British Ghost Acres and Environmental Changes in the Laurentian Forest during the Nineteenth Century

This article explores the consequences of the environmental transformations of the Laurentian Valley on the timber trade uniting the Province of Canada and the industrialization of Great Britain during the nineteenth century. The notion of *ghost acres* used to describe the ecological footprint of resource consumption from abroad is extended to accommodate landscape transformations and enrich our understanding of the environmental impacts of imperial trade. Moving beyond the mere calculation of a surface area to assess the *ecological ghost acres* of British industrialization, we reconstitute the exchange circuits of wood products, from the extraction sites of different forest areas of the Laurentian Valley to their final destination in the British market, to identify the environmental consequences resulting from the insertion of the colonial forest economy into imperial trade networks. We also explore the adaptation of the British market to the material differences of North American pine and spruce compared with the familiar timber from northern Europe and how this, in turn, shaped the geography of extraction.

Key words:

Ghost Acres, timber trade, Laurentian Valley, Imperial Trade, Canada, British urban growth, industrialization, economic growth, ecological limits, historical ecology, pine, spruce, timber frontiers

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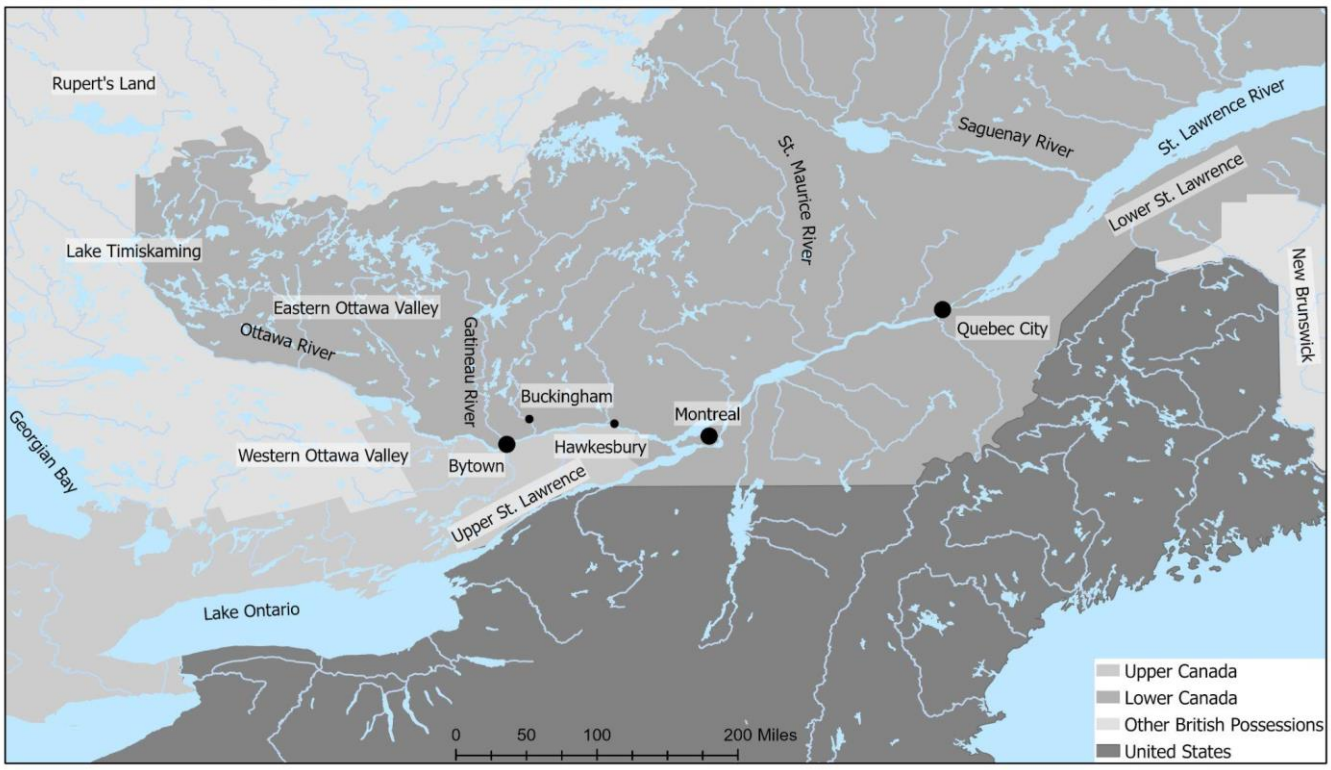
Starting in 1839, George McConnell and his seven sons began a logging operation on Lake Timiskaming, a fluvial lake on the Ottawa River located more than 500 miles northwest of Quebec City (Fig. 1).[1] Red pine timber from this region floated downstream to reach the port of Quebec where it was shipped to Great Britain. During the four decades after Britain turned to its North American colonies to meet its timber supply after the Bombardment of Copenhagen in 1807, loggers travelled further and further up the Ottawa and its tributaries, searching for the species of trees preferred by the Royal Navy and British builders. W.E. Logan, of the Geological Survey of Canada explained in 1846 that the greater value of red pine in the British market, caused "it to be sought for at greater distances" than other species.[2] White pine was more abundant in the lower Ottawa Valley, and timber merchants shipped huge quantities to the British market, despite initial hesitancy from builders to use this less familiar soft timber as a construction material. Spruce also found buyers overseas and was logged and sawn in mills closer to Quebec City.



[1] E.A. Mitchell, *Fort Timiskaming and the Fur Trade*, Toronto, 1977, 162.

[2] W.E. Logan, *Geological Survey of Canada. Report of Progress for the Year 1845—6*. Montreal, 1847, 26.

Fig. 1. The Laurentian Valley.

Rapid British urban industrial growth, the railway booms and a tariff policy that protected imports of colonial timber, all combined to transform the ecology of Laurentian forests across thousands of miles, from the Saguenay Valley and southern shore of the Lower St. Lawrence on the eastern edge of the Laurentian Valley to Lake Timiskaming in the west (Fig. 1). These forests, along with those in New Brunswick and northern Europe provided the essential building materials necessary for Britain's unprecedented growth, in a country later described by historian John Clapham as a 'land without forest.'[3] An industrializing society required wood to build a transportation system and to house its growing urban population—half the population lived in towns or cities by 1851 and that ratio grew to 80% by 1911—but a shortage of trees constituted a formidable problem. To overcome this ecological constraint that placed an upper limit on the development of its society and industries,[4] Great Britain needed to significantly alter distant forests in northern Europe and British North America. Had it not been for the mobilization of natural resources from outside its insular territory, Great Britain would not have been able to overcome the ecological lock caused by the full employment of its land.[5]

Imported timber helped free Great Britain from its land constraint. Geographer and biologist Georg Borgstrom suggested the metaphor *ghost acreage* for the domestic land not required when a country relied on imports of natural resources in his 1965 book *The Hungry Planet*.[6] Initially articulated to designate the space needed to meet the food requirements of a population, the notion of ghost acres has been taken up by Eric Jones and Kenneth Pomeranz to explain the 'European miracle' and the 'Great divergence' of the British economic take–off in the early nineteenth century: Britain imported

[3] J. Clapham, *An Economic History of Modern Britain: The Early Railway Age 1820—1850*, volume 1, second edition, Cambridge, 1930, 9.
[4] E. A Wrigley, *Energy and the English Industrial Revolution* Cambridge, 2010, 10—13.
[5] K. Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World Economy*, Princeton, 2000; J. Goldstone, Dating the Great Divergence, *Journal of Global History* 16 (2021) 274—285; E.A. Wrigley, The Supply of Raw Materials in the Industrial Revolution, *The Economic History Review* 15 (1962) 1—16; E.A. Wrigley, Reconsidering the Industrial Revolution: England and Wales, *Journal of Interdisciplinary History* 49 (2018) 9—42.
[6] G. Borgstrom, *The Hungry Planet: The Modern World at the Edge of Famine*, New York, 1965.

land-intensive products from ghost acres abroad to meet growing local demands without exceeding the ecological limits of its islands.[7]

Observing the oversea extraction and circulation of certain natural resources becomes highly instructive to understand the emergence of industrial societies, and scholars have used the notion of ghost acres to expand our understanding of the growth and scaling process of textile production, the differential diffusion of steel and wood for European industrialisation, and the nutritional transition of British society.[8] These studies of ghost acres usually refer to the importation of land and energy intensive commodities and have largely focused on the metropolitan impacts of distant ghost acres. Unlike environmental historian William Cronon who has demonstrated the centrality of commodity frontiers in shaping urban developments, studies on ghost acres have given little attention to ecological changes underlying the extraction of natural resources abroad.[9] None have been written from the geographical standpoint of the periphery, except to underline the contribution of distant trading partners in sustaining British industrialization by the importation of manufactured goods.[10] Anthropologist Anna Tsing has shown the importance of starting at the periphery to reconstruct commodity chains and changing ecological relationships underlying production and consumption under global trade.[11] Commodity historians have focused increased attention on the social and environmental histories of sugar, tobacco, rubber and cotton production in the Caribbean, South America, Africa and Asia, with little interest in settler colonies.[12] Scholars in land use science, ecology

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[7] E. Jones, *The European Miracle: Environments, Economies and Geopolitics in the History of Europe and Asia*, third edition, Cambridge, 2003 [1981]; Pomeranz, *The Great Divergence*; Goldstone, Dating the Great Divergence.

[8] P. Warde, Trees, trade and textiles: potash imports and ecological dependency in British industry, c.1550—1770, *Past & Present* 240 (2018) 47—82; I. Iriarte-Goñi and M.I. Ayuda, Not only subterranean forests: wood consumption and economic development in Britain (1850—1938), *Ecological Economics* 77 (2012) 176—184; S. Henriques and P. Warde, Fuelling the English breakfast: hidden energy flows in the Anglo-Danish trade 1870—1913, *Regional Environmental Change* 18 (2018) 965—977; J. Clifford, London's soap industry and the development of global ghost acres in the nineteenth century, *Environment and History* 26 (2021) 471—497.

