ACW BASELINE REPORT:
MANUFACTURING - FORESTRY

Jim Chorostecki

ACW | Adapting Canadian Work and Workplaces to Respond to Climate Change

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ACW Baseline Report: Manufacturing - Forestry

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Greenhouse Gas Emissions in Canadian Forestry

I. Research Focus

This background paper explores the emission of greenhouse gasses (GHGs) in Canadian forestry. It is an interesting time to be looking at this topic as 2015 marks the target year, announced in 2007, by which the forest industry had targeted to achieve industry-wide carbon neutrality without the purchase of offsetting carbon credits.[1] Whether this goal has been achieved will not be known until late 2016.

While an introductory section gives insight to the different conversations that revolve around GHGs and forestry, the principle focus here is on energy use and the corresponding emissions created by the different stages of manufacturing in the forestry industry. A broad understanding of forestry's productive chain is adopted here – one that includes the initial harvesting of trees, their processing into intermediate and/or finished products, and the reforestation efforts that are required for Canadian forests to remain a *renewable resource*. With this said, individual production processes remain as potential emissions hot spots for the industry. A mapping of the various production chains in wood and pulp/paper is useful here as is understanding that unused wood is a source of GHGs in and of itself.

Following the introduction, the discussion moves onto trends in production, emissions, and employment in forestry before looking at the flow of these industrial processes. An obvious way to measure improvement in GHG emissions is by looking at the energy or emissions intensity of the industry – specifically the energy used and/or emissions generated for a set unit of output. This measure is employed in analyzing real changes in forestry emissions.

Overall, the industry is found to have improved immensely in its emissions intensity. Three trends are highlighted here: fuel switching, improved energy efficiency, and energy systems optimization. There are a variety of influences that have encouraged the continuous improvement of the industry. These incentives originate in public policy, economic incentives, and social pressure/responsibility.

A concluding section addresses the challenges inherent to addressing both these hot spots and the broader issues that forestry appears likely to confront. Included here is a highlighting of some of the issues and research opportunities that exist within these contexts.

II. Introduction

Though somewhat removed from the years of peak production, forestry remains a significant contributor to the Canadian economy. Combined; harvesting, wood manufacturing, and paper manufacturing contributed nearly $20 Billion CAD (roughly 1.25%) to Canadian GDP in 2014. The most recent annual report on forestry by Natural Resources Canada highlights that forestry remains an export-oriented sector – accounting for 6% of all Canadian exports in 2012.[2]

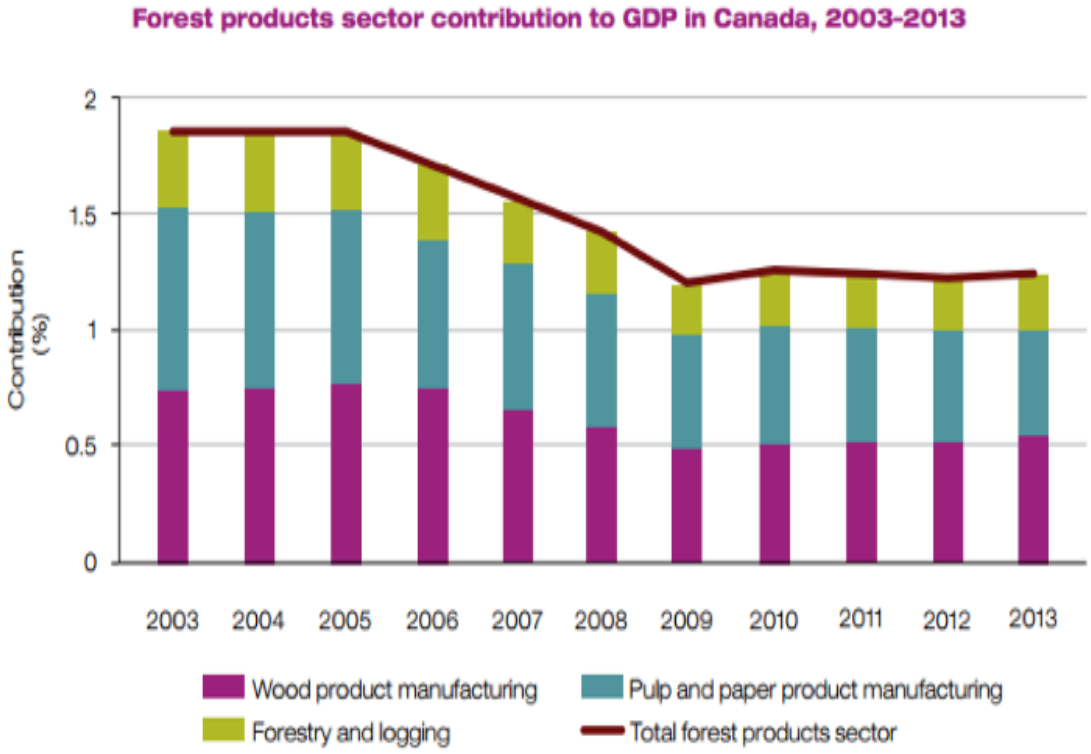
[1] "Canadian Forest Products Industry Aims to be First Canadian Carbon-Neutral Sector", The Forest Products Association of Canada, 31 Oct 2015 http://www.fpac.ca/canadian-forest-products-industry-aims-to-be-first-carbon- neutral-sector/.
[2] Natural Resources Canada, The State o f Canada's Forests – Annual Report 2014, (2014) 31 Oct 2015 <http://www.nrcan.gc.ca/forests/

Trade globalization has and will continue to impact the industry. While the United States has traditionally been the largest purchaser of Canadian forestry products, the rapid growth in demand from the Chinese economy is effectively leading to the evolution of a global marketplace in forestry products. As this occurs, price convergence and market diversification are suggested to be sources of opportunity for Canadian industry as they buffer against the cyclical swings and price volatility that can plague regional markets.

