



# A GENOMICS STRATEGY FOR BRITISH COLUMBIA'S **FORESTRY SECTOR**



**Genome**  
British Columbia

Leading ► Investing ► Connecting



2019

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## 1. Importance of the forest sector to the BC economy

Forests are BC's largest renewable resource and a vital part of its economy and environmental health. Our forests weave through the cultural, economic, ecological and political fabric of the province and are the foundation of many rural communities. BC has over 40 different species of native trees, including some of Canada's most valuable tree species such as pine, spruce, fir, hemlock and western redcedar. Coniferous, or softwood, species are predominant and represent ~90 per cent of B.C.'s forests, while most of the remaining forests are a mix of coniferous and broadleaf, or hardwood, species<sup>1</sup>. The social and economic significance of trees is reflected, for example, in the traditional value of western redcedar for the first nations in BC as well as the economic value of spruce, pine, and fir for the forest industry. In addition, BC is also a recognized global leader in sustainability by having more forest land certified to internationally recognized sustainability standards than any other jurisdiction in the world, except for Canada<sup>2</sup>.

The forest sector is a strong pillar of the provincial economy and a major source of GDP and revenue. Although, the global economic downturn in 2009 severely impacted BC's forest sector, it has since rebounded and in 2016 contributed \$12.9B in GDP and generated over \$4B in revenue for the government. During the same period, the exports almost doubled from \$7.6B to \$14.2B and currently accounts for 32% of the value of all BC goods exported. The sector provides over 140,000 jobs and supports 40% of BC's regional economies that work across the breadth of the forest sector value chain. This economic contribution is a critical source of funding for building infrastructure and government services in BC; accordingly, the sector remains one of the top priorities for BC government, which is committed to sustainable management of healthy and resilient forests<sup>3, 4</sup>.



SOURCE: GOVERNMENT OF BRITISH COLUMBIA, 2016

## 2. Current state of the sector

The forest sector is sensitive to global economic changes, as well as broader environmental and societal issues that continue to challenge its sustainable management, health and resilience. Climate change has emerged as a major threat on the environment front, and has been attributed to intense fires, droughts, as well as invasive alien species in forests not just in BC but across the globe. A changing and less predictable geopolitical environment and increasing trade and tariff barriers, further demand that the sector become innovative, and supply diverse markets to remain competitive. Recognizing the urgency of



these issues, the BC Ministry of Forests, Lands, and Natural Resource Operations and Rural Development (MFLNRORD) has shared its vision to maintain a globally competitive, high value, innovative and sustainable forest industry by growing healthy, resilient forests and continuing to build a diverse and globally competitive industry that will provide stability for forestry dependent communities and First Nations. This is outlined in publications such as Climate Change Strategy 2015–2020<sup>5</sup>; Competitiveness Agenda<sup>6</sup>, Value Added Action Plan<sup>7</sup>, Pulp and Paper Action Plan<sup>8</sup>, Forest Fiber Action Plan<sup>9</sup>, and CleanTech Innovation Strategy<sup>10</sup>.

First Nations, who own 0.1% (137,848 ha) of BC's forests and hold governance rights and a right to the economic benefits associated with the land, are a critical and integral part of the sector. Since 2002, the government has signed forest tenure agreements with 175 of the 203 First Nations in BC, which provide \$324 million in resource revenue sharing and access to 63.2 million cubic meters of timber<sup>11</sup>. Many companies are also executing bilateral agreements with First Nations to involve them in land and resource use decisions and to obtain their consent for operations, thereby building mutually beneficial relationships<sup>12</sup>. Overall, there is growing interest for First Nations, government, and industry to find collaborative ways to shape a new future for the forest sector in the province while addressing significant, new challenges.