[9] W. Cronon, *Nature's Metropolis : Chicago and the Great West*, New York, 1991.

[10] K. Rönnbäck, Balancing the Baltic trade: colonial commodities in the trade on the Baltic, 1773– 1856, *Scandinavian Economic History Review* 58 (2010) 188–202.

[11] A.L. Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*, Princeton, 2015.

[12] S. Hazareesingh and H. Maat (Eds), *Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History*, London, 2016; S. Hazareesingh, Cotton, climate and colonialism in

and sustainability have made similar contributions, but their studies of telecouplings, the "socioeconomic and environmental interactions between distant coupled human and natural systems,"[13] have largely ignored the historical depth of the movements of commodities and capital across long-distant trading networks.[14]

In this article we argue that ecological relationships at the periphery are crucial to understanding long-distance trade of raw materials, as they impacted both colonial extractive capacities and metropolitan consumptive activities. We extend the notion of ghost acres beyond the hypothetical surface area calculated by economic historians that would have been required to produce these raw materials domestically. Our methods of approaching ecological ghost acres seek to locate and analyze the disturbances of ecosystems in peripheral extraction zones. Based on a study of the timber trade between Great Britain and Canada during the nineteenth century, the article explores how changing patterns of metropolitan wood consumption and colonial timber extraction resulted from ecological changes in the North American forest environment. While historical geographers and economic historians have revealed different sources of British timber supply and varying impacts of deforestation on settler communities in the eighteenth and early nineteenth century, the specific roles of different tree species in the industrialization and urbanization of Great Britain have rarely been explored for this period.[15] Indeed, trade is a relational phenomenon and its study should move beyond

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Dharwar, western India, 1840—1880, *Journal of Historical Geography*, 38 (2012) 1—17; K. O'Connor, Beyond 'Exotic Groceries': Tapioca/Cassava/Manioc, a Hidden Commodity of Empires and Globalisation, in: J. Curry-Machado (Ed), *Global Histories, Imperial Commodities, Local Interactions,* London, 2013, 224—247.

[13] V. Hull and J. Liu, Telecoupling: A new frontier for global sustainability, *Ecology and Society* 23 (2018) 41. https://doi.org/10.5751/ES-10494-230441

[14] H. Eakin et al., Significance of Telecoupling for Exploration of Land-Use Change, in: K.C. Seto and A. Reenberg (Eds), *Rethinking Global Land Use in an Urban Era*, Cambridge MA, 2014, 141—161; C. Friis, J.Ø. Nielsen, I. Otero, H. Haberl, J. Niewöhner and P. Hostert (2016) From teleconnection to telecoupling: taking stock of an emerging framework in land system science, *Journal of Land Use Science* 11 (2016) 131-153, DOI: 10.1080/1747423X.2015.1096423 .

[15] G. Wynn, *Timber Colony: A Historical Geography of Early Nineteenth Century New Brunswick*, Toronto, 1981; M. Williams, *American and Their Forests: A Historical Geography*, Cambridge, 1989; M. Williams, *Deforesting the Earth: From Prehistory to Global Crisis*, Chicago, 2003; R. Davis, *The Industrial Revolution and British Overseas Trade*, Leicester, 1979; R. Hutchison, The Norwegian and Baltic timber trade to Britain 1780—1835 and its interconnections, *Scandinavian Journal of History* 37 (2012) 578—599; A.R.M. Lower, *Great Britain's Woodyard: British America and the Timber Trade, 1762—1867*, Montreal, 1974.

the 'ballistic metaphor' of the impact of imperial demand plundering foreign lands.[16] This article analyzes the materiality of timber extraction and consumption to seize the ecological conditions under which trees extracted from an expanding ecumene in a distant colony were introduced into a rapidly industrializing and urbanizing society. By emphasizing the changing forest geography and ecology of the imperial timber trade, our analysis of ecological ghost acres considers how the needs and uses of a society undergoing industrialisation and urbanisation adapted to the scarcity or abundance of different natural resources as their availability was impacted by extractive activities.

This article focuses on British North American forests, and more precisely on the forest area of the Laurentian Valley, a territory covering the Canadian watershed of the Great Lakes and St. Lawrence River system (Fig. 1). That territory mostly corresponded to the boundaries of Lower Canada and Upper Canada until 1842. These colonies were then united under the political regime of the Province of Canada, before becoming respectively the provinces of Quebec and Ontario following the adoption of the *British North American Act* and the creation of the Canadian Confederation in 1867. In the rest of this article, we describe that territory whose administrative boundaries corresponded to the Province of Canada by using interchangeably the words Laurentian and Canadian in its pre-confederation meaning. We exclude from our analysis New Brunswick, a British "'timber colony" that became a Canadian province in 1867.[17]

After a brief historical overview of the British North American forest exploitation and its integration in the imperial timber trade and the British economy, this article analyzes the intensity and spatiality of forest resource extraction activities in the Laurentian Valley, as well as their consequences on the forest cover. First, we estimate the ghost acres of the timber trade between Great Britain and the Province of Canada using British and Canadian customs data and present the surface area of the extra-territorial forest in the St. Lawrence valley that Britain mobilized in the course of its industrialization and urbanization. This is an opportunity to discuss the limits of the notion of ghost acres, but also to consider its heuristic value in building an environmental historical geography of

[16] J. Beattie, E. Melillo, and E. O'Gorman, Rethinking the British Empire through Eco-Cultural Networks: Materialist-Cultural Environmental History, Relational Connections and Agency, Environment and History 20 (2014) 561–75, https://doi.org/10.3197/096734014X14091313617406.
[17] On New Brunswick, see Wynn, *Timber Colony*, and S. Galavan, Transoceanic Networks of Exchange: New Brunswick Lumber, Merchant Trade, and the Building of Victorian Britain, *Acadiensis* 48 (2019) 90—116.

British industrialization. To refine this portrait of the British ghost acres, we identify the logging areas as they expanded outward from the Port of Quebec according to the wood products exported on the British market and resort to historical ecological studies to present the impact of the timber trade on the forest landscape of the Laurentian Valley. The identification of environmental changes and of their consequences on the supply of specific wood products leads us to consider how industrial demand in Britain evolved over the century to adapt to the varying timber material available from the different Laurentian forests. In our conclusion, we reflect on the scope of the notion of ecological ghost acres to explore how the changing geography and ecology of timber extraction in the St. Lawrence Valley went hand in hand with changes in the metropolitan landscape.[18]

British consumption of Canadian and Baltic timber

The timber trade features prominently in North American historical geography for its role in the economic and spatial development of British colonies. Early in the seventeenth century, the British Navy supplied the Royal Dockyards with pine masts from New England, after centuries of reliance on the Baltic ports as the main source of foreign timber.[19] Following the American War of Independence, Great Britain turned to the North American colonies of Nova Scotia and New Brunswick, but only in the wake of the continental blockade of Napoleon (1806) were the colonies of Lower and Upper Canada pulled in the timber supply chain of the Royal Navy.[20] The effects of the Continental System were immediate on the quantity of Laurentian timber shipped to Great Britain: the number of exported masts and square pine and oak timber doubled in 1808 (30,876 'pieces' compared to 15,501 in 1806) and tripled again by 1810 (110,046 pieces).[21]

The profits made under wartime conditions alleviated the high costs of transatlantic shipping and pushed forest exploitation in remote areas of the colony. White spruce (*Picea glauca*), red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), eastern white cedar (*Thuja occidentalis*), and deciduous

[18] S. Hazareesingh, Interconnected synchronicities: The production of Bombay and Glasgow as modern global ports c. 1850–1880, *Journal of Global History* 4 (2009) 7—31.
[19] R. G. Albion, *Forests and Sea Power: The Timber Problem of the Royal Navy, 1652—1862*, Cambridge, MA, 1926; J. Malone, *Pine Trees and Politics: The Naval Stores and Forest Policy in Colonial New England, 1691-1775*, Seattle, 1965.
[20] Wynn, *Timber Colony*; Hutchison, The Norwegian and Baltic Timber Trade; M. Crevier, The making of a timber colony: British North America, the Navy Board, and global resource extraction in the Age of Napoleon, *Itinerario* 43 (2019) 466—488.
[21] General Statements of Export, *Journal of Lower Assembly of Canada*, 1807—1810.

trees of limited immediate commercial value dominated the forests located close to the agricultural settlements in St. Lawrence River valley where most of the colonial population lived. At the confluence of the Etchemin and St. Lawrence Rivers, facing the Port of Quebec, sawmills supplied by local farmers started manufacturing spruce deals for the British market in the first decade of the nineteenth century.[22] However, it was British demand for familiar white pine (*Pinus strobus*) masts, red pine (*Pinus resinosa*) timber, and oak (mostly *Quercus alha* and *Quercus macrocarpa*s) that sent loggers searching for these species in the vast forests of the St. Lawrence watershed.

Once the blockade ended, Great Britain encouraged the growth of a logging industry in its North American colonies by maintaining high tariffs on timber imported from the Baltic Sea.[23] The war and tariff policies stimulated British timber merchants to risk capital on remote extractive activities and the establishment of sawmills in North America. In the first decades of the nineteenth century large sawmills were built on the Ottawa River, in Bytown (today, the City of Ottawa), Buckingham and downstream, in Hawkesbury. From these sawmills, deals–pieces of sawn lumber measuring 2½-3 inches thick, 7-11 inches wide, and at least 12 feet long–were loaded on rafts heading to the port of Quebec, en route to Great Britain. Until the 1840s, the sawmills in the Ottawa valley supplied nearly half of the pine deals leaving the Port of Quebec, the rest being provided by sawmills in the vicinity of the port using logs driven down the St. Lawrence from the Ottawa.