With this said, the industry's relevance to Canada's overall economy has diminished of late. Specifically, the contribution of forestry to Canadian GDP is down almost a third from the high water mark of the early 2000s and the same can be said of employment in forestry (Diagram I). While still employing nearly 200,000 Canadians in 2014, this is significantly lower than the 308,000 employed just ten years earlier.[3]

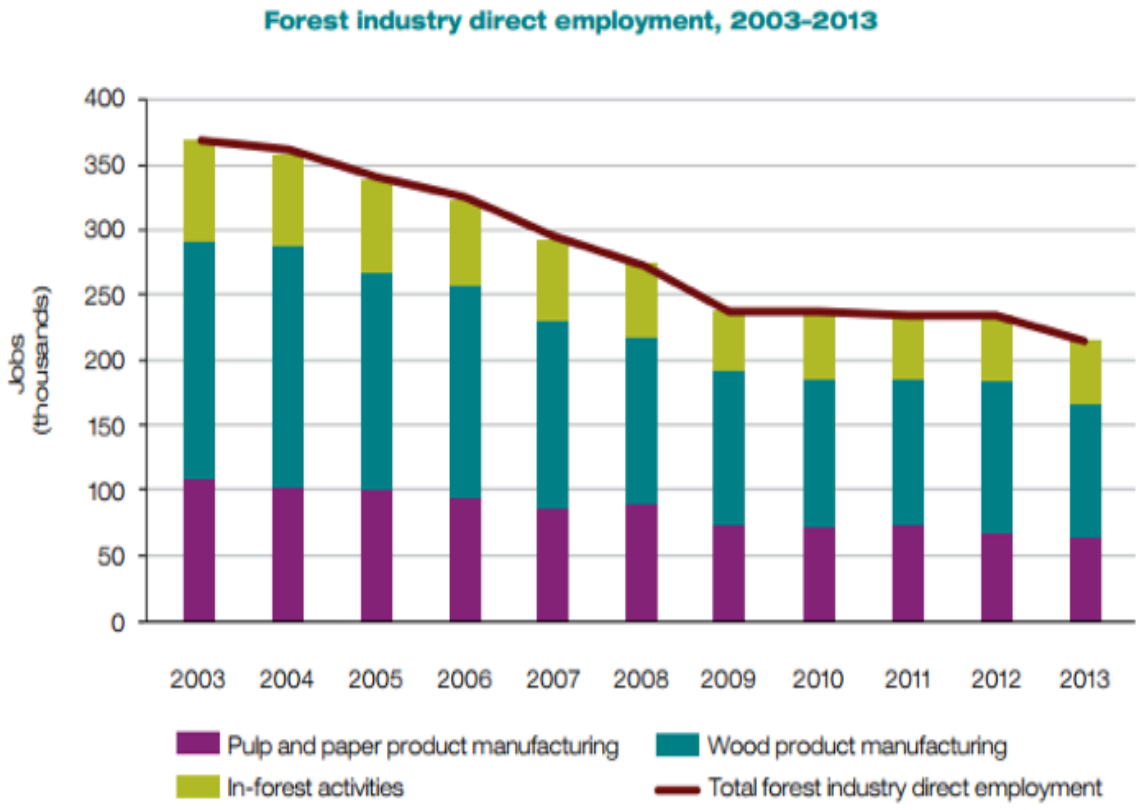
Diagram I – Trends in Forestry – Employment and Contribution to GDP

Source: Natural Resources Canada (2014)



report/16496>.

[3] Greg Keenan, David Parkinson, and Brent Jang, "Paper Trail: The decline of Canada's forest industry", The Globe and Mail 5 Dec 2014, 31 Oct 2015 http://www.theglobeandmail.com/report-on-business/economy/paper-trail-the-fall-of-forestry/article21967746/.



The forestry industry is a complex subject to broach, particularly in in the context of GHG emissions. Not only is the industry composed of multiple constituent sectors but, by nature, it has a unique influence on the net transfer of carbon dioxide (the most emitted GHG) to the atmosphere. To this point, discussions about forestry and GHGs typically involve three concepts – sequestration, emissions, and avoided emissions.

SEQUESTRATION AND AVOIDED EMISSIONS

Sequestration, while not the focus here, is important to understand as a concept related to forestry. Simply, it is the process by which trees (and other plants) soak up and store carbon dioxide (CO_2). This CO_2 remains stored in the tree while alive and growing and is released after that (through burning or decay, for example). Thus, the net contribution of CO_2 from forestry is directly impacted by the net balance of trees that are taken out of Canadian forests. If more trees are removed (deforestation) than replanted there will be a net increase in CO_2 to the atmosphere and if more trees are replanted (afforestation) there will be a net decrease.