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Government initiatives are directed at providing relief from the challenges impacting the sector both upstream and downstream of the value chain. The upstream of the value chain, which includes forestry and logging activities (planning, planting, forest management, road building and harvesting), is particularly impacted by the consequences of climate change, whereas the downstream of the sector, which includes wood product manufacturing, pulp and paper, bio-refining, and forest product marketing, is facing challenges in maintaining its traditional market and competitiveness. Although greater employment opportunities and better prospects for high value products exist in the downstream value chain, success relies heavily on a sustainable and thriving upstream forest sector. BC has an extensive network of forest specialists in government, academia and industry who are working in these areas to improve forest health, breed better trees, diversify forestry products, and extract value from residue across the sector's entire value chain. The province relies on these experts for meeting the overarching objective of maximizing valorization of the forest biomass, particularly by extracting value from residue such as trunk, branches, and bark.

### 3. Sector challenges and opportunities

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The competitive advantage of BC's forest sector, particularly in softwood lumber products and pulp and paper industry, is heavily reliant on healthy, resilient, and sustainably managed forests. Climate change, which has aggravated the bark beetle, mountain pine beetle and spruce beetle infestations, droughts, forest fires, and policy changes are impacting the economic fiber supply. In addition, disruptive technologies, such as digital and electronic media that is substituting the print media, are impacting the pulp and paper industry. Forests associated communities are experiencing both, economic and societal challenges due to these changes.

#### *Impact of challenges on BC's forest sector*

One of the biggest impacts of climate change on forest was the mountain pine beetle (MPB) outbreak in the early 2000s. Peaking in 2004, the outbreak resulted in the loss of millions of hectares of pine forest in BC over a period of 15 years and is estimated to incur current and future losses of ~\$57.37B in GDP from 2009 to 2054<sup>13</sup>. Similarly, the recent outbreak of Spruce Beetle in Northern BC is threatening to alter the spruce forests in northern BC permanently<sup>14</sup>. Invasive species, such as Gypsy Moth, Balsam woolly



adelgid and White pine blister rust are expected to expand their territories in the warming climate and cost BC millions of dollars annually<sup>15</sup>. The unmitigated spread of native and invasive pests and pathogens is a real threat to the province's mid and long-term timber supply.

### *Identifying opportunities from the challenges*

Adding value to, or extracting full value from forest biomass residue, such as bark, leaves, hog fuel, and other typical waste streams could supply products for diverse markets and enable an added revenue stream improving profitability. Currently, these residues are burnt to obtain renewable process energy at pulp and paper mills. While innovative and environmentally sustainable bioproducts, such as high value chemicals and biomaterials, can be derived from the waste residue, challenges such as remote location of mills, transportation costs, as well as technological barriers in scaling and developing economically viable products need to be addressed in order to realize success.



In appreciating some of these challenges, Forestry Innovation Investment Ltd, a BC government market development agency, has highlighted the need for diversification of softwood lumber exports and a 'Wood First Culture' supporting the use of wood for constructing new buildings and biomaterials<sup>16</sup>. BC's Forest Fibre Action Plan and the provincial government's report on pulp and paper sector, encourage the transformation of lower quality timber unsuitable for manufacture into lumber and other solid wood products. They also prioritize generating more value from BC's forest resources and acquiring leadership in the production of low carbon, sustainable products. Nonetheless, the complex matrix of high volumes of low quality fibre, the decline of high value fibre availability, the economics of harvesting and transportation, innovation and investment are inherently challenging and requires a strategic approach to obtaining valuable and sustainable solutions.

### *Maintaining competitiveness of BC's forest sector*

To further address sector competitiveness the BC government in 2016 published BC's Forest Sector Competitiveness Agenda, which the current service plan (2019–22) of MFLNRORD<sup>17</sup> further builds on under the following: (1) economic benefits for all British Columbians with thriving and resilient rural communities; (2) partnerships supporting reconciliation with Indigenous people; and (3) sustainable natural resource management. For long-term success, the BC government and FPInnovations have also developed a Clean Tech Innovation Strategy for the forest sector<sup>10</sup>. Focused on enhanced economic viability, environmental sustainability, aboriginal and community technical support, the strategy commits to adapt, adopt, and develop cutting edge innovations aimed at benefiting BC's forest sector within the new competitive realities and the global clean tech and natural resource based bioeconomy.

Softwood lumber and biorefineries including pulp and paper cover both upstream and downstream of the forest sector value chain. Healthy and resilient forests hold the key for economics of softwood lumber industry upstream of the sector, whereas innovation and market diversification in the pulp and paper industry are critical for sustainable and profitable biorefineries downstream of the value chain.

