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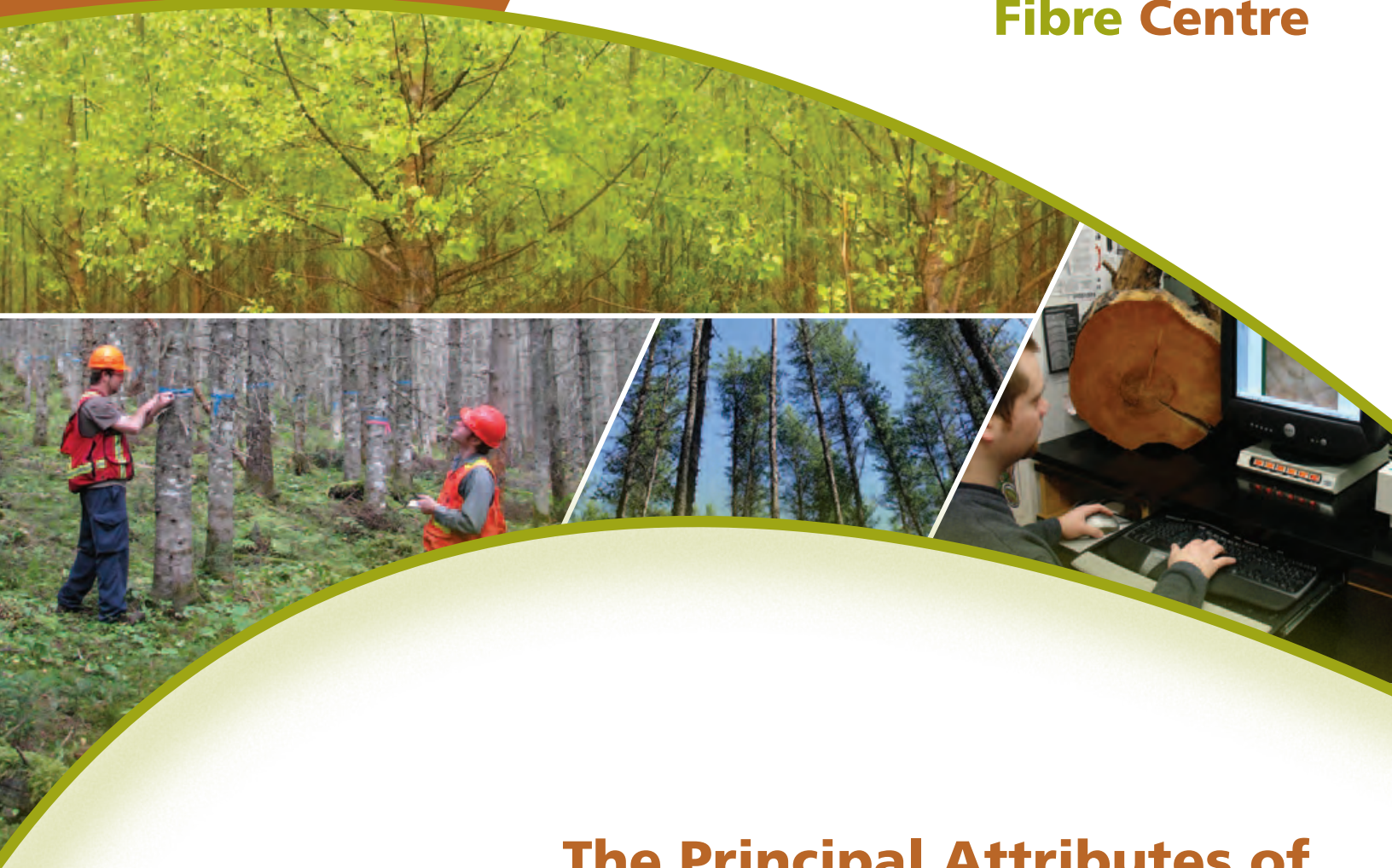
Canadian Wood Fibre Centre



The Principal Attributes of Canadian Wood Fibre

Canadian Wood Fibre Centre
Working together to optimize wood fibre value – creating forest sector solutions with FPInnovations

Canada

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Canadian Wood
Fibre Centre

The Principal Attributes of Canadian Wood Fibre

Contents

Executive Summary

The global forest sector is in rapid transformation. Canada needs to adopt appropriate strategies in response to changing markets and demands. The Canadian Wood Fibre Centre (CWFC) holds the position that the attributes of wood fibre are of crucial importance to the competitiveness of Canada's forest industry. The diversity of the resource base and the superior quality of the Canadian wood fibre have the potential to confer a competitive advantage to our forest industry in the world marketplace.