Imperial protectionist tariff policies allowed Canadian timber and lumber exports to capture a majority of the British market until the 1840s when, after decades of continuous debates, significant reductions of tariffs on foreign timber starting in 1842 and the end of the Corn Laws in 1846 marked a major turning point towards free trade. In 1866, the final timber duties were eliminated, and the forest industry of the Laurentian Valley was left to compete directly with northern Europe. The overall trend saw a significant increase in British timber imports during the first seven decades of the nineteenth century, notably thanks to the contribution of the Laurentian forests. Free trade allowed for the rapid expansion of in European timber, while imports from the Province of Canada continued to grow

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[22] Thomas Wallance, Select Committee on Means of Improving and Maintaining Foreign Trade. First Report (Timber Trade), Minutes of Evidence, Appendix, *19th Century House of Commons Sessional Papers*, volume 6 (January 1, 1821), 66, 73 and 139, ProQuest U.K. Parliamentary Papers, https://parlipapers.proquest.com/parlipapers/docview/t70.d75.1821-006933. R. Samson, *Histoire de Lévis-Lotbinière*, Quebec City, 1996, 157—9.

[23] J. Potter, The British Timber Duties, 1815—60, *Economica* 22 (1955) 122—136.

through to the mid-1860s (Fig. 2). In the wake of the repeal of the British timber tariff, Russia and Sweden had deregulated logging in state-owned forests, and built railways and sawmills throughout their hinterlands to supply an expanding and accessible British market.[24] This competition contributed to the end of growth in Canadian exports in 1862, but they remained on average very high for the remainder of the century (Fig. 3). A broader shift in the British demand for sawn lumber contributed to the decline in square timber exports from the Province of Canada. Fig. 3 clearly shows the impressive rise in lumber exports from the beginning of the early free trade period. The growth of this flourishing trade slowed in the aftermath of the Great Depression of 1873, but the housing booms in Great Britain during the last decade of the nineteenth century sent sawn lumber exports from the Laurentian Valley to new heights (Fig. 3).[25]

[24] J. Björklund, From the Gulf of Bothnia to the White Sea: Swedish direct investments in the sawmill industry of Tsarist Russia, *Scandinavian Economic History Review* 32 (1984) 17—41; C. Lotz, Expanding the space for future resource management: explorations of the timber frontier in northern Europe and the rescaling of sustainability, *Environment and History* 21 (2015) 257—279.
[25] G. Gaudreau, *Les récoltes des forêts publiques au Québec et en Ontario, 1840—1900*, Montreal, 1999.

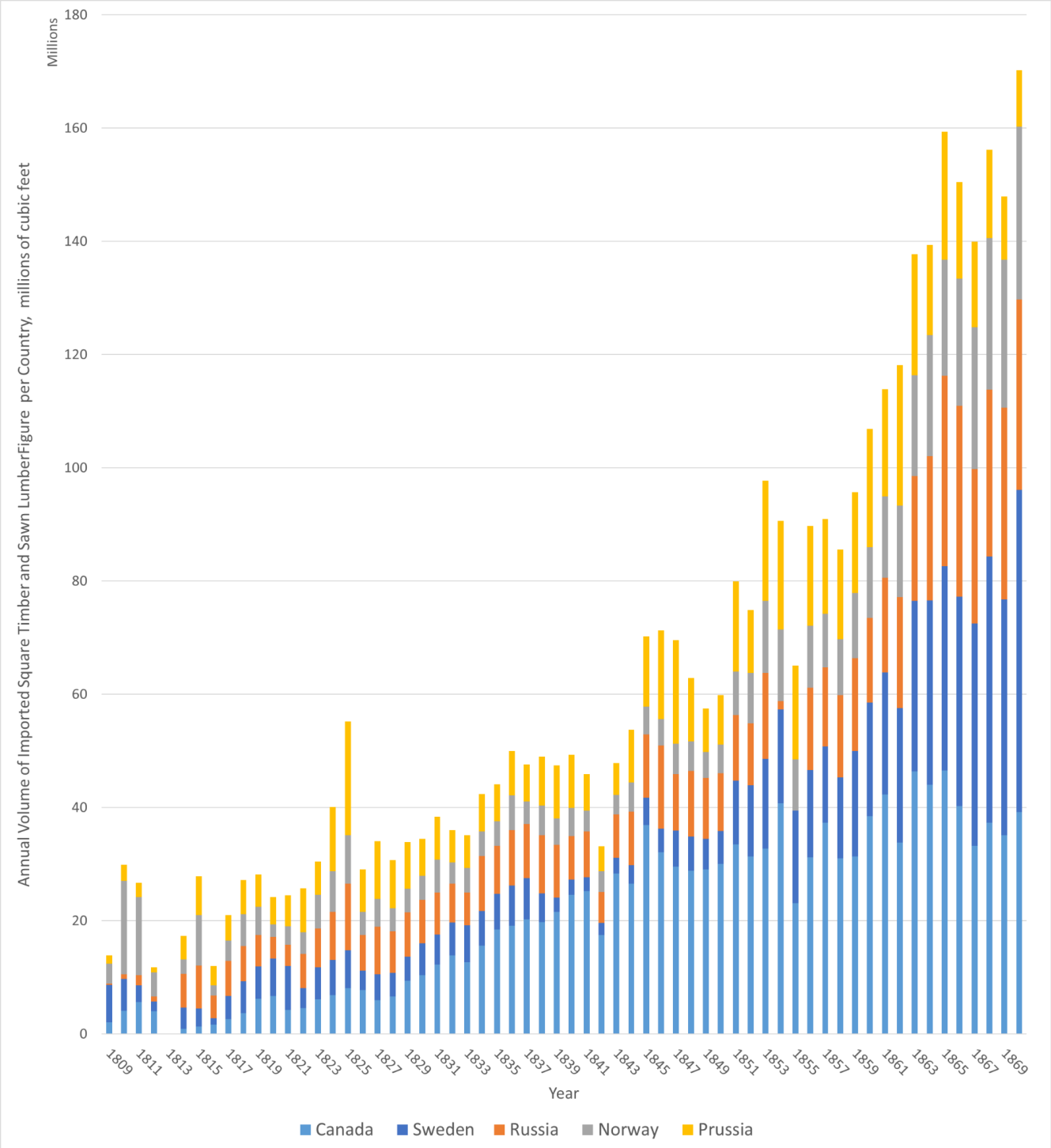

Fig. 2. British timber imports from the Province of Canada and European countries, 1809—1870.

Sources: Kew Archives, CUST-04, 'Ledgers of imports under Countries' (1809-1851), 1813 missing, and *Annual Statement of Trade of the United Kingdom* (1852-1871). See tables 2 and 3.

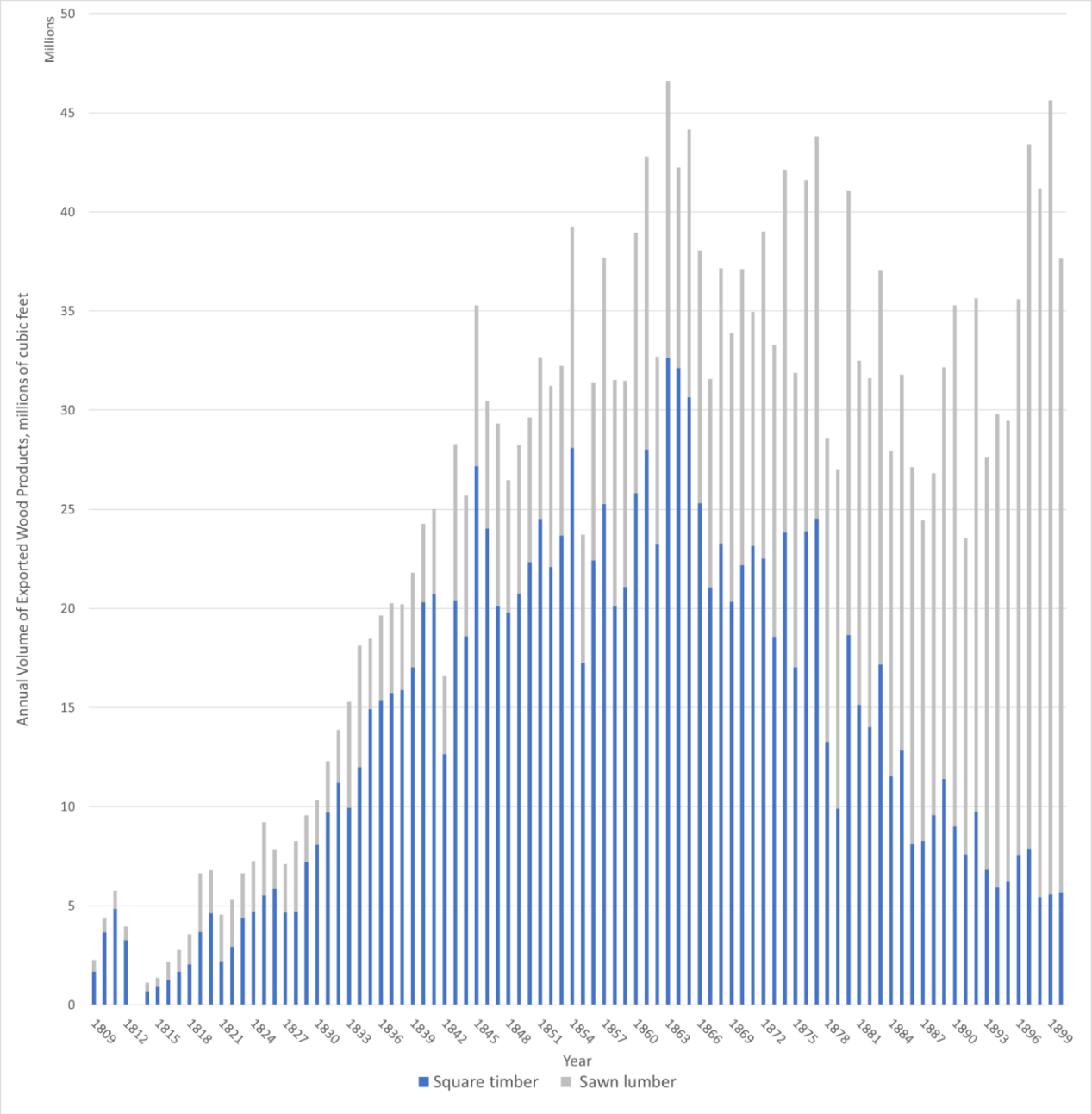

Fig. 3. The timber trade between Great Britain and the Laurentian Valley.