Similar approaches have been adopted elsewhere in the world and have yielded positive outcomes. In particular, Scandinavian countries such as Sweden, Norway and Finland have successfully pioneered building biorefineries that are not only adding value to the low quality fibre and residues but also lowering unit cost of production across the value chain<sup>18, 19, 20</sup>. While progress in Canada in this area has been slow, momentum is building. Canadian pulp and paper mills have started to adopt integrated bioconversion technologies for transformation of a broad range of feedstocks into commercially viable innovative products<sup>21</sup>. For example, forest residue in BC is being converted into wood pellets as a cheap and renewable source of energy<sup>22</sup>. In Prince George, Canfor pulp, in a joint venture with Licella, is investigating conversion of pulp residue into a renewable biocrude (pyrolysis oil), using catalytic technology, that can be used as raw material for biofuels and chemicals<sup>23</sup>. Modern biorefineries are also exploring nontraditional products such as Nanocrystalline cellulose (NCC) and cellulose filaments (CF)<sup>21</sup>.



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## 4. The role of genomics in addressing sector challenges:

Genomics, the science that deciphers and understands the genome – an organism's (humans, animals, plants, microbes) complete set of DNA, including all of its genes – to better understand biological systems at a molecular level, has revolutionized the world.

Advancements in genomic sciences coupled with decelerating costs of sequencing technologies has immensely benefited the forest sector. Since the sequencing of first tree (*Populus*) genome<sup>25</sup>, in 2004, there are several success stories that have impacted both up and downstream of the value chain.

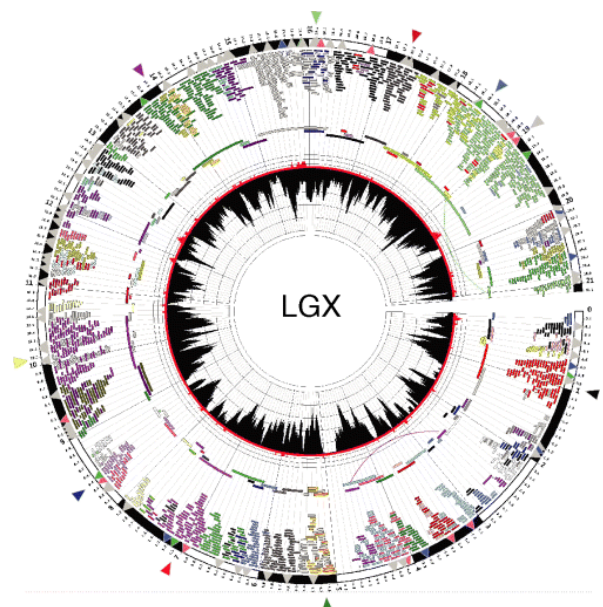
### *Success stories*

Recognizing the potential of genomics in the forest sector early on, Genome BC, along with Genome Canada, strategically supported the sector by providing funding support to several initiatives focused on discovery research. This led to outcomes including the sequencing of first tree (*Populus*) genome, sequencing of the Spruce genome, the development of genomic selection tools for improved breeding, applications of genomics for pest and pathogen control and the identification of microorganisms and enzymes for biomass valorization.

Significant progress was made related to research and economic analysis focused on the strategy for Climate Based Seed Transfer (CBST). This came from a large scale applied research project, called AdapTree, that used genomics tools to prepare our forests to adapt to the future climate. Funding support for this project came from

