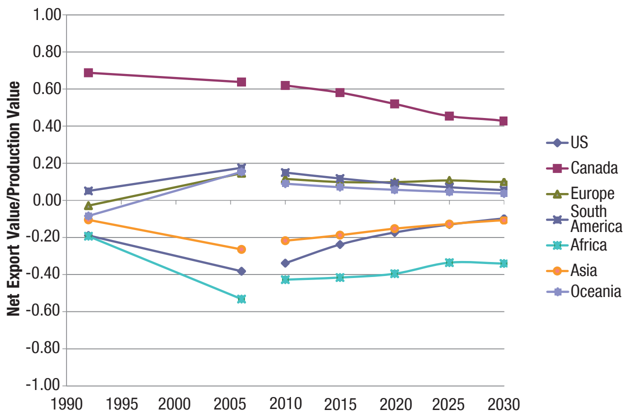
Source: FAO (2011), GFPM.

Figure 44: Total roundwood RCA, historical (1990, 2005), and projected to 2030 for scenario A1B-Low Fuelwood.



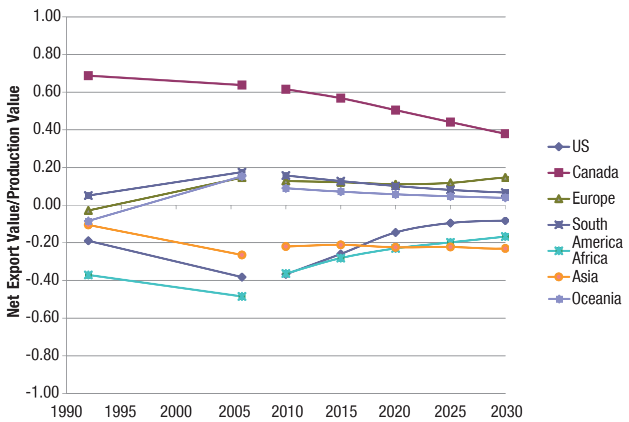
Source: FAO (2011), GFPM.

Figure 45: Sawnwood RCA, historical (1990, 2005), and projected to 2030 for scenario A1B.



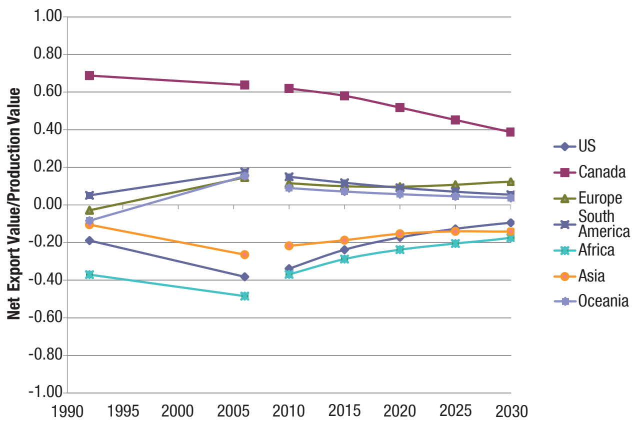
Source: FAO (2011), GFPM.

Figure 46: Sawnwood RCA, historical (1990, 2005), and projected to 2030 for scenario B2.



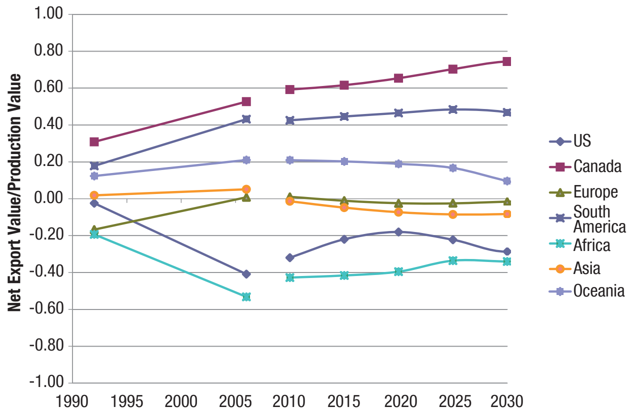
Source: FAO (2011), GFPM.

Figure 47: Sawnwood RCA, historical (1990, 2005), and projected to 2030 for scenario A1B-Low Fuelwood.



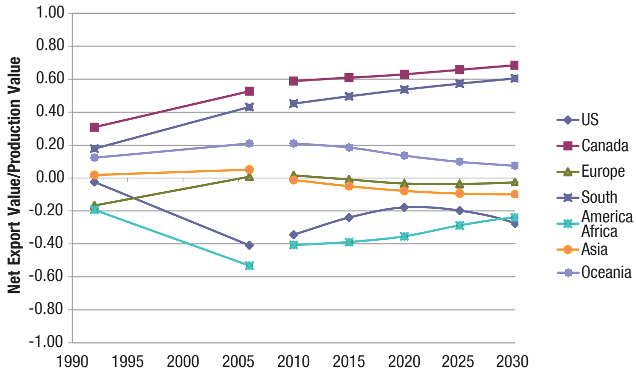
Source: FAO (2011), GFPM.

Figure 48: Wood-based panels RCA, historical (1990, 2005), and projected to 2030 for scenario A1B.



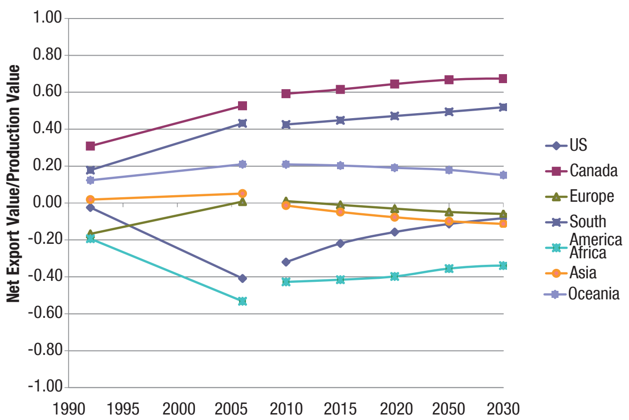
Source: FAO (2011), GFPM.

Figure 49: Wood-based panels RCA, historical (1990, 2005), and projected to 2030 for scenario B2.



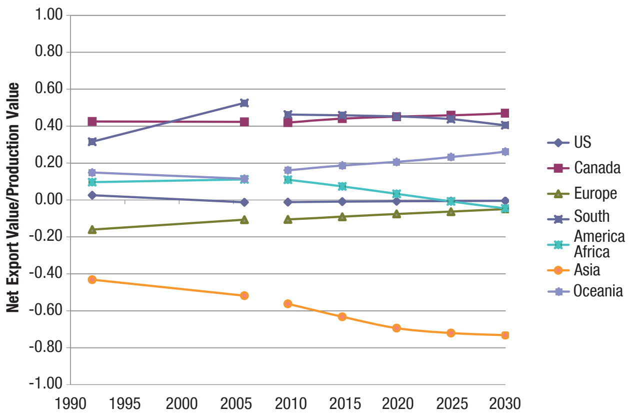
Source: FAO (2011), GFPM.

Figure 50: Wood-based panels RCA, historical (1990, 2005), and projected to 2030 for scenario A1B-Low Fuelwood.



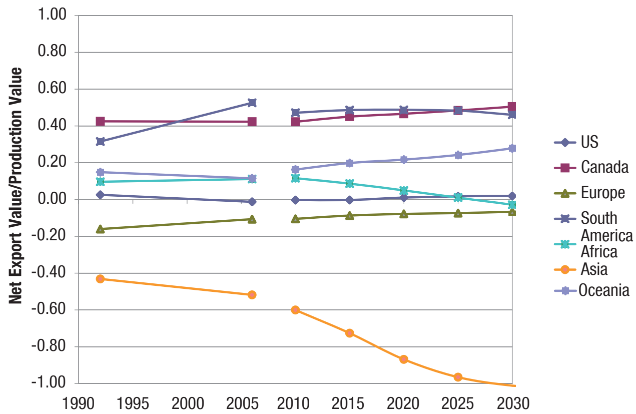
Source: FAO (2011), GFPM.