Sources: *Journal of the House of the Legislative Assembly of Lower Canada* (1793—1841); *Journals of the Legislative Assembly of the Province of Canada* (1842—1849); *Sessional Documents of the Province of Canada* (1860—1866); *Sessional Documents of the Dominion of Canada* (1868—1889); *Annual Reports of the Harbour Commissioner of Montreal* (1890—1900); *Annual Reports of the Harbour Commissioner of Quebec* (1890—1900). See table 1.

Through its cycles, the British economy and, above all, its shipbuilding, railway, and residential construction industries, constantly exerted pressure on the Laurentian forests and contributed to depressing or stimulating its timber exports throughout the nineteenth century. There were no available substitutes for many of the uses of timber. Iron hulls did replace wooden hulls, at least in British shipyards, during the middle decades of the nineteenth century. Bridges and similar large structures were another example where the use of wood declined. But iron was not a universal substitute and wood remained necessary as pit props, sleepers, furniture, barrels and packing-boxes, as well as for carpentry and joinery. Iriarte-Goñi and Ayuda correctly conclude that given the centrality of mines, railroads, buildings, and shipping goods for the nineteenth century British economy, these industries needed a growing supply of construction timber, deals, staves, and boxwood to support economic growth.[26] The railways alone created a significant new demand that helped offset the use of iron in shipbuilding, bridges and large buildings.

Even in a context of a free trade that made available at a lower cost Baltic timber, British growth created an increased demand for timber during the nineteenth century.[27] Timber imports from the St. Lawrence Valley were necessary to enable this growth. In the first decades of the nineteenth century, British merchants and builders praised Baltic timber for its superiority, especially during debates over timber tariffs when Laurentian imports flooded the docks of British ports. As concerns grew over the availability and high costs of Baltic timber in the second half of century, they set aside their qualms regarding the qualities of Canadian pine and spruce if these had ever been substantiated. The case of housebuilding illustrates how, considering the strong demand for wood, Baltic supplies could hardly suffice, notwithstanding the price. In 1801, there were 1,467,870 houses in England, Scotland, and Wales.[28] A century later this grew to 7,841,446.[29] The dearth of local timber and abundance of coal meant bricks were the dominant building material, but brick buildings still required significant quantities of wood. Every house required timber to frame interior walls, windows, doors, roofs, and hanging floors. An article in the *Builder* from 1854 estimates a common row house in

[26] Iriarte-Goñi and Ayuda, Not only subterranean forests, 180.
[27] Iriarte-Goñi and Ayuda, Not only subterranean forests, 176, 179—181.
[28] 1801 Census: Abstracts of the Answers and Returns Made pursuant to an Act, 1801, Vision of Britain, https://www.visionofbritain.org.uk/census/GB1801ABS_1 last accessed 16 June 2021.
[29] Houses, Great Britain, Vision of Britain, https://www.visionofbritain.org.uk/unit/10090283/cube/HOUSES last accessed 16 June 2021.

London and its suburbs, with the 'party-walls being 25 feet 6 inches apart,' used between 100 cubic feet (2 loads) to 120 cubic feet (2.4 loads) of timber for girders, floor joists, and ceiling joists.[30] So, leaving aside the likelihood that some of the homes standing in 1801 were torn down and replaced and the need for maintenance on existing homes, the increase in housing required somewhere around thirteen million loads of timber during the nineteenth century. The use of the more expensive Baltic timber and deals was probably restricted to the higher end of the housing market in London, and cheaper homes were built with Canadian wood.[31] Nevertheless, even the higher-end houses used Canadian white pine for doors, finishing carpentry, and blinds.

The increased use of wood for house building went together with further timber demands for construction and maintenance of railways. Between 1830 and 1879, the British built more than 13,000 miles of railways.[32] The initial construction required millions of loads of timber for the railroad ties, bridges, and fencing.[33] Maintaining the wooden infrastructure created a constant demand as sleepers exposed to the wet British climate needed replacing at least every 20 years, even when protected by creosote.[34] By 1870, the railways needed more than 250,000 loads of timber a year to maintain the sleepers. Railways also needed timber for rolling stock, fences, and stations. Not all of this timber, even during the early railway booms during the protectionist period came from British North America. Some railways used domestic timber while others preferred Scotch pine from the Baltic. Others choose to use Canadian timber. The chief engineer of the Great Western Railway Isambard Kingdom Brunel decided to use white pine for railway ties and the company continued to sign contracts for large

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[30] Commonplace House, *The Builder*, 15 April 1854, 197.
[31] Select Committee, House of Commons, 1821, 24—27; Select Committee, House of Commons, 1835, 200—201.
[32] L. Shaw-Taylor and X. You, The development of the railway network in Britain 1825—1911, The Online Historical Atlas of Transport, Urbanization and Economic Development in England and Wales c.1680—1911, https://www.campop.geog.cam.ac.uk/research/projects/transport/onlineatlas/railways.pdf last accessed 16 June 2021.
[33] One mile of track required up to 2,000 to 3,520 railroad ties with each ranging from 2 to 3.5 cubic feet and two miles of fencing. The railways were not standardized during the early years, so calculating the precise quantity of timber required is beyond the scope of this paper. Treasury Committee on Railway Communication between London and Dublin, Edinburgh and Glasgow Fourth Report, House of Commons Papers, 1841, 118, ProQuest U.K. Parliamentary Papers.
[34] W.H. Barlow, *On the Construction of the Permanent Way of Railways*, London, 1850, 6.

deliveries of this commodity during the 1850s.[35] By the later decades in the nineteenth century, the southern Baltic ports, including Riga and Memel, emerged as the dominant supplier of sleepers, so it is clear that Scotch pine proved better suited over time. Nonetheless, timber exports from the Port of Quebec peaked in 1845 and 1846 during the height of the railway boom, reaching 27,166,700 cubic feet in 1845 and 24,014,4000 in 1846 (Fig. 3). *The Economist* confirmed in 1848, that after the railway boom crashed, there was little demand for Canadian timber, because of the "suspension of railways" and the "reduction of building generally" brought by high interest rates.[36] Hence, the huge expansion of railways and housing across Great Britain created a sustained demand for timber from Canada *and* the Baltic throughout the nineteenth century. The continued shipping of white pine and spruce deals from the ports of the St. Lawrence confirms this commodity remained essential for Great Britain since Baltic timber alone could not compensate the limited forest area existing in the British Isles. By importing this colonial timber, Great Britain was free to devote its domestic surface area to functions other than forestry production. It overcame the ecological limits of its territory thanks to ghost acres of the Laurentian forest.

Data and methods

Ghost acres, building off the work of Pomeranz, are calculated to identify the number of acres of British land not required to support the production of essential raw materials like food, fiber and timber. The calculation of ghost acres is based on the quantity of imported resources derived from trade data. For each commodity, a coefficient is used to estimate the surface area that would have been required for its production domestically.

To begin with, our calculation of the British ghost acres of the Laurentian forests requires the enumeration of the quantities of wood products exported from the Province of Canada to Great Britain. Custom documents use different commercial units to measure the quantity of an exported commodity (pieces, tons, loads, feet, standard hundreds, great hundreds, etc.) whose trade format itself is not standardized (deals, planks, battens, boards, staves, battens, billets). To bring all of these

[35] Contract between George Hennet, John Pritchard, John Roberts and Thomas Daines and Great Western Railway Company, January 1855, RAIL 252/239, U.K. National Archives, https://discovery.nationalarchives.gov.uk/details/r/C10854858 last accessed 16 June 2021.
[36] The Commerical Times, *The Economist,* 29 January 1848, 131, The Economist Historical Archive, link.gale.com/apps/doc/GP4100386542/ECON?u=usaskmain&sid=bookmark-ECON&xid=6ec74762 last accessed 1 March 2022.

commodities under one common denominator, export data were converted into cubic feet (we use the imperial system of units in line with the denomination of ghost *acres*). In Canada, the 'General Statement of Exports' and the 'Tables on Trade and Navigation' present the number of pieces of wood products shipped to Great Britain, respectively between 1809 and 1849, and between 1850 and 1889.[37] For the most common sawn lumber products, we use conversion factors presented in table 1 and discussed in official publications and secondary sources. For square timber, we used the *Schedule of documents relative to the supervisor of cullers' accounts* of 1845 and 1846 to determine the volume of a piece of white pine (62 c.f.), red pine (38 c.f.), oak (48 c.f.), elm (36 c.f.) and birch (21 c.f.); cullers measured pieces of square timber before their transhipment in the coves surrounding the port of Quebec.[38] Starting in 1826, quantities of exported masts and square timber were measured using the unit "ton" (one ton equals 40 cubic feet). For the period between 1890 and 1900, *Annual Reports of the Harbour Commissioner of Montreal* presented the quantity of deals shipped to Great Britain in foot board measure. *Annual Reports of the Harbour Commissioner of Quebec* reprinted the annual circular of the timber merchant Bell Forsyth (published since 1844), with the amount of timber and deals shipped from the port of Quebec, respectively in tons and in Quebec standards: one Quebec Standard is composed of 100 deals. The conversion factors relate only to the volumes of exported products and do not take into account waste which, in the case of squaring, for example, reached one quarter to one third of the volume of the tree left on the ground.[39]

[37] 'General Statement of Exports' from the *Journal of the House of the Legislative Assembly of Lower Canada* (1793—1841) and the *Journals of the Legislative Assembly of the Province of Canada* (1842—1849); 'Tables on Trade and Navigation' from the *Journals of the Legislative Assembly of the Province of Canada* (1842—1859), the *Sessional Documents of the Province of Canada* (1860—1866) and the *Sessional Documents of the Dominion of Canada* (1868—1889). Hereafter GSE-TNT.