A clear understanding of the fibre characteristics of Canadian commercial tree species enables the industry to better adapt to a wide variety of future realities and unpredictable market trends. Based on an intensive process of structured interviews with leading experts across the country, seven attributes of Canadian wood fibre have been identified as most important to industry: wood density, microfibril angle, knot size and frequency, fibre length and coarseness, stem taper, proportion of juvenile wood and chemical composition. The CWFC believes that the future success of the Canadian forest industry depends upon a thorough understanding of these attributes.

Apart from these important fibre attributes, the state of competitiveness of the Canadian forest industry is also influenced by a number of other factors, including the certification of sustainability, the potential for product diversity, technological change, governance structures, the business environment, wood supply security and a host of market forces.

As we enter a new era characterized by an emerging bioeconomy, the role of wood will become more and more important. Canada has excellent potential to become a world leader in the emerging bioeconomy, based on the country's vast forest resource base and superior fibre quality. There will be new products and innovative ways of utilizing wood fibre, thanks to our significant forest product research capacity, notably within FPInnovations, and the keen interest of the forest industry and other sectors in producing bioproducts and bioenergy with wood.

The CWFC plays a key role in advancing the scientific understanding of the quality and diversity of Canada's wood fibre resource. Focusing on the upstream end of the forest products value chain, CWFC's research seeks to understand the composition of Canada's wood basket, identify desirable attributes for present and future market products and provide guidance on the production of wood fibre attributes that meet industry needs. Guided by prevailing innovation strategies of the Canadian forest industry, this research will help to ensure the long-term sustainability of a healthy and competitive forest sector in Canada.

1. Introduction

The global forest sector is transforming rapidly, and Canada needs to position itself in response to changing markets and demands.

Much work is being undertaken to envision the prospects of the Canadian forest industry in the 21st century and to develop effective strategies that help the industry capitalize on Canada's strength and potential. In this context, the Bio-pathways Project commissioned in 2009 by the Forest Products Association of Canada (FPAC)–in collaboration with the Canadian Forest Service, Natural Resources Canada and FPInnovations–has focused on determining possible avenues leading toward ensuring the success and prosperity of the Canadian forest industry (FPAC 2010).

The magnitude, heterogeneity and superior quality of Canada's wood fibre resource provide the basis for the revitalization of the forest industry as it adapts to the transition from a society fuelled by depleting fossil fuels to one dependent upon renewable energy. To pursue the emerging bioeconomy, a clear understanding of the optimal ways to utilize Canadian wood fibre is crucial to maximizing the economic opportunities that arise in the bioage. A deep understanding of the attributes of Canadian wood fibre is doubly important in light of the analyses being conducted in the Bio-pathways Project, which examines, among other things, the role of wood fibre in optimizing the forest value chain. This line of inquiry dovetails with much of the work undertaken at the CWFC.