Figure 51: Total wood pulp RCA, historical (1990, 2005), and projected to 2030 for scenario A1B.



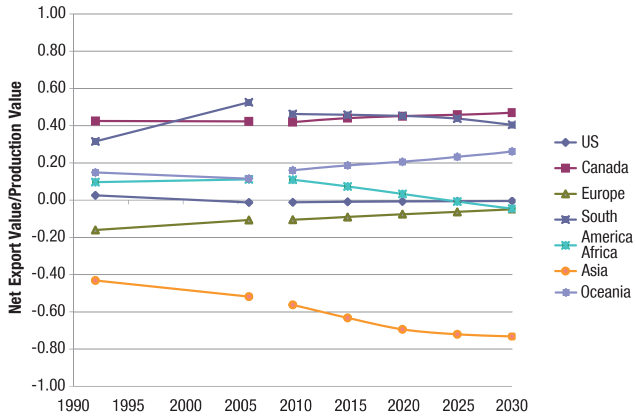
Source: FAO (2011), GFPM.

Figure 52: Total wood pulp RCA, historical (1990, 2005), and projected to 2030 for scenario B2.



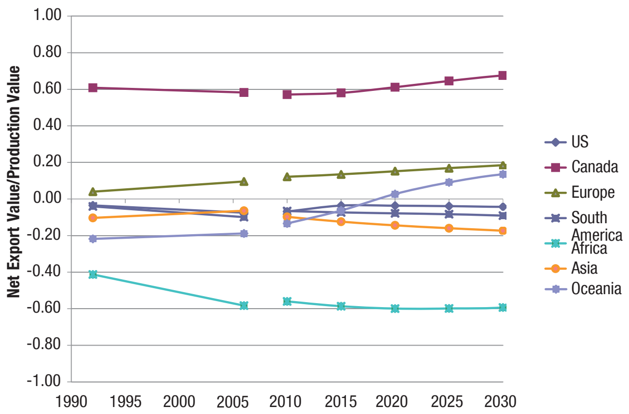
Source: FAO (2011), GFPM.

Figure 53: Total wood pulp RCA, historical (1990, 2005), and projected to 2030 for scenario A1B-Low fuelwood



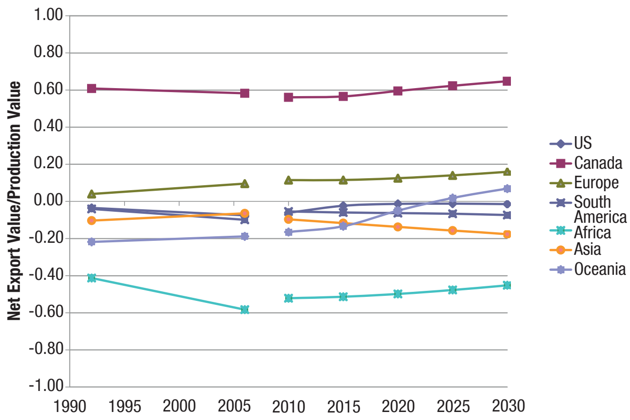
Source: FAO (2011), GFPM.

Figure 54: Total paper and paperboard RCA, historical (1990, 2005), and projected to 2030 for scenario A1B.



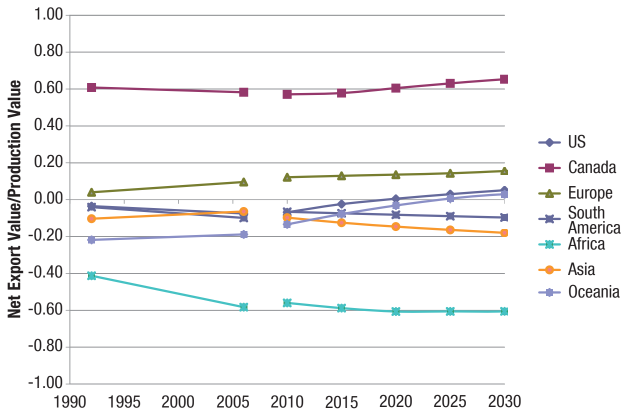
Source: FAO (2011), GFPM.

Figure 55: Total paper and paperboard RCA, historical (1990, 2005), and projected to 2030 for scenario B2.



Source: FAO (2011), GFPM.

Figure 56: Total paper and paperboard RCA, historical (1990, 2005), and projected to 2030 for scenario A1B-Low Fuelwood.



Source: FAO (2011), GFPM.

5 Summary and conclusions

The United States and Canada have experienced large changes in their forest sectors over the past 50 years. Projections for the two countries to 2030 have been made with a global model to account for concurrent changes in other countries. Three future scenarios were investigated: two IPCC-based scenarios assuming the rapid growth of wood-based energy, and one IPCC-based scenario without this assumption. The future of the sector broadly derives from changes in population and income, as human use of forest land and consumption of forest products shape market development over time.

Economic and demographic growth, along with changes in product demand and technology such as increased waste paper in papermaking and efficiencies in wood use, combine to affect future forests. Forest area is projected to decline globally at a rate of 0.25% to 0.4% per year between 2006 and 2030. Slower changes are expected in North and Central America, and faster changes in other regions. Global stock levels are projected to decline relatively less than area, indeed to increase in North America, but to decrease substantially in Asia, indicating that although projected forest growth may nearly match harvests globally, there may be serious deficits in regions with large populations and fast growing economies.

Markets for wood products, which mainly are destined for the construction sector in North America, are projected to recover by 2015 under all three scenarios examined. Sawnwood production is then projected to continue to grow in the United States. In Canada, all scenarios project a decline in output following an initial recovery. But in wood panels, both countries are projected to resume rising rates of production, reflecting continuing demand for products (for example, structural wood panels in engineered glulam beams) that can partially substitute for solid lumber in some building applications (Engineered Wood Systems, 1999), especially in the United States.

The pulp and paper sector faces an onslaught of rapid changes: new production capacity outside the United States and Canada, rapid rising consumption in Asia, declining uses of newsprint and printing and writing paper in communications, and continued growth in the use of recycled fibre in manufacture. The net effect of these changes is to keep the United States' wood pulp production from recovering much from the recently low levels. But Canada's comparative advantage in pulp and paper and the growth of markets outside the United States, especially in Asia, is projected to lead wood pulp production to higher levels. Projections suggest that, in spite of declining use of paper for media, other paper and paperboard for packaging and miscellaneous uses will continue to enjoy strong global demand, stimulating Canada's exports especially to Asia.

The effect of the development of a major wood-based bioenergy sector has been investigated through the separate simulation of the A1B scenario that drops the IPCC assumption of its rapid emergence (A1B-Low Fuelwood). The results show that development of a wood-based bioenergy sector would be to divert industrial wood currently used in making sawnwood, panels, and paper, thus leading to higher wood prices and lower output of products. Wood-based panels would be particularly affected as they would increase more than the price of lumber. Nevertheless, the

United States would remain a net importer of forest products and there would be little effect on Canada's positive trade position.

The development of a wood-based bioenergy sector has the effect, other things being equal, of increasing the price of wood raw material (fuelwood and industrial roundwood), and decreasing but relatively less the price of manufactured products (sawnwood, panels, paper). In essence, the expansion of wood use for energy would benefit timber (and timberland) owners in the United States and Canada and erode the profits of manufacturers, basically representing a transfer.