With that said, Natural Resources Canada (NRC) reports that the rate of deforestation in Canada is among the lowest in the world and that the forest industry is legally bound to reforest all logged areas.[4] This is corroborated by a National Council for Air and Stream Improvement (NCASI) report's finding that less than 10% of annual deforestation can be directly attributed to the forest sector and that this portion predominantly owes to the construction of permanent settlements and logging roads in previ-

[4] Natural Resources Canada, Deforestation in Canada: *Key myths and facts*, 31 Oct 2015 http://www.nrcan.gc.ca/forests/fire-insects-disturbances/deforestation/13419.

ously forested areas.[5]

Sequestered CO_2 can remain stored in a piece of wood or released through the combustion of that-wood and the corresponding production of energy. Both of these strategies are compared to next best alternatives – wood versus concrete houses, or bio instead of fossil fuel for example – to calculate the avoided emissions that correspond to using wood in a specific application. This is a popular topic as of late as advances in wood technology are increasing its viability as a replacement for more emissions intensive materials (concrete, for example).

EMISSIONS

Though found to have a negligible impact on deforestation and a positive impact on decreasing GHGs through avoided emissions, forestry is also a source of GHG emissions. This happens primarily through the energy consumption of the industry's production processes – be it through the use of fossil fuel, natural gas, electricity (indirectly), or biofuels. In addition to this, unused wood waste that ends up in a landfill emits methane (another GHG) and warrants mention in this discussion.

These emissions are the focus of this background paper. The discussion is a complicated one as the forest industry is a diverse one made up of multiple production processes in multiple sectors. Specifically, though they originate from the same place, one must differentiate between the sectors of pulp/paper and wood products. Further, wood products might take the form of lumber, plywood, oriented strand board (OSB), particleboard (PB), and medium density fibreboard (MDF).[6] These products can differ not only in energy and emissions intensity, but also in the fact that some are inputs – both as physical ingredient and fuel source – for others. These production chains and the emissions that they produce are discussed in the next section.

III. The Forest Industry's Production Chain

HARVESTING

Regardless of final destination, the first stage in forestry's production process involves the actual harvesting of the tree. While often overlooked, this activity is not insignificant – contributing roughly $4 Billion to Canadian GDP in 2014. Further, though deforestation in Canada is reported to be negligible, the contribution of harvesting activities to net GHG production may not be.

A 2015 study compared the fuel consumption of specific harvesting techniques in three different countries.[7] The results are reproduced in Table I and highlight that there may be room for improvement in Canadian operations. These findings bear consideration in the context of a harvesting industry that has become increasingly reliant on fuel- powered machinery.

Once harvested, felled trees are transported to the respective plants and mills that will process them

[5] Brad Upton, Rein Miner, and Kirsten Vice, "The Greenhouse Gas and Carbon Profile of the Canadian Forest Products Industry Special Report No. 07-09", *National Council for Air and Stream Improvement,* Research Triangle Park, NC, USA: NCASI Publications (2007), 14.
[6] Natural Resources Canada, *Status of Energy Wood Use in Canadian Wood Products Sector* (2010), 2.
[7] M.R. Ghaffariyan, R. Apolit, and M. Kuehmaier, "Analysis and control of fuel consumption rates of harvesting systems: A review of international studies," *Industry Bulletin-Australian Forest Operations Research Alliance* (AFORA) 15 (2015), 3.

into intermediate or finished objects. This is a fossil fuel intensive process and the largest source of pre-mill emissions.[8] From here, harvested trees might travel down one of two distinct paths.

PULP / PAPER

Environment Canada reports that the Canadian pulp and paper industry is the world's largest exporter of market pulp and paper and generates 57,500 direct and 250,000 indirect jobs. The wood fiber inputs for the industry are a mix of sawmill residue (55%), logs and chips (21%), and recycled paper (24%). Pulping generally takes one of two forms. The first is a mechanical process wherein fibres are pressed through narrow plates with steam, pressure, and/or chemicals often assisting the process.

The second involves the cooking and breaking down of raw materials using an aqueous chemical solution that is generally recycled after use.[9] In these processes, energy is used to power the equipment used in the pulping process – be it the mechanized operations or the heating and cooling applications (the generation of steam or hot water, for example).

WOOD PRODUCTS

LUMBER

Softwood lumber production is the largest sector in Canada's wood products industry. Three distinct stages occur in its production – sawing, kiln drying, and finishing (surface planing and packaging). Along the way, wood waste is produced as logs are transformed into finished lumber. This waste is either burned on-site to heat buildings and dry lumber, or sold to other wood processors to be used as an input into their systems.

The sawing process involves the initial breaking down of felled logs into different dimensions of rough lumber. It is a highly automated one that involves computer controlled scanning, optimizer and conveyor systems. Next, lumber is loaded into kilns and dried to predetermined moisture content. Different factors – such as wood species, dimension, and initial moisture content can influence this drying process. This is the most energy intensive stage of the lumber production chain.

Once dried, the lumber is then moved to the planing mill to be trimmed down to final dimensions, graded, and then stacked and packaged by grade. In this stage, energy goes into operating the various machinery associated with planing and packaging and wood waste is produced as lumber is trimmed, shaved, and planed down to a finished product.