[38] *Schedule of documents relative to the supervisor of cullers' accounts*, 1845 and 1846. Journal of the Province of Canada. See also J.M. Keyes, *The Dunn family business, 1850-1914: the trade in square timber at Quebec*, Quebec City, 1987, 118.

[39] J. Little, *The timber supply question, of the Dominion of Canada and the United States of America*, Montreal, 1876, 22.

Table 1

Timber products listed in the General Statements of Exports and the Trade and Navigation Tables, exported from the Ports of Quebec and Montreal to the United Kingdom, 1809-1900, with estimated dimensions and volume per piece.

Product	**length (ft.)**	**width (in.)**	**thickness (in.)**	**volume (cu. ft.)**
Deals	10-12	7-11	1-3	2.3
Planks	10-12	7	1-2	0.97
Boards	10-12	7	1	0.49
Battens	12	7	1-2	0.58
Billets and logs	12	NA	180-480	40
Staves, standard	5.5	5	1.5	0.29
Staves, West Indian	2.5-3.5	4	0.75-1.25	0.08

Sources : D. McCalla, *Planting the Province: The Economic History of Upper Canada, 1784–1870*, Toronto, 1993, 47–48; Gaudreau, *Les récoltes des forêts publics*, 150; G. Wynn, Timber Production and Trade to 1850, R.L. Gentilcore (Ed), *Historical Atlas of Canada,* volume 2, Toronto, 1993, plate 11 ; H. Simard, *L'exploitation et la transformation des forêts précoloniales du Haut-Saint-Laurent d'après les ventes de bois consignés dans les actes notariés*, Montreal, 1995, 9-11.

Data obtained from the conversion of Canadian custom documents were compared with data from British custom documents to confirm the appropriateness of our method. Between 1809 and 1850, 'Ledgers of imports under Countries' compiled the volume of square timber in loads (one load equals 50 cubic feet), and the amount of imported deals (and deal ends), battens, boards and staves in great hundreds (120 pieces).[40] Wood products were delivered in varying dimensions for different countries (table 2), depending on local industrial specifications and the length of available tree

[40] 'Ledgers of Imports Under Countries,' British National Archives, Kew, CUST-4, available online 1809—1871 (1813 missing), https://discovery.nationalarchives.gov.uk/browse/r/r/C5581, Hereafter CUST.

species.[41] The British tariff schedules also influenced the length of imported wood products. For example, the imposition of a new tariff schedule in 1821 encouraged Baltic timber merchants to introduce longer deals to pay less duties (table 3). For the period before 1821, we use the *London Commercial Dictionary* to specify the length of battens.[42] For the period between 1821 and 1842, we use the *Report from the Select Committee on Timber Duties* (1835) which provided the average cubical content of deals from the major exporting countries and of battens for Northern Europe and North America imported in 1833.[43] After 1842, 'Ledgers of imports under Countries' and the print publication *Annual Statement of Trade of the United Kingdom* (starting in 1851) present the volume of imported hewn (square) and sawn (deals, battens and boards) timber in loads. After 1870, imports from the Province of Canada ceased to be considered separately.

[41] N. Gallagher, A methodology for estimating the volume of Baltic timber to Spain using the sound toll registers: 1670–1806, *International Journal of Maritime History* 28 (2016) 752–773; M. Kumar, A method for estimating the volume of Baltic timber products exported through the Sound and its application to Portugal, 1669–1815, *Scandinavian Economic History Review* 66 (2018) 246-263, DOI: 10.1080/03585522.2018.1452789.

[42] W. Anderson *London Commercial Dictionary,* London 1816.

[43] *Report from the Select Committee on Timber Duties together with the minutes of evidence*, 1835, p. 272 and 394 for deals, p.398 and 403-413 for battens.

Table 2

Sawn timber products imported in Great Britain and listed in the Records of the Boards of Customs, Excise, and Customs and Excise (1809-1820), with estimated average dimensions and volume per piece in cubic feet.

Product	length (ft.)	thickness (in.)	width (in.)	volume (cu. ft.)
Deals Canadian	12	3	11	2.75
Deals Norwegian	12	3	9	2.25
Deals Swedish	14	3	9	2.63
Deals Prussian*	18	3	10	3.75
Deals Russian	16	3	10	3.33
Battens Canadian	12	2.5	7	1.46
Battens Norwegian	12	2.5	7	1.46
Battens Swedish	12	2.5	7	1.46
Battens Prussian*	14	2.5	7	1.70
Battens Russian	14	2.5	7	1.70

*Including Dantzig, Duchy of Pomerania, Germany, Hanseatic Towns, Hanover, and Oldenburgh.

Sources: *First Report relative to the timber trade from the Select Committee of the House of Lords, appointed to inquire into the means of extending and securing the Foreign Trade*, 1820, 91, for deals and battens. The sizes of the deals in the report of the House Select Committee (1820) were slightly longer.

Table 3

Sawn timber products imported in Great Britain and listed in the Records of the Boards of Customs. Excise, and Customs and Excise (1821-1842), with estimated average dimensions and volume per piece in cubic feet.

Product	length (ft.)	thickness (in.)	width (in.)	volume (cu. ft.)
Deals Canadian	12	2.75	9.5	2.18
Deals Norwegian	15	3	9	2.81
Deals Swedish	17	3	9	3.19
Deals Prussian*	19	3	11	4.35
Deals Russian	21	3	11	4.81
Battens Canadian	12	2.5	7	1.46
Battens Norwegian	12	2.5	7	1.46
Battens Swedish	12	2.5	7	1.46
Battens Prussian*	12	1.5	11	1.38
Battens Russian	12	1.5	11	1.38
Boards	7	1.5	11	0.80

Sources: *Report from the Select Committee on Timber Duties together with the minutes of evidence*, 1835, 272 and 394 for deals, 398 and 403-413 for battens, 389 for boards.

Once the volumes of wood products annually exported from the Laurentian Valley to Great Britain are calculated under a common denominator, their translation into forest areas requires the use of a land-coefficient. Economic historian Dimitrios Theodoridis has surveyed coefficients of land use per unit of product for different natural resources traded in the nineteenth and twentieth century. For timber, Dimitrios determined nineteenth century European forests could sustainably produce 35 to 44 cubic feet per acre per year.[44] We use the lower figure, a more conservative estimate also used by Pomeranz and geographer Vaclav Smil to stress the centrality of domestic coal extraction,[45] but acknowledge the total acreage might be somewhat lower if nineteenth century British forests yields something closer to the top end of the range.

Calculating ghost acres

Using our estimation of the volume of timber imported from the Laurentian Valley between 1809 and 1900 (Fig. 1), the ghost acres freed up for other uses in Great Britain grew to a peak of 1,353,875 in 1863 before fluctuating with the market for the rest of the century (Fig. 4). The hypothetical domestic forest might have absorbed the occasional surge in demand in the second half of the nineteenth century, so taking an average during the 50 years between 1850 and 1899, we find Great Britain required an additional 996,950 acres of forest to offset imports from the Laurentian Valley. This would have required the reforestation of 2 per cent of the island to mature forest sometime before the second half of the nineteenth century to meet this demand. These estimates drop to 1.6 per cent and 797,560 acres if the British forests yields 44 square feet of timber per acre. Canadian exports allowed Great Britain, whose forest had been greatly reduced to only 5 per cent of its territory by the nineteenth century, to continue building its cities and railways without reaching its ecological limits.[46]

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[44] D. Theodoridis, The ecological footprint of early-modern commodities Coefficients of land use per unit of product, *Göteborg Papers in Economic History* 21 (2017) 65—66.

[45] Pomeranz, *The Great Divergence*, 314; V. Smil, *Biomass energies: resources, links, constraints*, New York, 1983, 36; D. Theodoridis, P. Warde and A. Kander, Overcoming land constraints in British Industrialization: An empirical assessment, *Journal of Global History* 13 (2018), 336. doi:10.1017/S1740022818000189

[46] P. Warde, Fear of wood shortage and the reality of the woodland in Europe, c.1450—1850, *History Workshop Journal* 62 (1 October 2006) 34; Iriarte-Goñi and Ayuda, Not only subterranean forests, 182.