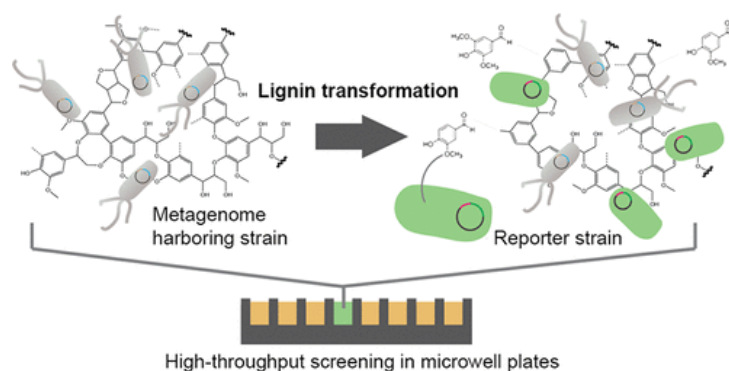
Genome Canada, Genome BC, and SelectSeed – a seed company owned by BC Forest Genetics Council. At the 2019 Annual General Meeting of the Association of BC Forest Professionals, BC MFLNRORD recognized CBST as an innovative strategy to promote healthy, resilient and productive forests and ecosystems through the matching of seedlings/seedlots to future (projected) planting site climates.

Similarly, funding early stage metabolomics research, the branch of genomics analyzing the metabolites in a living organism, provided tools for understanding the defense mechanism of trees that could shield them from the impact of invasive alien species. Research funded by Genome BC also led to development of genomic tools for identification of species in our forests and environment and to track local timber.



**Poplar genome**  
SOURCE: [The Plant Journal](#)

While the upstream forest sector value chain has benefited from genomics, genomics enabled downstream successes are fewer. A noted example is the development of a biosensor based high throughput screening platform for discovering enzymes that are active on forest biomass residues. This technology, developed as part of a large scale applied research project, was commercialized via a spin off company and holds promise in the discovery of enzymes that can potentially convert forest waste into high value products.



**Biosensor based enzyme discovery**

SOURCE: [ACS Synthetic Biology](#)

With the downstream sector opportunities in mind, Genome BC is focusing on biorefineries, particularly, helping the pulp and paper industry adopt genomic tools, including synthetic biology, where engineered microorganisms can be used to transform industry waste into bioproducts. These approaches could help develop both traditional and non-traditional bioproducts that can lead to product diversification and create new market opportunities.

Genome BC's early investments in discovery research has laid the foundation for applied and translational research for the forest sector. The successful outcome of these early investments is also reflected in the active engagement and participation of sector partners in ongoing genomic adoption initiatives that address sector challenges.

**Current initiatives**

Several of the early Genome BC investments into the Forestry sector have yielded advanced tools and technologies that have attracted several user partners into projects that are currently user partner driven projects. Some of these discovery research projects were focused on the adoption of genomic tools for the provincial tree breeding programs, using genomics for bio-surveillance against invasive alien pests and pathogens in BC, as well as application of synthetic biology based approaches for upgradation of waste streams from the pulp and paper industries. Currently, with support from Genome BC and Genome Canada, under the Genomics Application Partnership Program (GAPP), BC MFLNRORD is working as a receptor



**Genomics is at the core of a hand held device that can monitor the transmission of forest pests and pathogens in real time and thereby protect Canada's forests.**

organization with UBC researchers to apply genomic selection in the provincial breeding program for western red cedar. Similarly, Genome BC and Genome Canada have supported another GAPP project in which the Canadian Food Inspection Agency (CFIA) is working with UBC researchers to apply genomic tools for bio-surveillance to protect forests from invasive alien species. On the bioproducts side, FPInnovations and seven pulp and paper industries from BC have created an alliance – the BC Pulp & Paper Bioproduct Alliance – which has received co-funding from Genome BC, under the GeneSolve program, to develop methods for valorization of industrial waste streams.

Genome BC has also ensured that First Nations partners remain actively involved in relevant projects co-funded by the organization. We have invested in projects that are using educational tools and methods to inform First Nations and forest dependent communities about the value that genomics offers in maintaining forest health and climate resiliency.

Our strategy is consistent with global approaches including those adopted by the US Department of Energy (US DoE) as well as Scandinavian countries, where academia, industry, and government have collectively supported genomics research and innovation to efficiently convert biomass residue into high value products such as next generation biofuels, specialty chemicals, and biomaterials.