PLYWOOD

The production of plywood is a more complex one than lumber. Logs are first soaked to facilitate easier debarking and then moved to a lathe. The lathe peels the log down into a continuous sheet of veneer which is then dried to predetermined moisture content. Once dry, the veneers are coated in an adhesive resin, layered in overlapping and perpendicular patterns, and then hot pressed into plywood. The plywood is then trimmed, patched, and sorted by grade for shipment.

OSB

[8] Upton, Miner and Vice, 8.
[9] Environment Canada, "Pulp and Paper", 31 Oct 2015 https://www.ec.gc.ca/Air/default.asp?lang=En&n=CB1E071C-1.

The manufacture of OSB involves the breaking down and then recomposition of logs into strand board. After soaking, logs are debarked and then cut into strands which are dried to predetermined moisture content. Once dry, strands are blended with an adhesive resin, formed, and then pressed into panels before being cooled, cut, graded and edge-coated.

COMPOSITE PANEL BOARD (PARTICLEBOARD AND FIBREBOARD)

Being almost entirely dependent on the by-products of other wood manufacturers for raw material, the composite board sector has been called the original recycler of the wood industry.

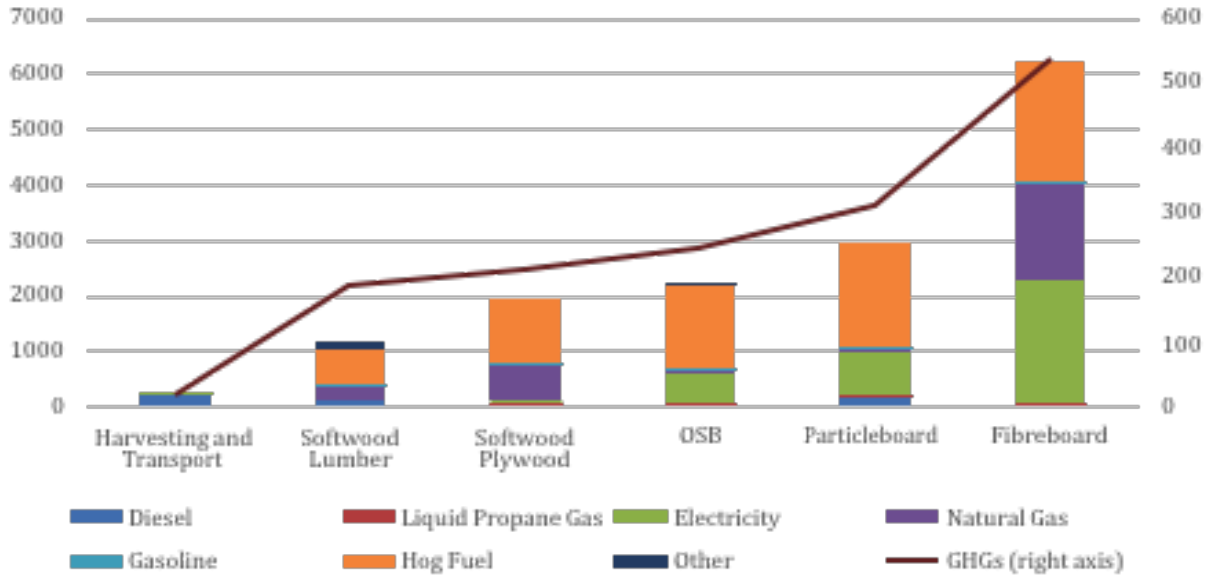
Inputs used in composite board production include sawdust, shavings, wood chips and clippings procured from other wood processors. Once these materials are procured, they are refined and then sized and screened. Next the material is dried and blended with wax before being formed into a mat that is then pressed and finished.

ENERGY REQUIREMENTS OF WOOD PRODUCT MANUFACTURING

In 2009, NRC published a document outlining the energy requirements, wood resource use, and global warming potential of the Canadian wood industry. Information was derived from surveys of selected mills and the information derived is considered a representative sample of resource and energy use in each product category.

Diagram II summarizes energy requirements per m^3 of output and highlights the report's finding that energy requirements per unit of output increased with the complexity of the good being produced. Corresponding with this are higher GHGs per unit of output. These GHGs are produced along multiple stages of the production process in both direct (through the consumption of fuel to power machines and kilns) and indirect (unused wood waste) manners.

Diagram II – Energy Intensity of Select Wood Product Production
Source: Natural Resources Canada (2010)



REFORESTATION

To bring forestry full circle, we return to the original site of harvest. Specifically, the reforestation that the industry undertakes is what ensures that net emissions from deforestation are indeed zero. Little information exists with regards to the emissions produced by reforestation, though the manual nature of this work suggests that it might be low in emissions intensity.

OVERALL – EMISSIONS IN FORESTRY

Putting all of this together allows for an overall understanding of operations and potential sources of emissions in the forest industry. Significant here are the energy requirements for transportation and operation as well as the net change in carbon stored in forests and wood products. With this said, some energy sources are lower in emissions intensity than others – with biofuels leading the way as a carbon neutral fuel source.