The development of a wood-based energy sector could be stimulated in several ways: through targeted incentives (taxes or subsidies) legislated by governments, the creation of a carbon emissions trading system that included standing timber or wood products as carbon offsets, technical innovations, or a market-driven increase in the profitability of wood-based energy. Profitability could rise due to higher energy prices, which might emerge from high demand for and limited supply of fossil fuels, higher taxes on the same fuels, or through subsidies that encourage the consumption of wood-based energy. The effect of those changes could be investigated in the future with the GFPM structure which can accommodate multiple exogenous changes such as a rise in the price of energy.

The consequences of future income and population growth, technology changes, and the possible emergence of a large wood-using bioenergy sector have been condensed into measures of comparative advantage of countries and regions in forest product industries. A consistent thread in the results is that Canada is expected to retain a high comparative advantage relative to the United States and other world regions. Meanwhile, the United States, which has exhibited in the past a comparative disadvantage, is projected to improve its position slightly, but still remain a net importer.

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7 Annexes

7.1 Annex 1: GFPM in the 2010 RPA Assessment

The 2010 RPA Assessment is the latest effort by the United States Government, specifically the United States Department of Agriculture, Forest Service, to meet the language and requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974. The RPA Assessment describes current forest and rangeland conditions and recent trends, identifies the factors understood to be the drivers of past and future changes in these conditions, and projects 50 years into the future the likely state of many variables important to policy makers, forest product consumers and producers, and the users of forests. The 2010 RPA Assessment is labelled an integrated assessment because it jointly predicts the future conditions of multiple categories of factors important to policy makers and the public.

The 2010 RPA Forest Assessment System contains several models that operate jointly to project the future of forests and their outputs. The models receive exogenous information (projections) about the future of wood used in the bioenergy sector, climate and climate change, economic growth, and human populations at large and small spatial scales. The model outputs are assessments of forest and range conditions, markets, urban forests, water, wildlife, recreation, and landscape patterns.

The Forest Assessment contains information specific to the forest product sector, which is the focus of NAFSOS. Included in the Forest Assessment System is a domestic (US) inventory projection model and a global market model with enough detail about the United States to meet the precise objectives of the RPA. The global market model is the GFPM. One version of the GFPM, called the US Forest Products Module (USFPM), contains specific detail about product markets and forest inventory that are required for the RPA Assessment. This version works iteratively to project domestic market conditions. The version of GFPM used in this study, utilizes some of the information from the domestic forest sector of the US provided in the USFPM-GFPM to also model the US in the context of the rest of the countries of the world.

7.1.1 Population and income projections

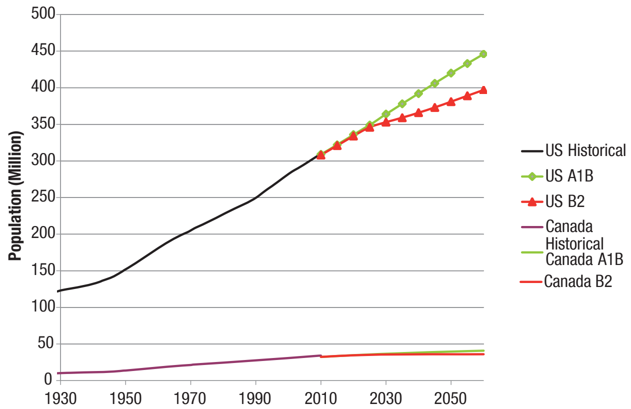
The 2010 RPA modelling of the global forest sector using the GFPM required projections by country of population and income, necessary inputs deriving demand shifts over time across these countries. The IPCC provides national projections of income and population (Center for International Earth Science Information Network, 2009). However, the IPCC projections assumed essentially constant income growth rates across all countries residing within an IPCC region. These IPCC income growth projections may be valid projections of regional economic output over time, but the income growth results in projections of income for wealthy countries within poor regions that are too high to match historical observations regarding convergence in per capita incomes globally.

Similarly, poor countries within wealthy regions delineated by the IPCC are projected to grow to incomes per capita that also depart significantly from historical data on income convergence. For the 2010 RPA, and by extension NAFSOS, we used international income convergence theory to upwardly adjust the income projections of poorer countries within wealthy regions and downwardly adjust income projections of wealthier countries within poorer regions. These adjusted income (and income per capita) projections were used to develop the forest area projections that form part of the GFPM output that is also reported for this NAFSOS for Canada and the United States.

The 2010 RPA did not face the regionally accurate but by-country inaccuracy problems with respect to the population projections of the IPCC under each scenario. For scenario A1B, US population was projected according to the US Bureau of the Census (2004), adjusted upward so that base year projected population matched the Census estimate for 2006. For scenario B2, proportional differences in population between the IPCC projections of A1B and B2 were maintained to the ending projection year. For US GDP, a specially commissioned US macroeconomic outlook report from the USDA Economic Research Service (ERS) was used. To match 2006 base year values, the official GDP (US Department of Commerce, 2008) was used. For scenario A1B, GDP growth rates as projected by ERS were used to project GDP from 2006 to the ending projection year. For B2, US GDP was projected such that the proportion difference between A1B and B2 as given by the IPCC (Center for International Earth Science Information Network, 2009) was maintained.

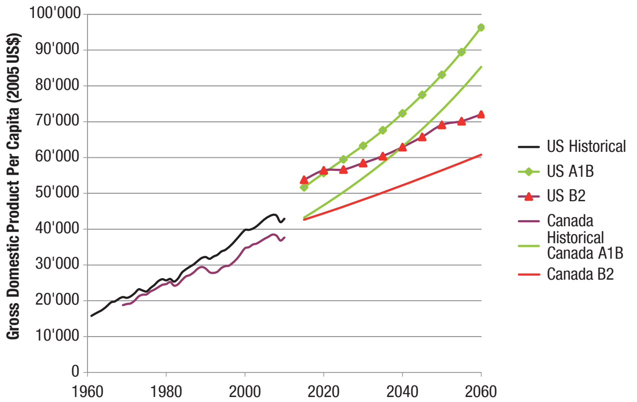
For Canada and all other countries, population projections under each scenario were made consistent with economic growth convergence theory for income. The population and income per capita and population projections used in the GFPM are shown in Figures 57 and 58, respectively. We note that the projection from 2006 for population built into the GFPM model yields a projected Canadian population of about 32 million by 2010, which is roughly 2 million below the figure estimated by Statistics Canada (2010). For the United States, projected figures for 2010 under both A1B and B2 scenarios (309 and 308 million, respectively) bracketed the observed (308.7 million). The effect of this difference on Canadian and global market projections is small, as GDP per capita is what drives forest area and some demand shifters.

Figure 57: Population, 1930-2010, and projections to 2060.



Source: Source: US Bureau of the Census (2004), Statistics Canada (2011c, 2011d), Center for International Earth Science Information Network (2009).

Figure 58: Real (2005 USD) GDP per capita, 1961-2010, and projections to 2060.



Source: USDA Economic Research Service (2011), US Bureau of the Census (2004), Statistics Canada (2011c, 2011d), Center for International Earth Science Information Network (2009).

7.1.2 Forest area changes and land use changes

Forest area and land use projections for the 2010 RPA Assessment were not linked to the regional IPCC scenario projections of forest area and land use. Land use was projected using methods described in Wear (2011). Disposable Personal income by projection (USDA Forest Service, In preparation) and endogenous forest product price projections were used to achieve final land use and forest area change projections. For the GFPM, forest area projections were made to total the forest areas projected by region under the three IPCC scenarios. Allocations of forest area changes under each scenario were made by combining an Environmental Kuznets Curve-consistent projection of forest area based on empirical studies and a convergence methodology developed to allocate economic output changes across countries within IPCC regions.