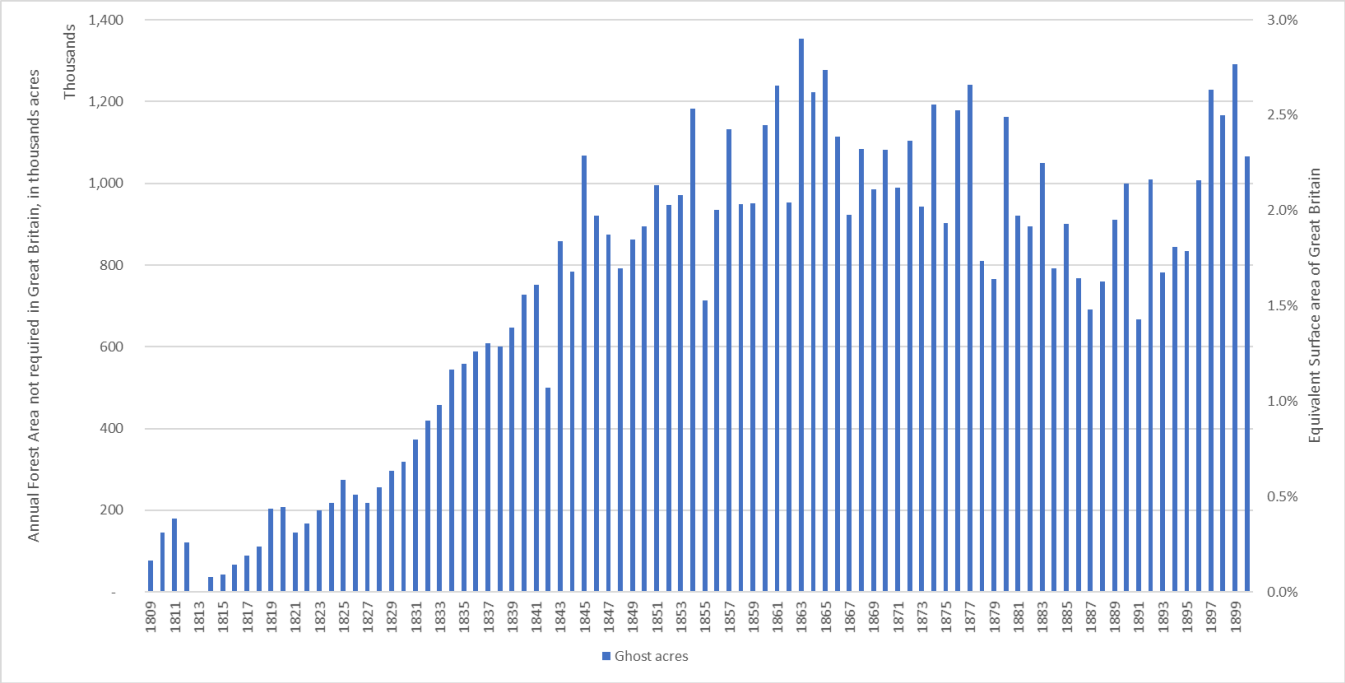

Fig. 4. The ghost acres of British industrialization in the Laurentian forests.

Sources: GSE–TNT (1809—1890); *Annual Reports of the Harbour Commissioner of Montreal* (1890—1900); *Annual Reports of the Harbour Commissioner of Quebec* (1890—1900). See table 1.

Ghost acreage is a useful measure of the centrality of overseas resources for British economic and urban growth, but it does not represent what was happening in the actual forests that supplied the timber. Canadian forests were not under an intensive mode of exploitation, where the same area was regularly cultivated to provide a quantity of timber necessary to supply the commerce and industries of Britain.[47] Loggers were targeting two- to three-hundred-year-old pine and oak trees and harvesting any trees located close enough to a stream for transport. This approach necessitated a continuously moving frontier as the loggers searched for new trees in the mixed forests of the Laurentian Valley. The extensive harvesting methods practiced in North America in the nineteenth century were at odds with the silvicultural methods practiced in several European countries at that time. In no way did Canadian

[47] D. Theodoridis, K. Rönnbäck and W. Scheltjens, Factor endowments and international trade: a study of land embodied in trade on the Baltic Sea region, 1750–1856, *European Review of Economic History* 24 (2020) 722.

loggers aim at the regeneration of the timber resource then considered inexhaustible.[48] The mature pine trees that were logged in the wake of the Napoleonic blockade were not a renewable resource. Decades later, some of the forests were logged again, not to extract regrowth in cut-over areas, but for smaller trees that mills could process into marketable deals and boards. The same holds true for spruce forests that were extensively logged starting in the 1840s. Spruce trees cut down to supply the British market at the end of the century were not new growth from forest logged decades earlier, but the products of a moving logging frontier.

The acres of disrupted Canadian forests do not correspond with the size of the ghost acres shown in Fig. 4. Shifting our attention from the abstracted estimate of the number of British acres freed for other uses, to the actual landscape and ecological transformation in Canada, requires a different approach from the coefficients normally used to estimate ghost acres. We propose ecological ghost acres as a novel approach to better understand the overseas consequences of British imports. Ecological ghost acres are an estimate of the actual geographical scale of the forest disruption combined with an effort to map the spread of the extractive industry and analyze the long-term ecological consequences.

Calculating timber ghost acres requires a more nuanced perspective, even if the available evidence creates a high range of uncertainty. Rather than converting exports into areas harvested on an annual basis, we can extend our analysis to the whole century and calculate ghost acres according to specific tree densities in the North American old-growth forests. Such calculations are fraught with many difficulties as we do not have complete archival records of the yields and locations of most of the logging. Research in historical ecology, however, provides a better estimate than the coefficients used to calculate ghost acres, as it allows us to base our estimates on the composition of the pre–industrial forests instead of the yields of a hypothetical British pine plantation.

Historical ecologists Eduard Mauri Ortuno, Frédérick Doyon, and Danny Jean have used nineteenth century survey books to calculate the total volume of gross merchantable pine timber in the pre-industrial forests of the eastern portion of the Ottawa River Valley, in Lower Canada (an area of more than 5,500,000 acres). The total amounted to 3,987,025,873 cubic feet for pine trees only (these were mixed forests where trees with no commercial value grew alongside the pine). Mauri Ortuno and

[48] S. Castonguay, La fin de la forêt laurentienne : une géographie forestière de la première mondialisation, *Cahiers de Géographie du Québec* 64 (2021) 183.

Doyon calculated that a minimal volume of 1,413,327,394 cubic feet (and maximal volume of 2,115,023,853 cubic feet) of white and red pine was cut on the eastern side of the Ottawa Valley between 1827 and 1901.[49] Part of that wood was sold on the local market, part exported to the United States or South America, but most was shipped to Britain. Our data shows that, between 1827 and 1900, exports from the Laurentian Valley to Great Britain totaled 1,736,714,600 cubic feet of pine timber and deals. This volume represents 43.6% of the total of gross merchantable pine timber (3,987,025,873 cubic feet) that, according to historical ecologists, was available in the pine forests on the eastern side of the Ottawa Valley.[50] This allows us to estimate to about 2,298,000 acres (43.6% of 5,500,00 acres) being the forest area required to supply Great Britain with the pine exported from the ports of Quebec and Montreal. This estimate of the ghost acres, which does not take into account spruce, oak and other hardwoods like elm and maple, roughly equals the British forest left in the nineteenth century. Replacing the Laurentian wood exports by home-grown timber would have needed to fully harvest all the forest available on the British Isles. Much of the British forest, however, was managed coppices for charcoal and bark production, as well as oak timber for shipbuilding and limited amounts of Scotch pine for construction. Britain simply did not have a domestic production of tree species appropriate to replace those imported from the Laurentian Valley for construction timber, let alone the additional imports from New Brunswick, Nova Scotia, and northern Europe.[51]

The forest geography and ecology of the British ghost acres

More than two million acres is a large area, but it still does not capture the materiality of the ghost acres on the ground. The commercially valuable trees were found in mixed forests and the geography of extraction eventually extended over 600 miles across the Laurentian Valley in a forest ecosystem which had reached an advanced stage of succession. Selective logging resulted over the long term in the transformation, but not the destruction, of the Laurentian forests. Most of the regions logged in the nineteenth century remained forested at the start of the twentieth century. Evidence collected and published by historical ecologists instead shows how logging transformed the forests,

[49] E. Mauri Ortuno, F. Doyon and D. Jean, *Distribution Historique du Pin Blanc et Rouge en Outaouais — Phase 2. Évaluation de la Quantité Exploitée dans les Forêts Publiques au 19e Siècle*, Ripon, QC, 2010, 60.
[50] Mauri Ortuno, Doyon and Jean, *Distribution Historique du Pin Blanc,* 62.
[51] J.C. Brown, *Works on Forestry: Forests of England*, London, 1883, 135; Williams, *Deforesting the Earth*, 279; Iriarte-Goñi and Ayuda, Not only subterranean forests, 182.

with mature pine and spruce giving way to other species. If one wishes to consider the size of the forest logged for the imperial timber trade, the simple universal conversion factors used in economic history based on the annual production of an acre of European forests are of limited use.

A detailed knowledge of the transformations of forest ecosystems is required to identify the impact of logging in forest areas solicited for British industrialization. To take a closer look at the vegetational changes experienced in the Laurentian forests and provide a richer understanding of the environmental impacts of imperial trade, we distinguished the quantities of the different wood products exported to Great Britain according to each tree species. 76% of the exported Laurentian timber consisted of white and red pine wood products. Spruce (12%) and oak (8%) were the other major tree species. In turn, these quantities can be related to a corresponding forest area, and more significantly, to specific ecosystems that were commercially exploited.

Forest inventories of the nineteenth and early twentieth centuries document the state of the pre-industrial forest and the vegetational succession following logging activities. Surveyors of the Canadian state and holders of timber limits on Crown Lands produced these inventories. In their logbooks (Fig. 5), they enumerated the principal tree species that appeared on a survey line, and their occurrence, in terms both of their frequency (the number of times that a species appears on inventory lists of a given area) and their abundance (the position that a species occupies on inventory lists of a given area). Although surveyors were concerned with commercial tree species, and that they sometimes neglected to specify the taxon and simply list the genus of the trees (for example, pine, or *Pinus* spp., instead of white pine and red pine, or *Pinus strobus* and *Pinus resinosa* — the same holds true for spruce, birch, and maple), the content of inventories is sound enough in historical ecology to provide a robust portray of pre-industrial forests.[52]

[52] R. Terrail, D. Arseneault, M.-J. Fortin, S. Dupuis and Y. Boucher, An early forest inventory indicates high accuracy of forest composition data in pre-settlement land survey records, *Journal of Vegetation Science* 25 (2014) 691—702.