Using a network of national labs, and a multidisciplinary team of engineers, scientists and economists, the US DoE have built capacity to address several of the challenges faced during the development of first generation biofuels, while continuing the focus on the application of genomics in tree breeding, climate change, and the development of bioproducts from forest biomass<sup>26</sup>. The EU, via European Forest Genomics Network<sup>27</sup> has supported projects aimed at producing ultra-high density maps of conifers, adoption of systems biology for identification of adaptive traits, and efficient management of breeding stocks while maintaining long term diversity. Finland, Sweden, and Norway are pursuing development of integrated biorefineries in collaboration with academia and industry. Private companies, such as Borregaard, and public institutes, such as RISE Paper and Fiber Institute AS in Norway, have partnered to use genome wide mining for developing enzyme technologies for forest biomass processing<sup>28</sup>. Elsewhere, genomics is being used by Brazil<sup>29</sup> and India<sup>30</sup> in Eucalyptus breeding as well as by China to study Bamboo – the most important non-timber forest product in the world<sup>31</sup>. New Zealand's crown agency SION has also invested significantly towards application of genomics across the entire forest sector value chain<sup>32</sup>.

To receive advice and guidance on local, national and global initiatives that are relevant to BC's forest sector, Genome BC established a Forest Sector Advisory Committee (FSAC) in 2016 which includes senior representatives from industry and government. This Committee guides Genome BC's effort in reducing barriers to applications, and implementation of the forest sector strategy. They also advise on how the sector operates, key issues facing it, and opportunities to better serve the interests of the sectors' partners and key stakeholders in BC, while identifying the best genomic opportunities for socio economic benefits of the sector and to demonstrate its value to industry and all end users.

A major outcome of the consultations and advice from FSAC was the Forest Sector Innovation Centre (F-SIC). Genome BC established the F-SIC in 2018 through a Memorandum of Understanding with FPInnovations supporting the BC Pulp and Paper Bioproduct Alliance, as highlighted earlier. The

overarching goals of the F-SIC are to help support the BC pulp and paper industries adopt genomic tools for valorization of forest biomass residues into high value products. By integrating genomics driven technologies across the value chain of BC's forest sector, the F-SIC seeks to support an innovative and future ready sector.

## 5. Approach

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Since 2000, Genome BC has been strategically investing to advance the application and adoption of genomics in BC's forest sector. With initial investment focused on discovery stage research, the portfolio now has a mixture of discovery, applied and translational projects. Thus, over the last two decades, Genome BC has built a strong forest sector portfolio and supported the projects that have developed tools and technologies which can be implemented for benefit of the sector, particularly in the upstream, such as in tree breeding. Building on this strength, and continuing with the major focus on the downstream sector value chain, Genome BC has strategically chosen the following initiatives to advance the application and adoption of genomics in the sector:

1. Realize the concrete deliverables of *investment in research upstream of the value chain*;
2. Enhance focus on *downstream of the value chain*, targeting valorization of forest biomass residues for a zero waste industry;
3. Engage with First Nations and forest communities to inform about value of genomics and ensure their involvement, where possible, in Genome BC funded projects;
4. Strengthen the portfolio of projects in *discovery, applied* and translational research; and
5. Establish *productive partnerships* with leading institutes and corporations at national and international level.

Our investments in projects not only provide research solutions for sector challenges, but also create jobs, support education, and bring a skilled workforce to the sector. These further translate into intellectual property, knowledge creation, entrepreneurship and commercialization. Using the foundation that has already helped transform the landscape for forest genomics provincially, nationally, and internationally, Genome BC is well positioned to realize new opportunities for applied and translational research and deliver tangible impact in the short, medium and long terms.

The organization's performance and eventually its success will be measured by: (a) creation of valuable and productive partnerships; (b) leveraging public and private funding for adoption of genomics in the sector; (c) creating job opportunities for skilled personnel via funded projects, supporting entrepreneurs in the sector to bring innovations into practice and (d) supporting the ecosystem, particularly First Nations partners, with appropriate resources to realize the benefits of genomics for the sector.