Canadian Wood Fibre Centre's Vision, Mission and Core Values

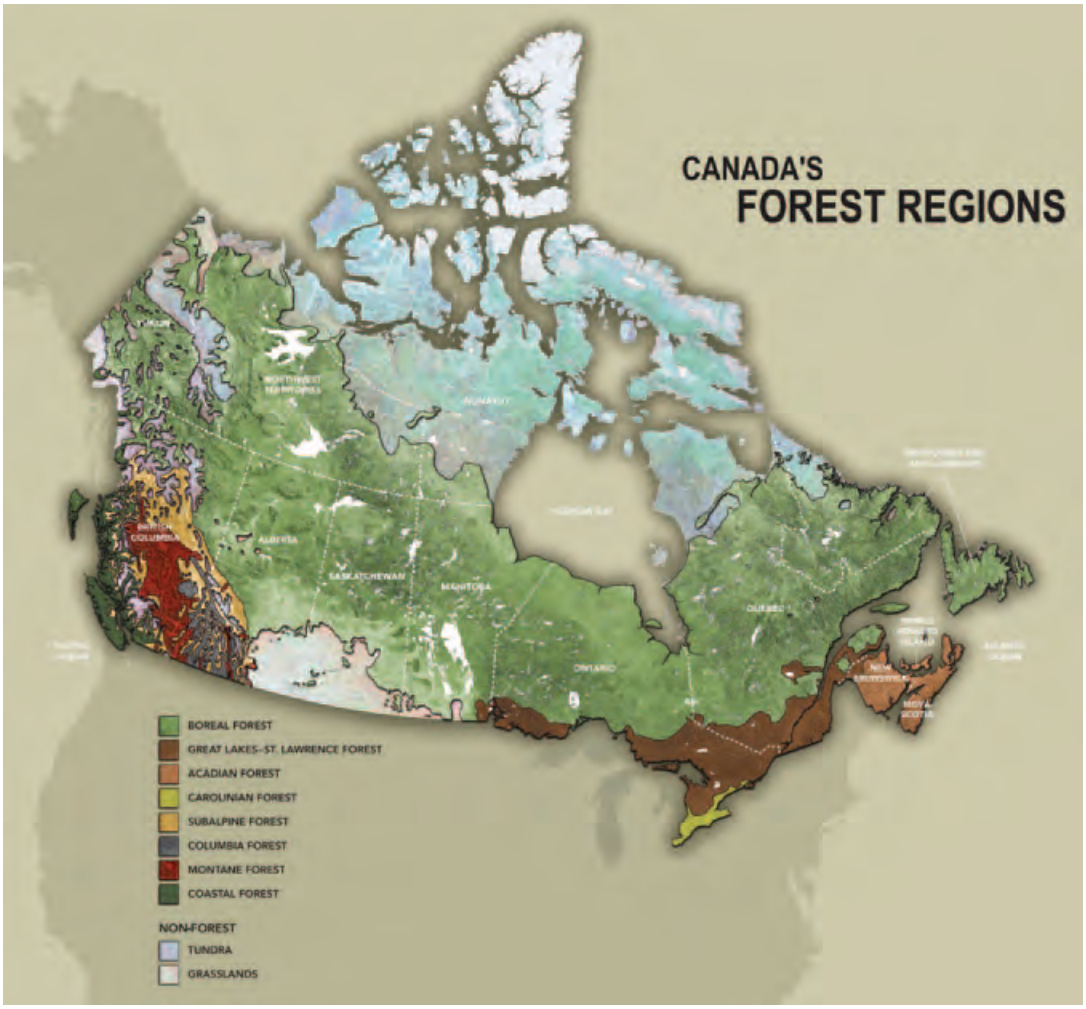
Vision: Canada's wood fibre is sustainably managed to give the forest sector a strong competitive advantage in a global marketplace.

Mission: To create innovative knowledge to expand the economic opportunities for the forest sector to benefit from Canadian wood fibre.

Core Values

- The CWFC will aggressively seek opportunities to increase economic benefits in both the short and long term while also promoting forest sustainability.
- The value of the CWFC will be measured as much by the relationships it fosters as by the research solutions it generates. It will strive for excellence, innovation, creativity, inclusiveness and impact in both.
- The CWFC will develop strong linkages to other research providers so that its response to clients' needs is comprehensive.

Long a forest nation, Canada possesses some 310 million hectares (ha) of forest land and 92 million ha of other wooded land, extending from the Atlantic coast to the Pacific coast and from the Canada–United States border to the edge of the Arctic tundra. With nearly 2 percent of the gross domestic product, the forest industry is one of the largest contributors to the Canadian economy, generating over $60 billion in revenue from manufactured forest goods. Each year, some 700 000 ha are harvested, supplying about 140 million cubic metres of wood to the Canadian forest industry (Natural Resources Canada 2010). The superior quality of Canadian wood fibre is internationally recognized and has been a key factor in the dominant position held by Canadian lumber, pulp and paper products and other forest products in the world marketplace. That the lumber sector will remain the cornerstone of the competitiveness of the traditional and emerging forest products industry in Canada is one of the key findings of the Bio-pathways Project (Forest Products Association of Canada 2010).