IV. Recent Performance

Some distinct stories emerge in analyzing forest industry indicators. While pulp/paper has suffered from a consistent downward trend in demand for its outputs, the demand for wood products – though interrupted by the global recession of the late 2000s – has enjoyed consistent growth in recent decades.

At the same time, the available data indicates that employment in both industries has dropped considerably since its peak in the early 2000s. Further, the aforementioned recession had a pronounced effect on these levels that has persisted in spite of a relative recovery in wood production.

For a variety of reasons, emissions in forestry have fallen considerably in the last quarter century. While some of this is the result of decreases in production, controlling for output (as best we can) illustrates that far more has been going on. Specifically, the emissions intensity of wood and pulp/paper has fallen consistently and significantly (with the exception of a slight increase in wood in recent years).

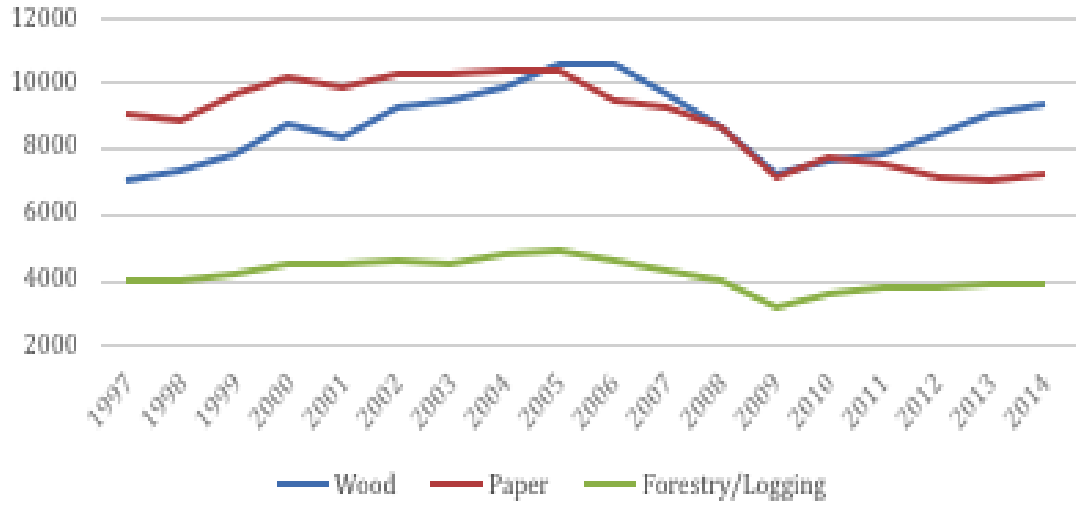
PRODUCTION AND EMPLOYMENT

Due to significant data limitations, a summary of productivity in wood and pulp/paper is limited to monetary indicators. While the dollar value of output might be a reasonable proxy for physical output, this is less than ideal as a variety of factors can influence monetary measures of output (cost of labour and product selling price, for example).[10] What we do know is that both industries enjoyed relatively stable growth from 1990 to the mid-2000s. Their experiences have diverged somewhat since-then as wood appears to have rebounded of late while the demand for pulp/paper has continued to fall as technological advances shift previously paper-dependent sectors to other mediums.

[10] John Nyboer, "Energy Use and Related Data: Canadian Wood Products Industry 1990, 1995-2013", *CIEEDAC* (March 2015), 7.

Diagram III – GDP of Forestry Related Industries in Canada 1997-2014 ($Billions)

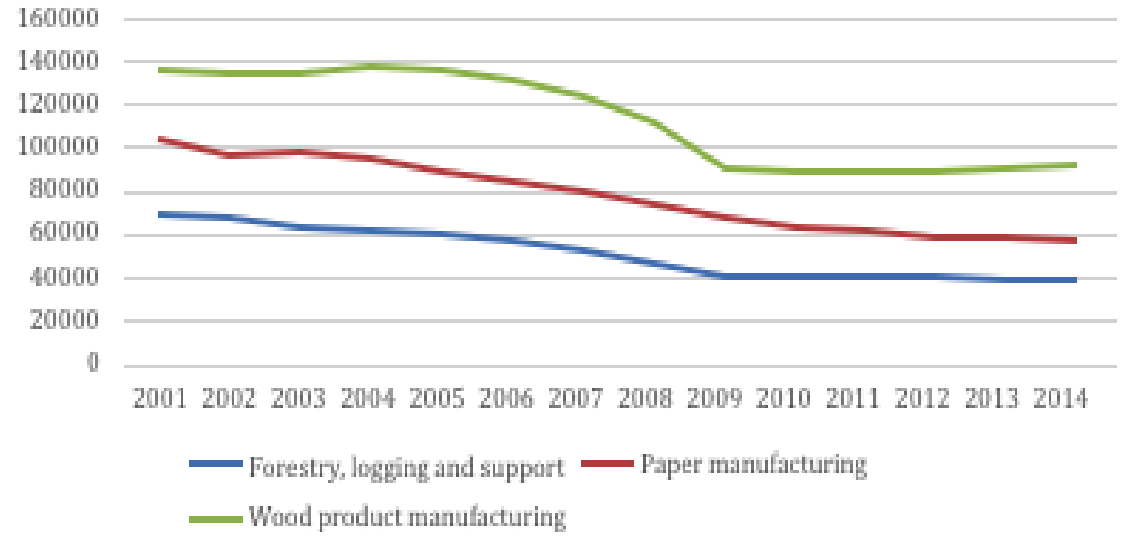
Source: Statistics Canada, CANISM Table 379-0031



Employment figures over the last decade tell a different story. In particular, employment in pulp/paper has suffered from a fairly linear decline since 2001. On the other hand, wood manufacturing and forestry have stabilized at new, post-recession levels of employment even as economic activity appears to have begun to recover. This could be indicative of efficiency gains in the industry, increased automation, and/or of the downturn catalyzing the termination of inefficient practices at both the employee and mill levels.