7.1.3 Climate projections

Biophysical projections of climate were enabled by applying downscaled versions of climate projections from general circulation models used in the IPCC third (TAR) and fourth (AR4) assessments linked to the emissions scenarios. Three GCMs were used for each chosen scenario. We used climate projections from three AR4 GCMs for the A1B scenario and three TAR GCMs for the B2 scenario.

The climate projections for the three GCMs from AR4 were provided by the Program for Climate Model Diagnosis and Intercomparison Climate Model Intercomparison Project 3 (CMIP3) website. The three AR4 GCMs were:

- Canadian Centre for Modelling and Analysis (CCCma) - Coupled Global Climate Model CGCM3.1, Medium Resolution (T47) (http://www.cccma.ec.gc.ca/models/cgcm3.shtml)
- Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), CSIRO-Mk3.5 Climate System Model (http://www.cmar.csiro.au/e-print/open/gordon_2002a.pdf)
- Japanese Center for Climate System Research (CCSR), University of Tokyo; National Institute for Environmental Studies (NIES) and Frontier Research Center for Global Change (FRCGC), Model for Interdisciplinary Research on Climate Version 3.2 (MIROC3.2) Medium Resolution (http://www.ccsr.u-tokyo.ac.jp/kyosei/hasumi/ MIROC/tech-repo.pdf)

The climate projections for the three GCMs from TAR were provided by the Data Distribution Center (DDC). The three TAR GCMs were:

- Canadian Centre for Climate Modelling and Analysis - Coupled Global Climate Model CGCM2, Medium Resolution (T47) (http://www.cccma.bc.ec.gc.ca/models/cgcm2.shtml)
- Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) CSIRO-Mk2 (http://www.cmar.csiro.au/e-print/open/hennessy_1998a.html#ccm)
- UK Hadley Centre for Climate Prediction and Research (HCCPR) UKMO-HadCM3 (http://cera-www.dkrz.de/IPCC_DDC/IS92a/HadleyCM3/hadcm3.html)

For the GFPM, no climate projections are used for countries outside of the United States. In effect, productivity of forests in countries outside the US is assumed to be not affected by emissions scenarios. A sensitivity analysis is planned to evaluate the potential impact of this assumption on global forest product markets, but has not been undertaken for NAFSOS.

7.1.4 Wood-based bioenergy projections

(1). How GFPM/USFPM implements the Bioenergy projections under the IPCC Scenarios

In the 2010 RPA Assessment, the GFPM (and USFPM) implements and achieves the 6x (actually, apparently, 5.5x), 3x, and 3x increases from 2006 to 2060 in wood biomass output (modelled as "fuelwood" in the GFPM and USFPM) under the A1B, A2, and B2 IPCC scenarios, respectively. The GFPM achieves this by adjusting the elasticity of fuelwood demand with respect to GDP to a level that achieves the production and consumption increase required (adjusting it upward, to about 1.9 for the A1B scenario). The 6x, 3x, and 3x increases in woody biomass are based on the IPCC projections of biofuels as a renewable energy source under the three scenarios. The woody biomass portion of the biofuels projection is set at a constant share, equal to the estimated 2006 share of bioenergy output provided by wood, averaged over 1990 and 2000 (Ince et al., 2011).

(2). Other details

(a). Europe and North America get 100% of their "fuelwood" (which is the category in which it is modelled) from forests (from the merchantable and non-merchantable portion of timber removed upon harvest). In other countries, this wood can also come from residuals of wood product manufacture (e.g., lumber residuals).

(b). Trade is allowed in fuelwood, and it occurs in the projections, especially later in the projections.

(c). The prices of fuelwood and industrial roundwood converge between 2025 and 2035 in all three projections.

(d). The fuelwood share of total wood removed (industrial + nonindustrial) globally increases from about 53% in 2006 to about 77% in 2060.

7.1.5 The Global Forest Products Model

The GFPM is a spatial dynamic economic model of the forest sector. The model simulates the evolution of competitive markets for forest products in 180 countries (Table 1) that interact through trade. In each country the model simulates the changes in forest area and forest stock, and the consumption, production, trade, and market-clearing prices for 14 commodity groups. The USFPM uses the same formulation as the GFPM, with more disaggregated products for the United States (Table 2).

The GFPM is dynamic in the sense that the state of the sector in a particular year is a function of last year's state, and of demographic, economic, and technical changes. An earlier version of the GFPM and several applications are described in Buongiorno et al. (2003). The most recent version, with the software, documentation, and one data set are available in Buongiorno and Zhu (2011a).

The model describes the flow and transformation of wood products in each country. At one end is the supply of raw materials, including fuelwood and industrial roundwood which depend directly on the forest area and forest stock. At the other end is the demand for end products, sawnwood, wood-based panels, and paper and paperboard. In between is the transformation of wood into products. Additional sources of raw materials consist of non-wood fibre pulp, and of the waste paper recovered after consumption of paper and paperboard. In this particular application, part of the industrial roundwood may be diverted to fuelwood where and when, due to high biofuel demand, the price of fuelwood approaches that of industrial roundwood.

Table 1: Countries and territories represented in the GFPM.

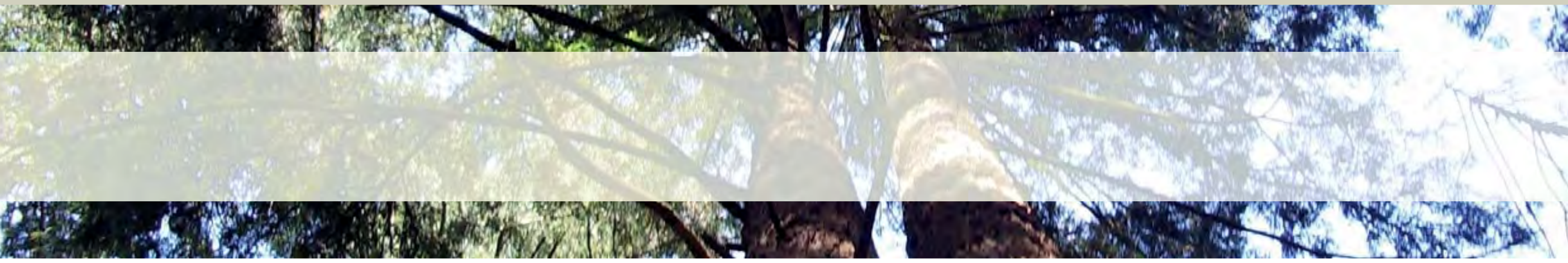
AFRICA	Uganda	Bhutan	New Caledonia
Algeria	United Rep. of Tanzania	Brunei Darussalam	New Zealand
Angola	Zambia	Cambodia	Papua New Guinea
Benin	Zimbabwe	China	Samoa
Botswana	**NORTH/CENTRAL AMERICA**	Cyprus	Solomon Islands
Burkina Faso	Bahamas	Georgia	Tonga
Burundi	Barbados	Hong Kong SAR	Vanuatu
Cameroon	Belize	India	EUROPE
Cape Verde	Canada	Indonesia	Albania
Central African Republic	Cayman Islands	Iran (Islamic Republic of)	Austria
Chad	Costa Rica	Iraq	Belgium
Congo	Cuba	Israel	Belarus
Côte d'Ivoire	Dominica	Japan	Bosnia and Herzegovina
Dem. Rep. of the Congo	Dominican Republic	Jordan	Bulgaria
Djibouti	El Salvador	Kazakhstan	Croatia
Egypt	Guatemala	Korea, Dem. People's Rep. of	Czech Republic
Equatorial Guinea	Haiti	Korea, Rep. of	Denmark
Ethiopia	Honduras	Kuwait	Estonia
Gabon	Jamaica	Kyrgyzstan	Finland
Gambia	Martinique	Lao People's Dem. Rep.	France
Ghana	Mexico	Lebanon	Germany
Guinea	Netherlands Antilles	Macau SAR	Greece
Guinea Bissau	Nicaragua	Malaysia	Hungary
Kenya	Panama	Mongolia	Iceland
Lesotho	Saint Vincent & the Grenadines	Myanmar	Ireland
Liberia	Trinidad and Tobago	Nepal	Italy
Libya	United States of America	Oman	Latvia
Madagascar	**SOUTH AMERICA**	Pakistan	Lithuania
Malawi	Argentina	Philippines	Macedonia, TfYR
Mali	Bolivia (Pl. State of)	Qatar	Malta
Mauritania	Brazil	Saudi Arabia	Moldova, Republic of
Mauritius	Chile	Singapore	Montenegro
Morocco	Colombia	Sri Lanka	Netherlands
Mozambique	Ecuador	Syrian Arab Republic	Norway
Niger	French Guiana	Tajikistan	Poland
Nigeria	Guyana	Thailand	Portugal
Réunion	Paraguay	Turkey	Romania
Rwanda	Peru	Turkmenistan	Russian Federation
Sao Tome and Principe	Suriname	United Arab Emirates	Serbia
Senegal	Uruguay	Uzbekistan	Slovakia
Sierra Leone	Venezuela, (Boliv. Rep. of)	Viet Nam	Slovenia
Somalia	**ASIA**	Yemen	Spain