Despite the importance of traditional products, the forest industry is currently facing a number of challenges, among them: the mountain pine beetle epidemic in western Canada; the closure of pulpmills and sawmills across the country due to market downturns; increased competition from forest plantations in southern countries such as Brazil, Chile and New Zealand; and growing rivalry from increasingly sophisticated European producers. Despite these challenges, there are opportunities to facilitate the economic health of the Canadian forest sector in two ways: by securing Canada's leading position in traditional markets and by investing in cutting-edge products and technologies. To ensure that Canadian businesses are in a position to capitalize on these opportunities, the Canadian forest sector needs to have a better understanding about those fibre attributes that add value to end products and thus provide the Canadian forest products industry with a unique competitive advantage.

Understanding the principal attributes of commercial tree species in Canada in the context of future market projections will offer practical insights into which key fibre attributes will provide Canadian forest products the greatest competitive advantage in world markets. For this reason, our continuously expanding knowledge of Canadian wood fibre attributes has real value. In addition, a clear understanding of the broad spectrum of the attributes of Canada's wood fibre inventory will enable the industry to better adapt to a wide variety of future realities and unforeseeable market trends.

This paper has three objectives:

1. present the principal attributes of Canadian wood fibre – in terms of potential to confer a competitive advantage for the Canadian forest products industry in the world marketplace – based on a recently conducted survey of the opinions of leading experts across the country
2. identify a number of other factors that also influence the competitiveness of Canada's forest products industry
3. discuss the role of wood fibre in the emerging bioeconomy and possible shifts in fibre characteristics that may be acquired in the Canadian context

The paper ends by stating the research priorities of the CWFC concerning wood fibre characterization to enhance the innovation agenda of the forest sector in Canada.

2. Principal Attributes of Canadian Wood Fibre

Promising opportunities exist for the Canadian forest sector to expand into bioenergy and post-disaster residential and non-residential reconstruction, as well as niche wood products markets.

The research conducted in the Bio-pathways Project suggests that bioenergy and bioproduct opportunities are stronger both economically and socially when they are integrated within traditional industry operations rather than being pursued as stand-alone ventures.

However, to take advantage of these opportunities and remain leaders in the solid wood and pulp and paper markets, it is necessary to better understand how fibre attributes contribute to end-product performance in order to be able to add value to production and increase market competitiveness. In achieving this wider understanding, Canadian forest product producers can ensure that their products are better positioned to meet changing market needs by taking advantage of the full range of options available to them.

Desirable fibre attributes are those physical, mechanical and chemical attributes that confer a competitive advantage to Canadian forest products in the world market. While both the volume of wood and the value of wood are important, this paper focuses on value. Because of their significantly longer growing seasons, plantations in the southern hemisphere far outperform volume growth rates of Canadian naturally regenerated forests and plantations. While many wood quality attributes are hereditary, differences between trees of the same species are also influenced by growing conditions (Jozsa and Middleton 1994). Thus, for a certain species, while a large part of the variation observed in some attributes is genetically controlled, attention must also be paid to silvicultural regimes and stand management strategies, such as rotation length, initial spacing, fertilization, thinning, stand tending treatments and pruning. As more is learned about the genetic control and cultural manipulation of wood attributes, it will be possible to select the best silvicultural regimes for naturally regenerated forests and the best genotypes for plantation regeneration programs.

A number of attributes have the potential to confer a competitive advantage to Canadian forest products in the world market, among them: reduced moisture content, reduced microfibril angle, increased rot resistance, reduced knot size and frequency, reduced stem taper, increased wood brightness, increased fibre length, increased strength, increased cell wall thickness, increased density, reduced coarseness and reduced ring width. While all of these attributes are important for determining the best use of wood fibre, the seven attributes highlighted here – wood density, microfibril angle, knot size and frequency, fibre length and coarseness, stem taper, proportion of juvenile wood and chemical composition – are directly measurable characteristics that influence product value in a significant way. These attributes were selected for inclusion based on the results of an extensive process of interviews with key stakeholders and experts across the country.