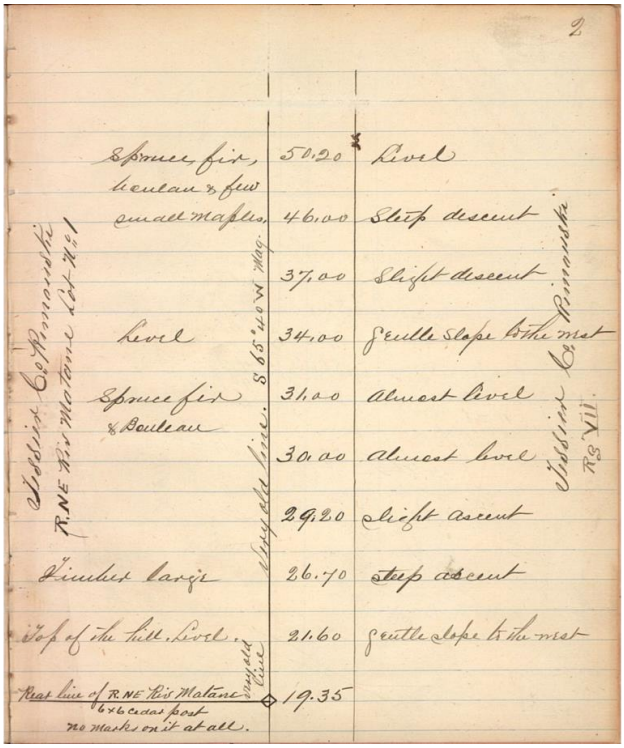

Fig. 5. Example of a forest surveyor's logbooks. Bibliothèque et Archives Nationales du Québec, Fonds Ministère des Terres et Forêts, E21, S60, SS2, P60, Carnet 60 Upper Saint-Maurice, Gatineau and Ottawa.

Exported as square timber or deals, pine was the preferred tree species for most of the nineteenth century. The Ottawa Valley dominated that trade, providing between 60% and 80% of the total of squared white pine timber during the 1840s and between 70% and 90% for the 1850s and 1860s. Other forests in the Canadian colony that supplied white pine were the Georgian Bay and Lake Ontario watershed in Upper Canada, as well as the valleys of the St. Maurice and the Saguenay rivers. Contribution from these areas did not exceed 3% of the total until the mid-1840s; it increased a little thereafter, reaching an all-time high of 8.5% in 1861.[53] As for red pine, about 95% of exports from the Port of Quebec also arrived from the Ottawa Valley until the late 1850s, while the Upper St. Lawrence supplied 10% to 20% of the shipments afterward.[54]

A wood closer to the familiar European red pine sourced from Norway and the Baltic region, North American red pine commanded a higher price than white pine on the British market thanks to

[53] M. Vallières, *Histoire de Québec et de sa région, 1792—1939*, Quebec City, 2008, 70.
[54] Ibid.

this familiarity and partly because of its lesser abundance in the Laurentian forests. This higher price drew loggers further upriver as Fig. 6 shows. Red pine was well recorded in forest inventories and other primary sources, unlike white pine which was rarely specifically noted because of its relative abundance. The one location at Bennett's Brock labelled white pine on Fig. 6 was the furthest upstream anyone mentioned having harvested this species by 1846. Notification of the red pine frontier extended well past this location, reaching Lake Timiskaming by the end of the 1830s, and up tributaries that included the Madawaska and Bonnechere Rivers on the western side of the Ottawa Valley.[55] Extension of the timber frontier was aided by the construction of log booms, timber slides and dams on the Ottawa and its tributaries. Fig. 6 shows the location of some of the infrastructure built to improve the flow of timber downstream. In some cases, the difficulty and cost of building timber slides around rapids and waterfalls delayed the logging of a region until the second half of the nineteenth century.

The movement of the timber frontier significantly extended the reach of colonialism into the unceded Indigenous territory that was meant to be protected by the Royal Proclamation of 1763. Already in the first decade of the century, Algonquin leaders were in conflict with a settler named Philemon Wright for having cleared their land in 1802. As the government in Lower Canada sided with Wright, this decision set a precedent and led loggers deeper and deeper into Algonquin territory. Algonquin leaders continuously petitioned the government to stop loggers from intruding into their territory, but to little avail.[56] Wright and his competitors moved upstream where white and red pine of large dimensions abounded. This process continued throughout the nineteenth century, with logging operations reaching north up the Gatineau River between 1838 and 1855. Logging extended to the

[55] G.W. Hotchkiss, *History of the Lumber and Forest Industry of the Northwest*, Chicago, 1862, 752; Select Committee, House of Commons, 1821, 20—28.
[56] B. Lawrence, *Fractured Homeland: Federal Recognition and Algonquin Identity in Ontario*, Vancouver, 2013, 19.

northern reaches of Algonquin territory on the Blanche and Le Lièvre Rivers by the end of the century.

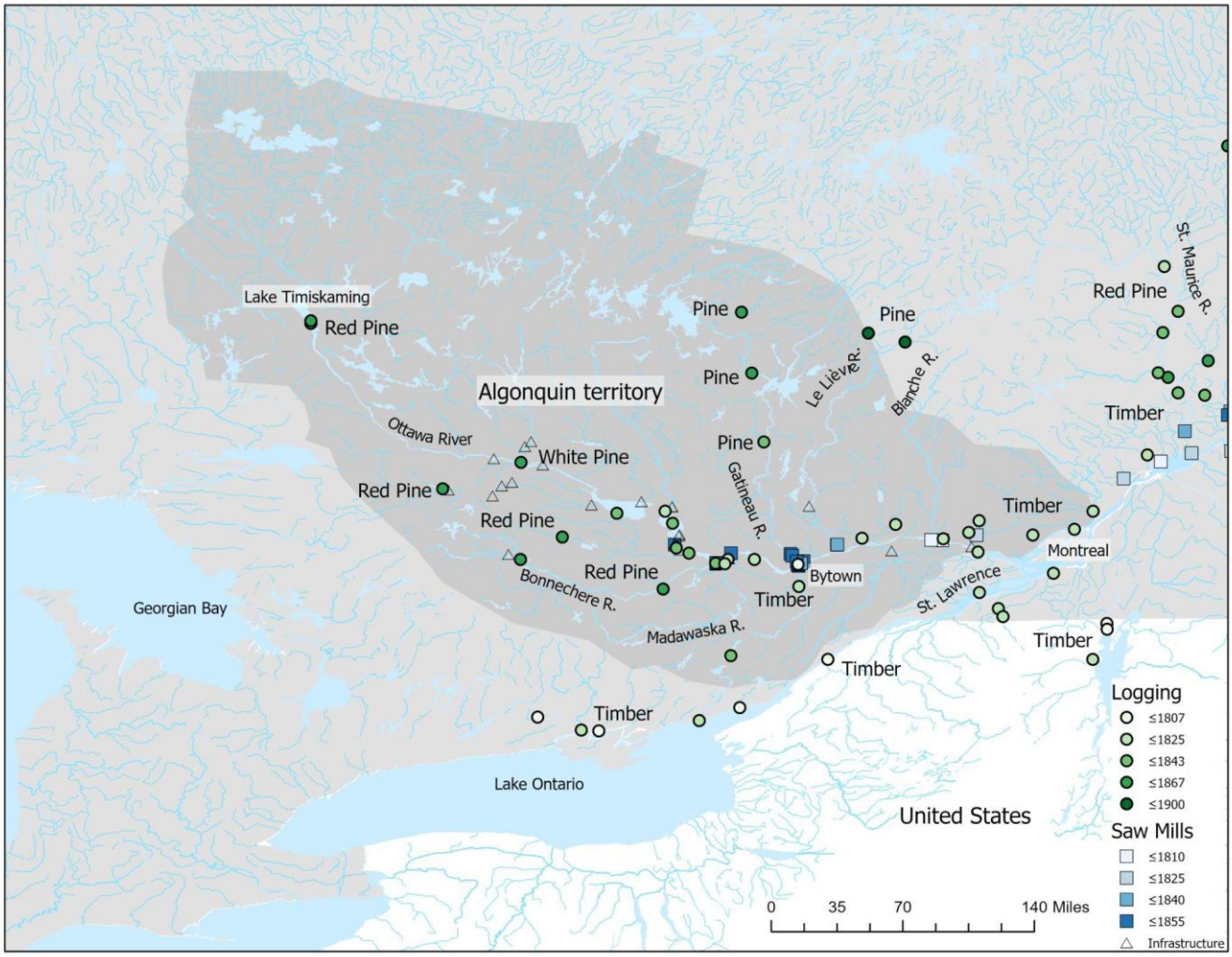

Fig. 6: The Moving Timber Frontiers in the Ottawa Valley. We searched primary and secondary sources for references to “timber”, “pine”, “white pine”, “red pine” and “oak”, terms related to river improvement infrastructure (i.e., “slides” or “booms”) and “saw mill” along with geographic terms like “Ottawa” or “Madawaska”. The points do not represent all logging sites. Instead, they show the rare occasions where logging sites were documented in records that have been digitized or reviewed by historians. The many sources referenced in the creation of this database are recorded on the interactive online version: https://spatialsk.maps.arcgis.com/apps/webappviewer/index.html?id=da3a50330242413f9cdae6b660894fb6

Despite its abundance in the pre-industrial forest, white pine — the taxon most often listed by surveyors — had experienced by the end of the nineteenth century a great decrease in the pre-industrial forest of the Ottawa Valley. Its frequency had decreased from 47% to 26% and its

abundance, from 43% to 30%.[57] Pine was often present in pure stands (15% of all occurrences), but otherwise, balsam was its most common companion species. The selective cutting of pine made room for the reproduction of balsam fir, a shade-tolerant species that produces many seedlings that increased its frequency at the expense of pine. Hardwoods (sugar maple and American beech) also increased in frequency and in abundance in the forest cover after the felling of pines.[58]

Pine felling was not necessarily excessive, but selective logging drained mature and large specimens, usually the seed trees, out of the forests. Other factors that prevented the regeneration of pine trees were the destruction of topsoil and seedling and young pines by fire, as well as the occurrence of logging during wintertime. Forest fires are part of the natural dynamics of pine populations because they open the canopy and eliminate competition, but their occurrence is detrimental to young pine trees when the thickness of the bark cannot protect the cambium against the heat of the fire.[59] As for winter cutting, cones left by the loggers on a thick layer of snow would biodegrade in the damp spring instead of germinating.[60]

Forests of the eastern edge of the Laurentian Valley were initially exploited for pine trees, but it was spruce logging that led to their close integration into the imperial timber trade. That was especially so in the last quarter of the nineteenth century when spruce consumption averaged 40% of the Canadian deal trade on the British market. Spruce exports steadily grew around the organization of timber merchant William Price, who as a clerk for Scott, Idle and Co., organized the supply of the Royal Navy from the port of Quebec between 1810 and 1820. Price already possessed sawmills on the south shore of the St. Lawrence River and in the St. Maurice valley when he acquired timber limits on the north shore, in the Saguenay valley, in the 1830s.[61] These Crown Lands were initially leased by the

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[57] E. Mauri Ortuno and F. Doyon, *Estimation de la Distribution des Essences Forestières au 19e siècle dans l'Outaouais à l'aide des Carnets d'Arpentage des Limites des Concessions Forestières*, Ripon, QC, 2010, 7.