Diagram IV – Employment in Forestry Related Industries in Canada (2001-2014) Emissions

Source: Statistics Canada, CANISM Table 281-0024



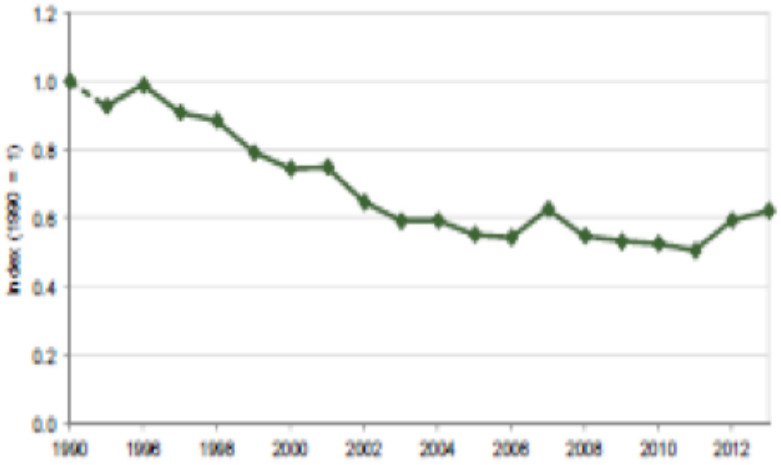
EMISSIONS

Both wood and pulp/paper have made considerable progress in emissions mitigation since 1990. Specifically, pulp/paper has seen a relatively consistent downward trend in emissions that likely relates to both improved processes and decreased production. This has culminated in the industry's emissions intensity (emissions / production) declining to 40% of its 1990 level. Concurrently, the wood industry has lowered its emissions intensity to 60% of 1990 levels, though there has been a slight shift upwards in recent years. This increase of late is attributed to the increased use of natural gas in production processes.

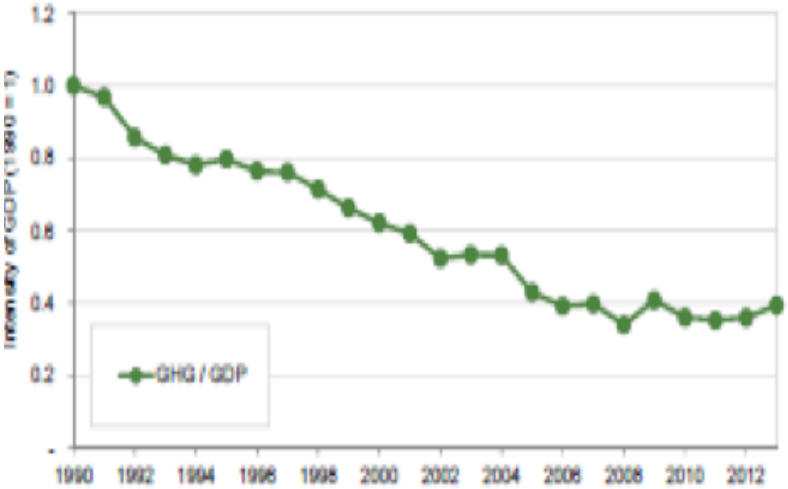
Diagram V - GHG Emissions Intensity in Canadian Forestry Production

Source: Canadian Institute of Energy End-Use Data and Analysis Centre (CIEEDAC), Wood Products Industry Factsheet, 2014; CIEEDAC, Pulp and Paper Industry Factsheet, 2014.

WOOD PRODUCTION



PAPER PRODUCTION



Much of the decrease in emissions intensities in both industries has been attributed to the increasing adoption of fuel switching technologies. Fuel switching is the process of substituting away from more to less GHG intensive energy sources (electricity and biofuels specifically). Switching to biofuels is an especially attractive strategy in forestry because of the fact that many of the byproducts of their production processes can be burned for energy. Additional benefits to fuel switching are that biofuels are less emissions intensive than alternative fuels and that fuel switching negates the emissions associated with sending wood waste to landfills (both through decomposition and the emissions related to transporting wood waste to landfills).

While fuel switching had a relatively significant effect on industry emissions through the late 1990s and early 2000s, more recent emissions reductions have been achieved through systems optimization and gains in energy efficiency. To this point, research has highlighted that drying kilns are the biggest energy consumer in the forest industry. Improvements in kiln use and design, for example, have helped to decrease the energy requirements of wood and pulp/paper mills. Design related improvements include a conversion to continuous-flow kilns as well as the realization that drying can be achieved more efficiently by accounting for the characteristics (species, dimension, original moisture content, for example) of wood that is being dried. While both social[11] and financial incentives have facilitated these gains, three significant public programs have promoted energy efficiency in forestry.