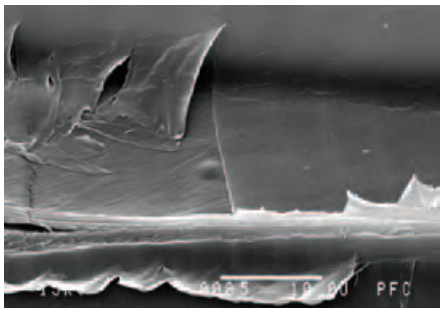
2.1 Wood Density

Wood density is a key wood fibre attribute because it is an excellent indicator of the strength properties of forest products (Wegner et al. 2010; Mullins and McKnight 1981). Wood density is defined as "the ratio of the oven-dry weight of a sample to the weight of a volume of water equal to the volume of the sample at a specified moisture content (green, air-dry, or oven-dry)" (Côté 2003).

Wood density has a strong influence on lumber strength (which determines lumber grade), pulp yield, pulp quality, timber shrinkage, stiffness, hardness, heating value, machinability and the energy requirement of the pulping process (Jozsa and Middleton 1994; Jaakkola et al. 2005). Although wood density may become less important for lumber strength as more engineered wood products are made stronger and stiffer by facing low-density wood cores with high-density wood, density is still important for other uses, including in the bioenergy sector, which values the higher energy content of dense wood.

2.2 Microfibril Angle

Microfibril angle (MFA) is the fibril orientation within the cell walls of wood. MFA affects the shrinkage and expansion of cell walls as water is removed or added. MFA is directly related to fibre strength and stiffness, which are properties important for a number of fibre applications, including paper and lumber. A low MFA leads to higher dimensional stability and tensile strength, while a large MFA leads to lower stiffness and dimensional instability in lumber and lower strength in paper.



2.3 Knot Size and Frequency

Knots are the remaining portion of a branch or limb that has been overgrown by subsequent growth of the stem (Côté 2003). They become visible only after sawing. Knot size and frequency affect lumber strength, stiffness, and appearance and, accordingly, negatively affect product grade. In structural lumber, knots lead to a reduced strength because of the grain deviation of the growth around the residual branch stub. Therefore, smaller knots are preferable to larger knots. The frequency of knots is also important, principally for aesthetics and appearance. The number of knots permitted in a piece of lumber is based on length, so a piece of lumber could make the top joinery grade on knot size and quality but fail because of knot frequency.

2.4 Fibre Length and Coarseness

While the range of strength properties of wood fibre is highly important for the solid wood products industry, fibre length and fibre coarseness (weight-to-unit-length ratio) are key attributes for the pulp and paper industry, which frequently uses solid wood product residues, including sawmill waste. Longer fibre tends to result in stronger paper sheets, while thinner fibre tends to form better quality sheets of higher tensile strength and greater bonding area (Watson and Bradley 2009).

2.5 Stem Taper

Taper is the "decrease in thickness … of a tree stem from the base upwards" (Côté 2003). Stem taper is a valuable integrating tree attribute that can predict knots, juvenile wood content, ring width and grain slope. The lower the taper, the more likely that the tree will have fewer knots, less juvenile wood content, thinner rings and a smaller slope of grain. Taper also affects the effective piece size of the log, the size and number of lumber products that can be cut from it and the amount of wane that appears on the lumber, all of which affect the final value of the lumber.

2.6 Proportion of Juvenile Wood

The proportion of juvenile wood to mature wood affects density, warping, shrinking, lumber strength and pulp yields. Often, juvenile wood has a larger fibril angle and twist of spiral grain than mature wood, resulting in lower strength. Furthermore, juvenile wood tends to have higher lignin-to-cellulose ratios, leading to lower pulp yields. The wider growth rings characteristic of juvenile wood are correlated with lower density wood, greater slope of grain (or direction of alignment), size, arrangement and appearance of wood. In mature wood, grain is more parallel to the long axis of the stem and will be more likely to have high strength and stiffness and less deformation when dried.