Table 1 (*continued*)

South Africa	Afghanistan	**OCEANIA**	Sweden
Sudan	Armenia	Australia	Switzerland
Swaziland	Azerbaijan	Cook Islands	Ukraine
Togo	Bahrain	Fiji	United Kingdom
Tunisia	Bangladesh	French Polynesia	

Table 2: Product categories used in the GFPM for all countries, including the United States and Canada, and those used for the United States in USFPM.

GFPM Product Category	USFPM Product Category
Sawnwood	Hardwood lumber
	Softwood lumber
Plywood/veneer	Softwood plywood
	Hardwood plywood
Particleboard	Oriented Strand Board
	Industrial particleboard
Fibreboard	Fibreboard
Newsprint	Newsprint
Printing and writing paper	Printing and writing paper
Chemical pulp	Chemical pulp
Mechanical pulp	Mechanical pulp
Other fibre pulp	Non-wood pulp
Waste paper	Recovered paper
Industrial roundwood	Softwood sawtimber
	Softwood non-sawtimber
	Hardwood sawtimber
	Hardwood non-sawtimber
Other industrial roundwood	Other industrial roundwood
Fuelwood	Fuelwood stock
	Softwood fibre residues
	Hardwood fibre residues
	Harvest (logging) residue
	Fuel residue
	Softwood short-rotation woody crops
	Hardwood short-rotation woody crops



The GFPM has a static part that describes the world spatial market equilibrium in a particular year, and a dynamic part that simulates the changes from year to year. The spatial equilibrium is computed by maximizing the value to consumers of the end products minus the cost of supplying the raw materials, the cost of transforming them, and the cost of transportation (Samuelson, 1952). Constraints ensure that for each country and product the supply is equal to demand: imports plus domestic production equals consumption plus exports.

In the GFPM the final demand and the raw materials supply are represented by econometric equations. The intermediate demand and supply are represented by input-output coefficients and manufacturing costs, which covers labour, energy, and capital. The marginal manufacturing cost depends on the level of production, and the transport cost depends on the export price of the product and on the import tax duty.

Together with quantities, the model gives the market-clearing equilibrium price for each product and country in each projected year. In the absence of trade limits, the export price is the same for all exporting countries, while the price in importing countries is equal to the export price plus the transport cost. Price distortions may occur in individual countries due to trade inertia constraints used in the GFPM to express the incomplete adjustment of trade to changes in economic conditions.

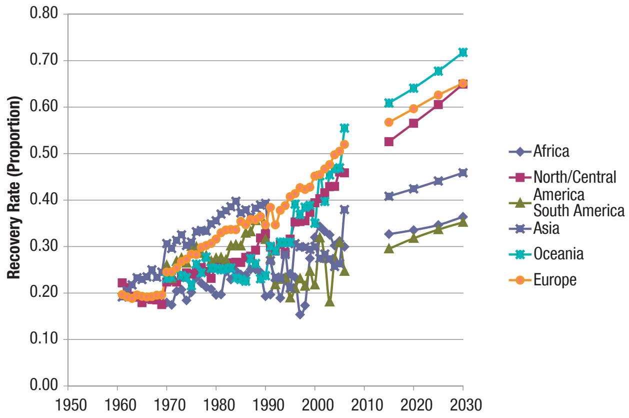
The dynamic part of the GFPM describes endogenous and exogenous changes in the conditions of the global sector. One important exogenous change stems from the yearly shift of the demand for the end products due to economic growth. The wood supply for industrial roundwood and fuelwood shifts endogenously over time according to changes in forest stock. Forest stock changes due to forest area change, harvest, and growth of stock on the remaining forest. The change in forest area in the GFPM depends on the level of GDP per capita according to an "environmental Kuznet's curve" (Turner et al., 2006) which implies that as GDP per capita increases, the forest area growth rate goes from negative to positive, reaches a maximum, and then declines up to a point where forest area stabilizes. The growth rate of forest stock is an inverse function of forest density, the ratio of forest volume to forest area. Technical change is represented by exogenous changes of the input-output coefficients and manufacturing costs. Given these changes from one period to the next, the GFPM calculates the global market equilibrium in the next period and the process is repeated until the end of the projection.

As an example, Figure 59 shows the GFPM projections of one endogenous variable, the recovery rate of waste paper defined as the ratio of waste paper produced to total paper and paper board consumption in two scenarios of NAFSOS. This recovery rate is determined by the market-clearing simultaneous solution in each projected year of the interlocked production, consumption, and trade of waste paper, of the wood fibre with which it competes, and of the paper and paperboard that uses waste paper.

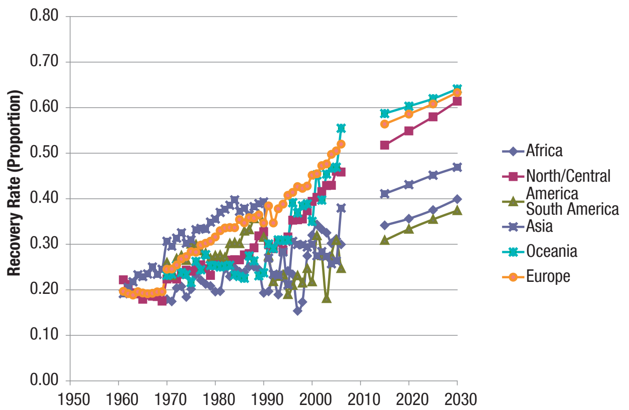
For this study demand elasticity parameters were based on Simangunsong and Buongiorno (2001), updated with more recent data (Table 3). The main database for production, import and export data was the FAOSTAT (FAO, 2009). The GDP and population data came from the World Bank Development Indicators Data Base (World Bank, 2008).The timber supply parameters were based on Turner et al. (2006). The data on forest area and forest stock were from the Global Forest Resources Assessment 2005 (FAO, 2006). In all countries, except the United States, the price elasticity of supply of fuelwood and industrial roundwood was 1.31, the elasticity with respect to growing stock was 1.10, and the elasticity with respect to forest area was -0.17. For the United States, the price elasticity and rate of shift of wood supply and the rate of forest area change, both exogenous, were the same as in the USFPM model (Ince et al., 2011).