INVESTMENTS IN FORESTRY INDUSTRY TRANSFORMATION (IFIT)

IFIT's goal was to "de-risk" the adoption of new technologies. With an initial budget of $100 million from 2010 to 2014, IFIT received 107 applications and granted funds for 14 approved projects. Amongst the objectives of IFIT were:

- *Deployed technologies that produced or would lead to the production of new non-traditional bio-products and bioenergy, including novel applications of technologies not traditionally found within the sector*
- *Involved value-chain optimization by matching the wood fibre attributes to the needs of the end products*
- *Increased environmental performance while diversifying markets with new, higher value products*

IFIT's most recent performance report indicates that 6 of the 14 projects have been completed with 7 more in progress (5 on time and 2 delayed) with one deemed unsuccessful. Though information is not available for all 14 projects, Natural Resources Canada has published a number of project summaries (http://www.nrcan.gc.ca/forests/federal-programs/13139). Approved projects have included involved adopting wood dust as a fuel source and switching from a chemical to a hot-water intensive pulping practice.

PULP AND PAPER GREEN TRANSFORMATION PROGRAM (PPGTP)

[11] A desire to avoid reliving the experiences of the "War in the Woods" that was waged over logging in the 1990s is cited as an impetu for proactive measures to improve sustainable practices.

Spanning from 2009 to 2012, the PPGTP invested nearly $1 billion into the pulp and paper industry's adoption of "green-focused" capital investments. The project rewarded pulp/paper mills with $0.16 per litre of black liquor produced between January and May 2009. This was a beneficial step in and of itself as black liquor – a by-product of chemical pulping – is a source of renewable energy and a catalyst in certain recycling operations at pulp and paper mills. These funds could then be invested in projects that would "achieve measurable environmental benefits through energy efficiency improvements, renewable energy production, emission reductions and similar means."[12]

In total, 24 different pulp and paper companies were awarded funding for 98 different projects in 38 different communities across Canada. Benefits from these projects include improved energy efficiency, reductions in GHG emissions, and the generation of renewable energies including thermal (steam) and electrical (biofuel).[13] Gains in energy generation are highlighted as a potential new revenue stream through which the pulp/paper industry might remain competitive amidst falling demand for its primary output.

FOREST INNOVATION PROGRAM (FIP)

While the FIP is expected to have a neutral or positive impact on mill-level GHG emissions, it bears mention as promoting decreased GHG emissions at the social level. Specifically, the FIP invested roughly $200 million in promoting research, development, and technology transfer activities in Canada's forest sector. The emphasis here was in supporting first-in-kind projects that promoted bio-intensive products and energy processes in four key areas:

- Next-generation building systems
- Bio-product development
- Integrated value maximization
- Innovation deployment

V. Emerging Issues, Challenges, and Opportunities

According to industry representatives, one of the biggest obstacles to reducing GHGs in forestry is that most of the possible reductions have already been achieved – though efforts continue unabated. In this context, a variety of opportunities emerge. One of the biggest challenges for research involves the aforementioned confidentiality related to output in the industry. As with any subject, a greater availability of data facilitates a deeper analysis of issues and trends. Unfortunately, this problem appears to be growing worse as CIEEDAC has highlighted that growing confidentiality in the wood and pulp/paper industries has become problematic in recent years.[14] Greater data availability in production levels, especially at the individual sector and mill levels is needed.

[12] Natural Resources Canada, "Pulp and Paper Green Transformation Program: Mission accomplished", 31 Oct 2015 http://www.nrcan.gc.ca/forests/federal-programs/13141/
[13] Natural Resources Canada, "Pulp and Paper Green Transformation Program – Report on Results", (2012),2.
[14] Nyboer 21.

In addition to this paucity of data, a number of other questions emerge with regards to emissions in forestry. While the industry is celebrated for making considerable gains in energy and emissions intensity, the emphasis has been on the mill-level and the growing reliance of biofuels therein. Against this backdrop, a 2011 article by the Canadian Centre for Policy Alternatives (CCPA) suggests that a greater carbon focus is still possible for the industry as a whole.

Specifically, the article begins by highlighting Rob Kozak's[15] question of why one of the world's largest manufacturers of Douglas-fir window frames is located in Manitoba and importing its raw materials from Oregon rather than British Columbia's Douglas-fir abundant sawmills. At the same time, the article points out that the "the products shipped in growing numbers to China are overwhelmingly commodities, and many of them low-end commodities at that – raw logs or cut boards used for nothing more than forming concrete."[16] These observations are framed as symptomatic of a larger issue in the forestry industry – namely an emphasis on the production of primary goods and the lengthening of production chains across national and international distances. It would be beneficial to understand the emissions related to these international supply chains.

In addition to this, the CCPA report questions the viability of the increasing reliance on bioenergy in the industry. Specifically, while bioenergy production is currently reliant on residual products from mill production processes and dead or dying trees (from the BC pine beetle phenomenon, for example), a time is envisioned when the supply of these materials might be stressed. With this in mind, the article is raises questions about whether living wood resources might be looked at as a fuel source in and of themselves – and what implications that will have for wood supply as a whole.[17]

The report also highlights some causes for concern with regards to reforestation activities. Specifically, both the health and mix of reforested areas are called into question. A growing prominence of low-value trees in reforested is highlighted to have a "locking-in" effect on future economic activity. At the same time, independent audits of reforestation efforts that were deemed successful have found that health and quantity indicators are lower than originally thought. Since the carbon neutrality of biofuel consumption is premised on the assumption of zero deforestation, better audits of forest health and species makeup are essential.