2.7 Chemical Composition

Chemical properties, such as cellulose and lignin content, are important in developing products in many emerging markets (Wegner et al. 2010). Lignin is an important chemical compound. While low lignin content was important for the pulping process in the past, future products may take advantage of lignin for its chemical properties or use as a biofuel. Minor chemical constituents of wood may also be valuable for emerging markets.

Historically, the chemical products such as rosin and turpentine were produced from pine resin, and resin derivatives remain a significant industry in North America with a wide range of end products, though the feedstock is often a by-product of the pulping process as well as coming from direct tree tapping (Coppen and Hone 1995). More recently, chemicals from trees have been identified as products that can be used to develop health remedies (e.g. taxol), and researchers are actively looking for ways to replace petrochemicals with compounds produced from wood. In the rapidly developing nanotechnology field, interest in nano-crystalline cellulose from wood fibre is also growing.

3. Placing Wood Fibre Attributes in the Wider Context

Identifying and prioritizing the principal attributes of Canadian wood fibre toward their best uses will be essential to confer a competitive advantage in both existing and emerging products.

However, the seven attributes will not be enough to confer a competitive advantage in isolation, since some of the newer technologies reduce the importance of biological attributes inherent in wood fibre. Canadian producers will benefit from enhanced knowledge about the particular fibre attributes that are important in creating specific end products. This understanding of fibre attributes must be embedded in a framework that is mindful of other factors that influence competitiveness in the marketplace. These factors include sound sustainability records, appropriate utilization of resource characteristics, technological change, adequate governance structures and favourable market forces such as exchange rates.

Maintaining excellent sustainability records is absolutely essential for securing the long-term vitality of Canada's forest products. In fact, safeguarding internationally recognized "green credentials" is becoming a critical determinant for sourcing materials and products, especially for high-value markets such as those in the European Union. Increasingly, consumers are looking for products that are certified as being sourced from a sustainably managed forest. To take advantage of the sustainably managed forests that already exist in Canada, producers need to continue to promote the sustainable forest brand and to leverage their established environmental records (Lazar 2007).

Canada is endowed with a diversity of forest types, species and age classes, all of which offer a large variety of fibre attributes to the country's wood basket. This diversity allows producers to mix fibres from different sources to manufacture the best product with the appropriate fibre strength, length, aesthetics and specific gravity (Barbour and Kellogg 1990). The diversity of forest types and variability of tree species are important for the forest as a whole, in terms of its biological and ecological health. This diversity in resource base also supports the potential for a wide range of forest products. Further work is needed to better understand the specific value chains that link fibre attributes to end products.

In contrast, homogeneity is desirable at tree and stand scales, since raw material uniformity helps ensure the ability to manufacture products of a consistent quality. Indeed, according to Watson and Bradley (2009), "uniformity is perhaps the attribute most prized by papermakers." A clear understanding of fibre attributes that foster consistency will therefore assure buyers that they will receive the same quality in repeat purchases. Inventory data will increasingly be used to direct harvesting and sorting protocols toward the goal of providing mills with uniform raw material that is sourced from heterogeneous and healthy forests.

Canada has been fortunate to have a plethora of natural old-growth stands that produced high-quality wood and pulp for the markets. These stands had superior quality compared to short-rotation plantations, including a higher ratio of mature-to-juvenile-wood content. As the Canadian forest industry increasingly turns to naturally regenerated second-growth stands and plantations, decreased fibre quality will become an issue. However, technological improvements may partially alleviate the problems caused by the decreased quality of wood from generally younger forests.

Combining a clearer understanding of fibre attributes with technological change can lead to substantive positive results. Changes in silvicultural production methods and processing can transform the ways in which the forest industry harvests timber, handles wood fibre and produces value-added products. Integrating new technology and science will lead to better management decisions and more effective use of fibre attributes, ensuring that the right fibre goes to the right end use with minimal waste.

In an age of globalization, political and market stability are key factors in sourcing materials and products. Canada is fortunate to have a stable political system with a sound governance structure in place and a widely respected business environment in which contracts are honoured. Institutions in Canada also have the capacity to innovate, allowing professionals, researchers and business owners to have confidence in the Canadian market system.