For the other countries, parameters of the Kuznets' curve describing forest area change as a function of GDP per capita, and the parameters of the relationship between forest growth and forest stock on the residual forest were taken from Turner et al. (2006), updated with more recent data. The constants of the forest area change equation and of the forest growth equation were calibrated so that the predicted values in the base year (2006) were equal to the most recent observed values in each country.

Figure 59: Waste paper recovery rate in NAFSOS scenarios (A) A1B and (B) B2 (Note: Recovery rates obtained with scenario A1B-Low Fuelwood were nearly the same as with scenario A1B.)



A



B

Source: FAO (2011), GFPM

Table 3: Elasticities of demand for end products.

	GDP	Price	Year
Fuelwood-developing countries	**0.05[1]**	**-0.10**	[2]
Fuelwood-developed countries	**0.22[1]**	**-0.10**	[2]
Sawnwood	**0.22**	**-0.10**	**-0.003**
Standard error	0.03	0.02	0.001
Plywood & veneer	**0.41**	**-0.29**	**-0.009**
Standard error	0.04	0.02	0.002
Particleboard	**0.54**	**-0.29**	**-0.006**
Standard error	0.07	0.02	0.002
Fibreboard	**0.35**	**-0.46**	**-0.002**
Standard error	0.06	0.02	0.002
Newsprint	**0.58**	**-0.25**	**-0.008**
Standard error	0.04	0.02	0.001
Printing & writing paper	0.45	-0.37	0.003
Standard error	0.03	0.02	0.001
Other paper & paperboard	**0.43**	**-0.23**	**-0.004**
Standard error	0.03	0.02	0.001

[1] Used only in Scenario A1B-Low Fuelwood.

[2] Set to conform with IPCC biofuel projections (see text).

The calibration methods used to estimate the input-output coefficients and the corresponding manufacturing costs were those described in Buongiorno et al. (2001), and updated in Buongiorno and Zhu (2011b). The main databases are the FAOSTAT (FAO, 2009) and the World Bank Development Indicators Data Base (World Bank, 2008). The calibration is done with goal programming. For each country, the method uses smoothed data on production, imports, exports, and prices from 1992 to 2007 to estimate input-output coefficients for the base year 2006 by minimizing the deviation of calculated from observed production for all products, given a-priori bounds on the input-output coefficients. Manufacturing costs are estimated as the difference between the price of a product and the cost of wood and fibre that go into it, under the assumption of equilibrium and thus zero net profit (beyond a normal return to capital).

7.2 Annex 2: Discussion of differing assumptions across the Outlook studies

Although detailed results at the country level for nearly all countries in the world, including those of Europe, are available from NAFSOS and although NAFSOS and EFSOS II (United Nations, 2011) both use IPCC-based scenario B2 in their projections, the projections to 2030 are not entirely consistent when common projected variables are compared side-by-side.

Some of the primary reasons for this include (1) the use of different mathematical models, (2) different assumptions about the global and regional development of a wood-based bioenergy sector, (3) different assumptions about how climate change may affect forest productivity, and (4) different starting years.

NAFSOS employs an updated version of the GFPM of Buongiorno et al. (2003), with separate (exogenous) projections for the United States only on forest inventory and climate. EFSOS II utilizes a combination of four models that characterize the continent's forest conditions and forest-based markets. One of them is the European Forest Institute-Global Trade Model (EFI-GTM) (e.g., Kallio et al., 2004), employed to model global forest product markets. The EFI-GTM used for EFSOS II has a larger number of product categories (e.g., more detail about the paper sector and separate coniferous sawnwood and nonconiferous sawnwood, medium density fibreboard, OSB, and wood pellets); has a smaller number of spatial units, although it does separately model each European and North American country, just as GFPM; has different assumptions about the responsiveness of producers and consumers to prices, income, and population; has a different description of the forest inventory for each modelled country or region; and has an incomplete overlap in the list of countries defined as Europe by NAFSOS and as the set of countries modelled in the EFSOS II.

These differences are highlighted when considering the price rises projected in EFSOS II for industrial roundwood, averaging about 2.4% per year. NAFSOS projects an annual rate of decline of about 1% per year over the same time period, partly resulting from its more robust projected increase in stocks in Europe outside of Russia compared to the EFSOS II scenario modelling the promotion of wood energy. However, the decline projected by NAFSOS ignores the recession when projecting 2010 prices (2006 is the base year). In that case, it should be noted that roundwood prices in Europe were markedly lower in 2010 compared to the projected price in 2010 by NAFSOS. When viewed from that perspective, prices are indeed projected to increase under NAFSOS by 2030, compared to those observed in 2010.

Although the EFI-GTM models the global market, details of domestic market conditions are connected in the EFSOS II modelling framework with individual product category econometric market models for each country (the econometric product market models iterate with EFI-GTM in achieving market solutions), with the Wood Resource Balance model (which models how wood from all sources enters and moves through the product stream, including in the energy sector), and with the European Forest Information Scenario Model (EFISCEN, which evaluates how global and domestic market outcomes are translated into effects on forest conditions across Europe, within specified constraints, notably about ecological limits).

With respect to the energy sector, NAFSOS takes as part of its scenarios (A1B and B2) a projection of the future development of the bioenergy sector offered by the IPCC as an exogenous input. In this way, GFPM does not need to identify relationships between fuelwood consumption and production and energy sector technology, prices, or related policies. The GFPM makes no assumptions about why demand for wood in the energy sector would grow to the levels assumed to be reached by the IPCC. In this way, NAFSOS, in its A1B and B2 scenarios, makes no particular assumptions about the creation of subsidies, taxes, technology, or market conditions that would be needed to drive consumption of wood to the levels envisioned by the IPCC. In EFSOS II, the wood-based energy sector in its reference scenarios is not assumed to change greatly in structure or in policy from historical conditions; separate policy scenarios are crafted in EFSOS II that evaluate the effects of unspecified incentives or programs that enhance the role of forests and/or wood in the energy producing sector or used directly to help sequester carbon as a means of mitigating greenhouse gas emissions from fossil fuel sources. Wood sources entering the energy sector are tracked in EFSOS II with the Wood Resource Balance model, with details of wood sources ranging from residuals of wood manufacturing, to harvest residues, stumps, and landscaping debris. In the GFPM model used in NAFSOS, wood entering the energy sector emerges from the fuelwood product category and from industrial roundwood when the price of fuelwood approaches that of industrial roundwood.

The direct effects of climate change on the forest sector are likely to be complex, especially because forests and forest product manufacture and consumption could have some feedback (indirect or secondary) effects on future climate. The direct effect of climate change on forests is likely to derive from alterations in ambient atmospheric carbon dioxide, precipitation, and temperature, and the seasonal and inter-annual distributions of the latter two. Precise predictions of how climate change, under alternative scenarios evaluated in these outlook studies, would affect forest conditions, including productivity, are not generally available by country for all countries and regions modelled either by the GFPM or by EFI-GTM under any scenario. EFSOS II contains sub-country level

projections of forest productivity effects for scenario B2 for European countries only.

NAFSOS is even more limited. It does not project effects of climate on forest productivity under scenarios A1B or B2 in most countries. Only the United States' forest conditions are allowed to vary due to climate change. For the United States, the effects of climate change on forest conditions are summarized in the GFPM by its effects on the rates and directions of shifts in aggregate roundwood supply curves for scenarios A1B, B2, and A1B-Low Fuelwood. Climate change does not affect forest productivity (hence does not shift supply curves) for Canada or for any other country in the GFPM. Regardless, the effects of climate change on forest productivity are likely to manifest themselves gradually, revealing significant impacts only well after the time horizon of these outlook studies. Near-term effects on rates of natural disturbances, creating widespread forest mortality, however, are less certain.