## 6. Conclusions

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Genome BC's strategic investments have advanced the application of genomics and the development of genomic tools in the forest sector upstream value chain. This is reflected in significant progress made in

the application of genomics for tree breeding, pest and pathogen diagnostics, and developing strategies for readiness against climate change. Projects funded by Genome BC have also developed genomic tools for tracing BC timber, which is critical for its uniqueness, and managing biodiversity, particularly, wildlife and species at risk. However, major challenges remain in the application of genomics downstream of the value chain, particularly for valorization of forest biomass residue. To this end, Genome BC is committed to investing in genomics and synthetic biology research and technologies focused on upgrading forest biomass residue into value added bioproducts. Thus, while strengthening the existing capabilities and approaches to maintain the leadership role and strong project portfolio upstream of the sector, Genome BC will strategically invest in the development of bioproducts to build a similarly strong investment portfolio downstream of the sector.

## 7. References

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1. <https://www.for.gov.bc.ca/hfd/pubs/docs/mr/mr112/page08.htm>
2. <https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources>
3. <https://www.cofi.org/wp-content/uploads/BC-Forest-Report-FINAL-Sept-2017.pdf>
4. <https://www2.gov.bc.ca/gov/content/data/statistics/business-industry-trade/trade/trade-data>
5. [https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nrs-climate-change/climate\\_change\\_strat\\_2015-20.pdf](https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nrs-climate-change/climate_change_strat_2015-20.pdf)
6. [https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/print\\_version\\_bcfs\\_agenda\\_final\\_lrsingles\\_r2.pdf](https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/print_version_bcfs_agenda_final_lrsingles_r2.pdf)
7. [https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/value\\_added\\_plan\\_sept\\_2016.pdf](https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/value_added_plan_sept_2016.pdf)
8. [https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/pulp\\_and\\_paper\\_sept\\_2016.pdf](https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/pulp_and_paper_sept_2016.pdf)
9. [https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-tenures/forest-fibre-action-plan/communication\\_strategy.pdf](https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-tenures/forest-fibre-action-plan/communication_strategy.pdf)
10. [https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/bc\\_innovation\\_strategy\\_2017-01-18.pdf](https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/bc_innovation_strategy_2017-01-18.pdf)
11. [https://www.bccpa.ca/CpaBc/media/CPABC/News\\_Events\\_Publications/Publications/Industry\\_Update/industry\\_update\\_fall\\_2015.pdf](https://www.bccpa.ca/CpaBc/media/CPABC/News_Events_Publications/Publications/Industry_Update/industry_update_fall_2015.pdf)
12. <https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-first-nations>

13. <https://academic.oup.com/forestry/article/89/1/100/2465746>
14. <https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/spruce-beetle>
15. <https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/invasive-forest-pests>
16. <https://www.bcfii.ca/bc-forests-and-markets/bc-forest-sector-overview>
17. <https://www.bcbudget.gov.bc.ca/2019/sp/pdf/ministry/flnr.pdf>
18. [https://www.swedishwood.com/about\\_wood/choosing-wood/wood-and-the-environment/the-forest-and-sustainable-forestry/](https://www.swedishwood.com/about_wood/choosing-wood/wood-and-the-environment/the-forest-and-sustainable-forestry/)
19. <http://www.fao.org/news/story/en/item/1142131/icode/>
20. [http://www.borealforest.org/world/world\\_finland.htm](http://www.borealforest.org/world/world_finland.htm)
21. <https://www.nrcan.gc.ca/simply-science/20336>
22. <https://www.pellet.org/images/WoodPelletFactsheet.pdf>
23. <https://www.canfor.com/our-company/media-center/blog?id=dbcd817d-de9d-68e6-8279-ff0000b4a60a>
24. <https://www.ncbi.nlm.nih.gov/pubmed/7542800>
25. <https://www.eurekalert.org/features/doi/2004-11/ddoe-stf1111104.php>
26. <https://jgi.doe.gov/>
27. <https://www.cost.eu/actions/E28/#tabs|Name:overview>
28. [https://www.elastopoli.com/sivu.tmpl?sivu\\_id=2302](https://www.elastopoli.com/sivu.tmpl?sivu_id=2302)
29. [http://www.scielo.br/scielo.php?script=sci\\_arttext&pid=S0103-84782016000901585](http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-84782016000901585)
30. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4300219/>
31. <https://www.nature.com/articles/ng.2569>
32. <https://www.scionresearch.com/home>



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0112.001.003 08/2019

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