Furthermore, Canada has a secure wood supply, and the country's geographic proximity to the United States allows for enviable accessibility to this major market. Meanwhile, it is increasingly recognized that exchange rates and other market forces play an important role in industry competitiveness. Given the volatility in market forces, diversification of markets will be desirable for ensuring the stability of the forest products industry, as it is vital to have numerous customers and many markets rather than concentrating sales efforts on a few big customers and markets.

4. The Role of Wood Fibre in the Bioeconomy

We are entering a new era characterized by a worldwide drive toward achieving economic, social and environmental sustainability wherein the role of wood is becoming increasingly prominent, particularly in the context of the emerging bioeconomy.

In essence, this bioeconomy is based on the sustainable use of renewable materials. Wood will play a crucial role in the bioera of the 21st century, including producing bioenergy and innovative biochemicals. Further, the global focus on reducing carbon dioxide emissions bodes especially well for the forest sector, given that wood from sustainably managed forests is a carbon-neutral material.

Wood biomass is also an important source of feedstock for bioenergy production. At present, wood-based fuels account for a significant proportion of the total energy consumption in Nordic Europe. Markets for wood biomass and solid biofuels such as wood pellets are expected to expand rapidly in the years to come. New research findings suggest that wood biomass energy production will be growing considerably in the foreseeable future (Wegner et al. 2010).

Canada has excellent potential to become a world leader in the emerging bioeconomy, on account of the country's vast forest resource base. This factor combines with Canada's significant forest product research capacity (notably within FPInnovations) and the keen interest on the part of the forest industry and other sectors in producing bioproducts and bioenergy with wood. Canada also benefits from a series of innovation strategies and partnerships that have been put in place by federal and provincial governments.

In the field of bioenergy, new government policy initiatives, including favourable feed-in-tariff rates for electricity produced from renewable sources in some jurisdictions, will provide the incentive for investors to consider developing electrical generation from wood biomass. Ultimately, the economic viability of energy production with wood will be dictated by energy prices in the marketplace and the cost of production factors. Another consideration is the transportation costs of supplying wood biomass for energy production. This is a major concern, as Canada's vast and variable geography impacts how wood fibre is produced and how it is delivered to end-users.

The Forest Products Association of Canada has set a new direction for the Canadian forest industry, based on the findings of the Bio-pathways Project. One key consensus is the recommendation for the integration of bioproducts and bioenergy production into existing manufacturing facilities. It is projected that mills will evolve to become fully integrated forest manufacturing complexes that make not only a variety of dimensional lumber products and pulp and paper products, but also ethanol, syngas and a host of chemical products formerly derived from petroleum.

The transition toward a bioeconomy will give rise to new products and, in turn, innovative ways of utilizing wood fibre. Along with changes in the variety of wood-based products, there will be new requirements in terms of wood properties. For instance, low bark content is one of the desirable properties of wood for pellet producers that serve residential markets. Also, short-rotation plantations are projected to increase in the future. Properties such as higher energy content per unit volume and higher bulk density to reduce transportation costs will be in demand (Wegner et al. 2010).

The degree to which particular properties of wood are favoured in silviculture will depend on the specific manufacturing pathways chosen. In the case of wood-based biochemical products, properties that will assume greater importance include tree species with higher cellulose and hemicellulose content and, perhaps, more readily separable lignin. When it comes to thermochemical production processes, higher biomass productivity will be a primary factor.

Obviously, the particular nature of end products will determine the degree to which specific attributes are emphasized. For instance, while wood properties that are currently recognized as important will remain desirable for conventional uses of wood, biochemical processes will tend to favour wood materials that are more uniform in certain chemical compositions, whereas bioenergy production will typically favour the use of high energy content species. As the bioeconomy unfolds, the changes in preference for specific fibre attributes will become clearer. But regardless of which pathways are chosen, delivered wood costs will always be a key consideration: for virtually all forest products, wood costs account for a large fraction of the total production costs (Wegner et al. 2010).

Advances in biotechnology represent another frontier where wood fibre can play a significant role. While large volumes of wood fibre will continue to be required for traditional forest products, new lines of technology will give rise to new opportunities for utilizing wood fibre. One example of this is the production of nano-enabled materials with wood fibre. Advancement in nanotechnology will boost demand for materials that are derived from natural resources including wood fibre. It is likely that developments in the use of wood will serve to drive wood property requirements and applications (Wegner et al. 2010).