While the modelling framework of NAFSOS and EFSOS II are clearly different, other distinctions between the North American and European studies include the kinds of scenarios that are produced. NAFSOS reports one scenario that differs from its two chosen main scenarios: the A1B-Low Fuelwood scenario, which ignores (as in the B2 reference scenario of EFSOS II) the possible development of a large, wood-utilizing bioenergy sector. EFSOS II builds one scenario which evaluates what extra supply would be needed to meet the official targets for renewable energy (i.e., that European nations obtain 20% of all energy from renewable sources by 2020), forest protection and sustainability, competitiveness of the forest sector in Europe, and the use of forests or wood products to sequester carbon as a climate mitigation strategy would be expected to affect forest conditions, markets, and the bioenergy sector.

NAFSOS makes no attempt to measure whether the various simulated futures exceed, meet, or fall short of historical or desired levels of indicators measuring sustainability or biodiversity maintenance, although the results of the projections, in particular of forest stock, could be used to generate some of those indicators.

While the end date for NAFSOS and EFSOS II is the same, 2030, the different starting point of the EFSOS II projections (2010) compared to NAFSOS (2006) makes direct comparisons difficult, even under B2, especially in the early part of the projections (e.g., before 2020). The reason this matters is because EFSOS II accounts for the global recession of 2008-2009 and the contraction of the housing market in Europe and North America from 2006. Because the GFPM used for NAFSOS was also used simultaneously for the 2010 RPA Assessment, with a 2006 start date that predated the economic contractions, NAFSOS was similarly bound. To the extent that the most recent recession and housing market contraction have affected forest conditions (e.g., growing stock volumes) and possible shifts in long-run trends in forest product demands, it is possible that EFSOS II accounts for them more completely than does NAFSOS.

7.3 Annex 3: Discussion of the role of North America in global markets

The United States and Canada together have the world's largest bilateral trade flow in forest products. In 2006, according to FAO statistics (FAOSTAT, 2011), Canada consumed 5.3% and the United States 12.7% of the world's total roundwood. The share of roundwood consumed was higher for wood destined for industrial processing: 11.1% for Canada and 24.2% for the United States. But the projected futures modelled in NAFSOS point to some declines in these shares over time: under scenario A1B, to 4.0% and 11.7% for total roundwood by 2030 and to 9.6% and 25.7% for total and for industrial roundwood in Canada and the US, respectively. Under scenario B2, these shares show a consistent decline for Canada but an uptick for the United States. By 2030, total roundwood consumed is projected to be 4.4% and 13.6% of global consumption by Canada and the United States, while industrial roundwood consumed falls for Canada to 9.6% and rises for the United States, from its current 24.2% to 27.8%.

These changes obscure a primary factor operating to increase consumption the United States relative to that of Canada: population growth. The United States' population is projected to grow more rapidly than that of Canada, and so the United States' share of global population will not decline by 2030 as much as it is projected to decline for Canada. Indeed, larger positive changes are projected for Asia, with several large countries set to rapidly increase total population: China, India, Pakistan, and Indonesia. Under scenario A1B, the total roundwood consumption share of Asia relative to global consumption rises from 31.3% to 37.7% between 2006 and 2030, while under scenario B2 it rises to 37.2%.

Trends are not dissimilar when examining the global changes in consumption (or production, for that matter) for processed products. For sawnwood, Canada's share of consumption under scenario A1B falls from 4.9% to 4.6% and the United States' share falls from 29.6% to 28.2%. With scenario B2,

these shares fall to 4.8% and 28.9%, respectively. For total wood-based panels, trends are the same: under scenario A1B, Canada's share falls from 2.8% to 2.0%, while the US share falls from 25.0% to 21.0%. Under scenario B2, those changes are declines to 2.2% and 22.4%. Asia's share rises from 36% to 42.5% under scenario A1B and to 41.5% under scenario B2. Finally, for total paper under scenario A1B, Canada's share remains nearly constant, at 1.8%, while the US share falls from 24.3% to 18.5%. Under scenario B2, these shares are 1.9% and 19.7% for Canada and the United States, respectively.

Production share trends for industrial roundwood are very similar, largely because roundwood undergoes little trade, so that production roughly approximates consumption in both Canada and the United States. Thus, such share shifts do not merit special discussion. But the share changes projected under the A1B and B2 scenarios for processed products are slightly different, as these products (sawnwood, panels, and total paper) are heavily traded. Notably, Canada's share of global production of sawnwood is projected to decline from 13.3% to 7.6% under scenario A1B and to 8.0% under scenario B2. The US share, in contrast, is projected to rise from 21.1% to 25.4% and to 26.5% under the A1B and B2 scenarios, respectively. This shift indicates that the US will become less dependent on Canadian production, in a relative sense, compared to today. Rises are also expected for five other major regions modelled by the GFPM—Africa, Asia, Oceania, and South America—falling only for Europe.

For wood panels, production share shifts for Canada and the United States are the reverse of those expected for sawnwood. For this product aggregate, Canada is projected to gain global market share and the United States is projected to lose it. In paper, as well, Canada is projected to gain market share under scenarios A1B and B2, while the United States is projected to lose it. Other regional aggregates of countries projected to gain market share for paper production include all others (Africa, Asia, Oceania, and South America) except Europe.

Canada and the United States have held large global shares of production and consumption for many decades. Projections indicate that these shares are likely to change, even though total production and consumption in each country may rise or fall. Canada is projected to generally gain market share in the production of more heavily processed products—wood based panels and paper—and lose in sawnwood, while the United States is projected to lose market share in panels and paper but gain it in sawnwood. The imprint of other regions of the world outside of Europe is projected under both the A1B and B2 scenarios to generally rise, with the largest increases expected in Asia.

7.4 Annex 4: Special issues

7.4.1 Assumptions and general findings of the A1B-Low Fuelwood scenario

The A1B-Low Fuelwood scenario referred to in section 4 above used the same GFPM model with the same assumptions and parameters as scenario A1B, except for the future fuelwood demand. For scenario A1B, it was assumed that from 2006 to 2060 the world fuelwood consumption would grow as the world biofuel consumption predicted by the IPCC, i.e. approximately 5.5 times.

Another assumption was that there would be a convergence of the consumption per capita of fuelwood (energy wood) across countries, analogous to the past convergence observed for other products (Buongiorno, 2009). Specifically, by 2060, the ratio of national to world fuelwood consumption would be equal to the ratio of national to world GDP.

From these two assumptions we computed the national fuelwood consumption in 2060 and the corresponding national annual growth rate of demand that would be needed from 2006 to 2060, at constant price, to achieve this 2060 consumption level. This demand growth rate was then applied to the GFPM, which gave projections of demand that differed from the desired level due to the endogenous change in price. The demand growth rate was then adjusted iteratively until the desired level of global consumption was achieved.

In contrast, the A1B-Low Fuelwood scenario simulated a continuation of past trends in fuelwood use, while economic and demographic growth were the same as in scenario A1B. Accordingly, the demand for fuelwood was entirely defined by econometric demand equations based on past data. For high-income countries, the price elasticity was -0.1 and the GDP elasticity was 0.2 (Simangunsong and Buongiorno, 2001). For low-income countries, the same price elasticity was used with a GDP elasticity of 0.05 to continue past trends.

The results showed the same forest area in 2030 for scenario A1B-Low Fuelwood as for A1B, as expected given the same assumptions regarding GDP per capita. However, the forest stock of North/Central America was 2% higher with the A1B-Low Fuelwood scenario. While the world price of fuelwood and industrial roundwood converged by 2030 in scenario A1B, the price of fuelwood was still 25% lower than that of

industrial roundwood in scenario A1B-Low Fuelwood. Fuelwood consumption in North/Central America, which reached 359 million m^3 with scenario A1B, was 60% lower with the A1B-Low Fuelwood scenario.