On the micro-level of production, research could look at the GHG emissions associated with specific steps of the manufacturing process and compare them to international best practices. For example, the fuel consumption in harvesting and emissions due to the deforestation associated with harvesting infrastructure and logging roads are potential areas of research in forestry's first stage. Further down the production chain, the increasing automation of mill practices could be evaluated both for its gross impact on emissions as well as on employment levels. The stagnation of jobs in the wood products industry while production seems to have rebounded could be of particular interest here.

[15] Rob Kozak, "Value-Added Wood Products From British Columbia – Getting Beyond the Rhetoric", *BC Forest Professional Magazine*, Jan-Feb 2007.
[16] Ben Parfitt, "Making the case for a Carbon Focus and Green Jobs In BC's Forest Industry", *Canadian Centre for Policy Alternatives*, (Aug 2011), 4.
[17] Parfitt, 10.

References

Canadian Institute of Energy End-Use Data and Analysis Centre (CIEEDAC). "Pulp and Paper Industry Factsheet, 2014". Available from http://www2.cieedac.sfu.ca/publications.

—.. "Wood Products Industry Factsheet, 2014". Available from http://www2.cieedac.sfu.ca/publications.

Forest Products Association of Canada. "Canadian Forest Products Industry Aims to be First Canadian Carbon-Neutral Sector." Available from http://www.fpac.ca/canadian-forest-products-industry-aims-to-be-first-carbon-neutral-sector/.

Environment Canada. "Pulp and Paper". Available from https://www.ec.gc.ca/Air/default.asp?lang=En&n=CB1E071C-1.

Ghaffariyan, M.R., R. Apolit, and M. Kuehmaier. 2015. "Analysis and control of fuel consumption rates of harvesting systems: A review of international studies". *Industry Bulletin-Australian Forest Operations Research Alliance* (AFORA), 15.

Keenan, Greg, David Parkinson, and Brent Jang. December 14, 2014. "Paper Trail: The decline of Canada's forest industry." *The Globe and Mail*. Available from http://www.theglobeandmail.com/report-on-business/economy/paper-trail-the- fall-of-forestry/article21967746/.

Kozak, Rob. January-February 2007. "Value-Added Wood Products From British Columbia – Getting Beyond the Rhetoric." *BC Forest Professional Magazine*.

Natural Resources Canada. *Deforestation in Canada: Key myths and facts*. Available from http://www.nrcan.gc.ca/forests/fire-insects-disturbances/deforestation/13419.

—. "Pulp and Paper Green Transformation Program: Mission accomplished." Available from http://www.nrcan.gc.ca/forests/federal-programs/13141/.

—. 2012. "Pulp and Paper Green Transformation Program – Report on Results".

—. 2010. "Status of Energy Wood Use in Canadian Wood Products Sector".

—. "The State of Canada's Forests – Annual Report 2014". Available from http://www.nrcan.gc.ca/forests/report/16496>.

Nyboer, John. 2015. "Energy Use and Related Data: Canadian Wood Products Industry 1990, 1995-2013." *Canadian Institue of Energy End-Use Data and Analysis Centre*.

Parfitt, Ben. August 2011. "Making the case for a Carbon Focus and Green Jobs in BC's Forest Industry." *Canadian Centre for Policy Alternatives*.

Statistics Canada. Cansim Table 281-0024. Available from http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=2810024.

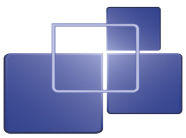
—. Cansim Table 379-0031. Available from http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=3790031&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid.

Upton, Brad, Rein Miner, and Kirsten Vice. 2007. "The Greenhouse Gas and Carbon Profile of the Canadian Forest Products Industry Special Report No. 07-09." *National Council for Air and Stream Improvement*. Research Triangle Park, NC, USA: NCASI Publications.

APPENDIX A: PRODUCTION CHAIN IN FORESTRY RELATED INDUSTRIES

Harvesting				
Transport				
Softwood Lumber	Softwood Plywood	OSB	Composite Panel Board	
Backing/Barking/Soaking	Soaking/Thawing	Soaking/Conditioning	Offsite Generation	(Slasking)
Breakdown and Sawing	Conditioning	Debarking		(Debarking)
End Trimming	Slashing	Flaking	Transport	(Cutting)
Sorting	Debarking	Screening		(Milling)
Stacking	Peeling	Drying	Screening	
Drying	Clipping	Blending	Drying	
Thickness Planing	Preliminary Sorting	Mat Forming	Cyclone	
Grading	Drying	Pressing	Blending	
End Trimming	Final Sorting	Finishing	Forming	
Sorting	Patching	Shipping	Trimming	
Stacking and Shipping	Splicing		Pressing	
	Glue Application		Cooling	
	Composting		Sanding	
	Pre-Pressing		Trimming	
	Trimming/Sanding		Finishing	
	Sorting		Shipping	
	Shipping			

Source: Natural Resources Canada (2010).



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