5. Research Priorities Concerning Wood Fibre Characterization

Increasing the competitiveness of the Canadian forest products industry depends largely on putting into place an innovative, well-coordinated strategy that takes advantage of the strengths of Canada's wood fibre basket to achieve fibre optimization.

The Canadian Wood Fibre Centre has a key role to play in advancing our understanding of the quality of Canadian wood fibre resource and making the knowledge available to research partners and industry clients in an effort to match the desirable attributes of wood fibre with end products, production processes and sector pathways.

Focusing on the upstream end of the forest products value chain, CWFC's research priorities concerning fibre attributes have three objectives:

1. Seek to understand the composition of Canada's wood basket.
2. Identify the desirable attributes in light of the market preferences of end products at present and in the future.
3. Provide guidance on the production of wood fibre with desirable attributes to meet industry needs.

One of Canada's strengths lies in its diversity and variability of its wood fibre. However, to ensure product standards and cost-effectiveness, the production of a particular product requires raw material uniformity. In the case of wood products, this uniformity is intrinsically difficult to achieve. At the forest management level, site conditions vary from coast to coast, from province to province, and from stand to stand. CWFC's research activities will therefore address questions on how to maintain the diversity and ecological health of Canadian forests while employing enhanced inventory methods to enable the cost-effective location, harvest and delivery of wood fibre of consistent quality to manufacturers and adopting appropriate silvicultural regimes to help optimize tree growth and fibre attributes.

Linking fibre attributes knowledge to manufacturing processes and establishing product quality parameters by grade will be extremely useful in guiding wood fibre allocation decisions over a specified planning horizon. However, focusing on particular attributes carries an element of risk. One fundamental risk is that future markets may favour a different set of attributes than those identified. In addition, changes in the economy on global, national and regional scales are difficult

to predict. Further, the demand for different products and, therefore, the types of attributes needed from wood fibre will fluctuate. But despite the difficulty in predicting the future, it is important to consider future scenarios for forest product markets in order to position the Canadian forest industry favourably. Attributes are only desirable in the context of the market that creates the demand for them; in other words, they are not intrinsically desirable. However, the availability of accurate and up-to-date inventories of fibre attributes will allow the forest industry to manage and exploit the fibre basket that we have in order to obtain maximum value from the resource. By understanding what attributes are important to the market and by matching them with high-quality inventories of the attributes of Canadian wood fibre, it will be possible to proactively anticipate future market changes to take advantage of market opportunities to add value to end products.

A clear understanding of the diversity and desirability of the attributes of Canada's fibre resource and the potential influence of management decisions on these values will give decision-makers the ability to respond to future markets. To adapt to changing market preferences, it will be necessary for the CWFC to adjust its research priorities to reassess, periodically, the key attributes of Canadian wood fibre that are favoured by market transitions over time.

6. Conclusion

Canada's vast and diverse forest resource base and the superior quality of its wood fibre have contributed, in a significant way, to the past success of the country's forest products industry.

The enhancement of the competitiveness of the industry will require implementing a new strategy that is aimed at taking advantage of the desirable attributes of Canadian wood fibre across the forest products value chain. The ability to identify, map and marshal homogeneous wood fibre for specific end-product uses will help position the forest industry favourably in the emerging bioeconomy of the 21st century while promoting the sustainability and ecological health of heterogeneous forests in Canada.

Enhancing our understanding of the principal attributes of Canadian wood fibre will contribute toward advancing the Government of Canada's innovation agenda for the transformation of the Canadian forest economy. The CWFC is aspiring to become the national authority on the knowledge, development and utilization of Canadian wood fibre. As an integral component of a broader science and technology initiative, CWFC's research priorities on wood fibre attributes will generate new knowledge about our forest resource base, which serves the long-term objective of securing a healthy and competitive forest sector in Canada.

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Experts Interviewed

The Canadian Wood Fibre Centre wishes to thank the following experts who generously agreed to be interviewed for this project.

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Notes