This much lower fuelwood demand under the A1B-Low Fuelwood scenario had only a positive impact on the consumption of industrial roundwood, which was 4% higher by 2030 under this scenario compared to scenario A1B. The effect was smaller on specific wood processing industries. North/Central America consumption of sawnwood and of paper and paperboard was 1% higher in 2030 under scenario A1B-Low Fuelwood than with scenario A1B. The consumption of wood based panels was 3% higher.

The value-added in forest product industries, defined as the value of the products minus the value of wood and fibres used in making them was 6% higher for North/Central America under the A1B-Low Fuelwood scenario than under scenario A1B, which suggested a substantial negative impact on traditional forest industries of policies calling for very large increases in the use of wood for heating and energy production.

7.4.2 Competitiveness analysis

The law of comparative advantage states that for two countries producing two goods each country will export that good which is cheaper in autarky conditions and import the other. Direct application of this concept is difficult because autarky prices are unobservable. To deal empirically with the issue, economists revert to the concept of RCA. A common indicator of comparative advantage in trade is the ratio of net exports to a measure of the size of domestic production measured for example by GDP. This RCA index has been used extensively (Balassa, 1979; Bowen, 1983). Leamer (1984) shows the theoretical base of the index and its connection to the Heckscher-Ohlin theorem according to which there should be a direct relationship between the RCA index of a country and its endowment in factors of production.

Bonnefoi and Buongiorno (1990) used this index to determine the relative comparative advantage of countries in forest products trade. They found that there was a strong positive relationship between comparative advantage and wood availability. Prestemon and Buongiorno (1997) also found that data on interstate trade of wood products within the United States were in strong agreement with the Heckscher-Ohlin theorem underlying the RCA index.

In this application, we computed RCA indices of countries and regions over time, for different products and product groups. The RCA was defined as the ratio of the value of net trade (exports minus imports) to the value of production, valued at local prices. Values rather than quantities were used to allow aggregation over all products, and thus compute RCAs for total paper and paper board, total panels, and total forest products. Production rather than GDP was used as the denominator to make the index more product-specific.

The results suggest that Canada will maintain a high comparative advantage (high positive RCA ratio) throughout the projected period in processed forest products—sawnwood, wood-based panels, and paper—and in total forest products, in all three scenarios. The United States, on the other hand, is projected to be a net importer (negative RCA ratio), in all scenarios. However, slight improvements are projected to occur over the coming decades in its RCA index, to values approaching zero (i.e., balanced trade), especially in the scenario A1B-Low Fuelwood, which does not involve the rapid growth of demand for energy wood.

7.5 List of abbreviations

AR4	Intergovernmental Panel on Climate Change Fourth Assessment Report
EFI-GTM	European Forest Institute-Global Trade Model
EFSOS	European Forest Sector Outlook Study
ERS	USDA Economic Research Service
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistics
GCM	Global Climate Model
GDP	gross domestic product
GFPM	Global Forest Products Model
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
m^3	cubic meter
MT	metric tonne
NAFSOS	North American Forest Outlook Study
NAICS	North American Industry Classification System
NATTS	North American Timber Trends Study
OECD	Organization for Economic Co-operation and Development
OSB	oriented strand board
RCA	revealed comparative advantage
RPA	(Forest and Rangeland Renewable) Resources Planning Act
SIC	Standard Industrial Classification
TAR	Intergovernmental Panel on Climate Change Third Assessment Report
UNECE	United Nations Economic Commission for Europe
US	United States
USDA	United States Department of Agriculture
USD	United States dollar
USFPM	US Forest Products Module

Some facts about the Timber Committee

The Timber Committee is a principal subsidiary body of the UNECE (United Nations Economic Commission for Europe) based in Geneva. It constitutes a forum for cooperation and consultation between member countries on forestry, the forest industry and forest product matters. All countries of Europe, the Commonwealth of Independent States, the United States, Canada and Israel are members of the UNECE and participate in its work.

The UNECE Timber Committee shall, within the context of sustainable development, provide member countries with the information and services needed for policy- and decision-making with regard to their forest and forest industry sectors ("the sector"), including the trade and use of forest products and, when appropriate, will formulate recommendations addressed to member governments and interested organisations. To this end, it shall:

1. With the active participation of member countries, undertake short-, medium- and long-term analyses of developments in, and having an impact on, the sector, including those offering possibilities for the facilitation of international trade and for enhancing the protection of the environment;
2. In support of these analyses, collect, store and disseminate statistics relating to the sector, and carry out activities to improve their quality and comparability;
3. Provide the framework for cooperation e.g. by organising seminars, workshops and ad hoc meetings and setting up time-limited ad hoc groups, for the exchange of economic, environmental and technical information between governments and other institutions of member countries required for the development and implementation of policies leading to the sustainable development of the sector and to the protection of the environment in their respective countries;
4. Carry out tasks identified by the UNECE or the Timber Committee as being of priority, including the facilitation of subregional cooperation and activities in support of the economies in transition of central and eastern Europe and of the countries of the region that are developing from an economic perspective;
5. It should also keep under review its structure and priorities and cooperate with other international and intergovernmental organizations active in the sector, and in particular with the FAO (Food and Agriculture Organization of the United Nations) and its European Forestry Commission, and with the ILO (International Labour Organization), in order to ensure complementarity and to avoid duplication, thereby optimizing the use of resources.

More information about the Committee's work may be obtained by writing to:

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Trade and Sustainable Land Management Division
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UNECE/FAO GENEVA TIMBER AND FOREST STUDY PAPERS

The UNECE/FAO Geneva Timber and Forest Study Paper series contains annual and periodic analyses of the forest and forest industries sector. These studies are the official outputs of regular activities conducted within the Integrated Programme of Work of the UNECE Timber Committee and the FAO European Forestry Commission and as such should contribute to policy formation. Target audiences are governments, industry, research institutions, universities, international organizations, non-governmental organizations as well as experts from other sectors. These publications often form the basis for discussions of the Timber Committee and the European Forestry Commission and their subsidiary bodies.

Study Papers are usually based on statistics, forecasts and information submitted by country correspondents in the UNECE region (Europe, North America and Commonwealth of Independent States). The basic information is often submitted via agreed questionnaires, and then complemented by expert analysis from outside and within the secretariat. Study papers are issued on the responsibility of the secretariat, although the studies most often are the work of many contributors outside the UNECE/FAO.

Study Papers are translated whenever possible into the three official languages of the UNECE: English, French and Russian. They are UN sales documents and are distributed accordingly via UN bookstores and their affiliates. They are automatically distributed to heads of delegation of the Committee and the Commission, as well as nominated repository libraries, information centres and official distribution lists. They are also available via the Sales and Marketing Sections in Geneva and New York via unpubli@unog.ch and publications@un.org respectively. Study papers are also available on the Timber Committee and European Forestry Commission website at: www.unece.org/timber

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North American Forest Sector Outlook Study

Projections to 2030 for the United States and Canada have been made with a global model to account for concurrent changes in other countries. Three future scenarios were investigated: two IPCC-based scenarios assuming the rapid growth of wood-based energy, and one IPCC-based scenario without this assumption. The model, under the IPCC scenarios, accounted for trends in population, income and land use along with emerging technology and predicted changes to consumption patterns for wood products and bioenergy. Markets for wood products, which mainly are destined for the construction sector in North America, are projected to recover by 2015 under all three scenarios examined. Projections suggest that, in spite of declining use of paper for media, other paper and paperboard for packaging and miscellaneous uses will continue to enjoy strong global demand.

UNECE Timber Committee and FAO European Forestry Commission

Further information about forests and forest products, as well as information about the UNECE Timber Committee and the FAO European Forestry Commission is available on the website: http://live.unece.org/forests/welcome.html

Information about the UNECE may be found at www.unece.org and information about FAO may be found at www.fao.org

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