[58] P. Nollet, É. Forget, D. Bouffard and F. Doyon, *Reconstitution Historique du Dynamisme du Paysage Forestier du Bassin de La Lièvre au cours du 20ième siècle*, Ripon, QC, 2001.

[59] L.E. Frelich, The relationship of natural disturbances to white pine stand development, in: R.A. Stine and M.J. Baughman (Eds), *Proceedings of White Pine Symposium: History, Ecology, Policy and Management*, St. Paul, MN, 1992, 22—37.

[60] R. Quenneville and M. Thériault, La restauration des écosystèmes de pin blanc (*Pinus strobus*): un enjeu majeur pour le parc national de la Mauricie, *Naturaliste Canadien* 125 (2001) 39—42.

[61] L. Dechêne, Les entreprises de William Price 1810-1850, *Histoire sociale/Social History* 1 (1968) 16—52; R. Hardy and N. Séguin, *Forêt et Société en Mauricie*, Sillery, 2011, 28—29.

Hudson's Bay Company for its fur trading activities, but after 1842 Price was able to circumvent both the Company and the Royal Proclamation of 1763 to open this other region to logging and settler colonialism more generally, thereby bringing Innu territory into the imperial trade. (Fig. 7). Selective cutting led to the quasi-disappearance of white and red pines from the lower elevations of the Saguenay valley. This was followed by an intensive extraction of spruce, the most frequent and dominant species of the pre-industrial forest along with balsam fir and yellow birch. In 1875, loggers cut 1,006,517 cubic feet of pine lumber and 1,207,283 cubic feet of spruce lumber from the crownland lands in the Lac-Saint-Jean and Saguenay region. This was the end of significant pine logging in the region as it dropped in half in the four years that followed and then fluctuated around that level during the 1880s, while the average spruce harvest increased by 61 percent between 1870-1874 and 1886-1890.[62] The extensive harvesting of spruce and pine resulted in the increase of pioneer shade-tolerant species like red maple and jack pine, as these two species benefited from the forest openings caused by industrial exploitation and human-induced fires.[63]

[62] G. Gaudreau, *L'exploitation des forêts publiques au Québec, 1842—1905*, Quebec City, 1986, 94.
[63] S. Dupuis, V. Danneyrolles, J. Laflamme, Y. Boucher and D. Arseneault, Forest Transformation Following European Settlement in the Saguenay-Lac-St-Jean Valley in Eastern Québec, Canada, *Frontiers in Ecology and Evolution* 8 (2020) 257 doi: 10.3389/fevo.2020.00257

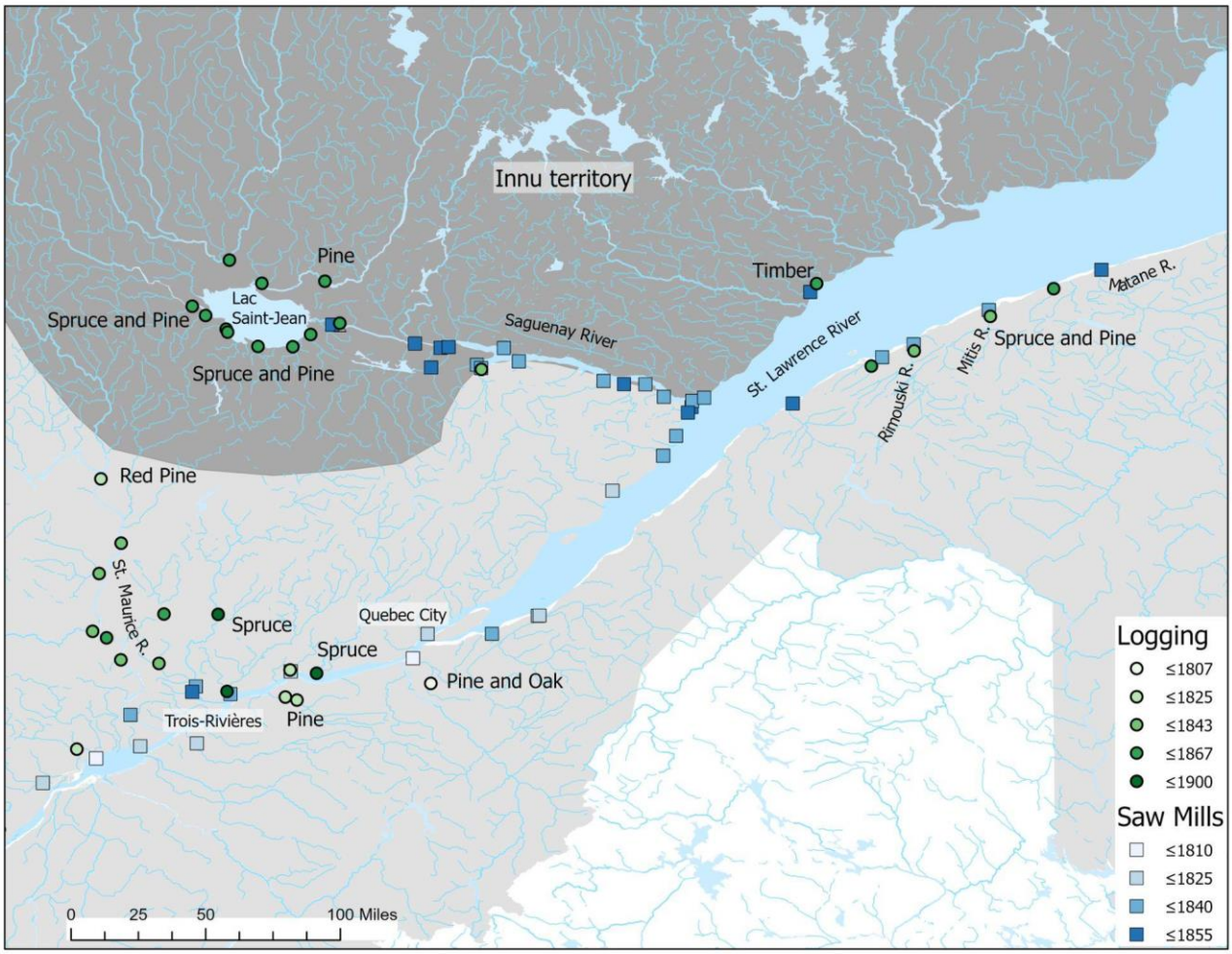

Fig. 7: The Moving Timber Frontiers in eastern Lower Canada. The map used the same approach as Fig. 6, but the sources had more information on the location and year of construction of saw mills at the mouths of tributaries than on the location of logging. The timber frontiers extended upstream from these mill sites in the years that followed.
https://spatialsk.maps.arcgis.com/apps/webappviewer/index.html?id=da3a50330242413f9cdae6b660894fb6

Spruce trees were also the most abundant resinous species of the preindustrial forest of the St. Maurice valley. The region underwent extensive exploitation after 1852, when the Province of Canada provided subsidies to facilitate log driving on the St. Maurice River and accelerate the felling of the disseminated pine stands: white pine's frequency in the middle of the St. Maurice Valley was of 28 %, i.e., pine would be visible in 28% of surveyed sites,[64] which was lower than in the Ottawa Valley, but

[64] E. Mauri Ortuno, *Les archives d'arpentage: témoins de l'état du pin blanc et du pin rouge au 19e siècle en Moyenne-Mauricie*, Quebec City, 2012.

higher than in the Lower St. Lawrence region (5%).[65] Following the exhaustion of white pines, improvements of tributaries in the middle and upper reaches of the St. Maurice River led to the intensive exploitation of white spruce and red spruce (*Picea rubens*). An increase in the proportion of balsam fir and paper birch (*Betula papyrifera*) resulted from that exploitation, but also from insect epidemics and forest fires.[66]

Finally, in the Lower St. Lawrence region, late-successional species like white spruce and balsam fir predominated in the pre-industrial forest. In the lowlands, close to the Rimouski, Mitis and Matane rivers, logging began around 1820 to supply the mills to produce deals and shingles.[67] Selective cutting rapidly eliminated the pines, which were initially scarce compared to other conifers. Already an abundant species, the white spruce rapidly expanded and dominated the area as it took advantage of the openings of the canopy, just like its companion species, balsam. As in other areas in eastern North America, sugar maple and red maple increased their frequency and abundance thanks to their capacity to grow under difficult soil and light conditions, and their abundant seedlings.[68]

Selective logging resulted in a recomposition of the forest cover in the different regions of the Laurentian Valley. Yet the surface area of the Laurentian forests remained practically constant despite decades of exploitation, as interspecies competition and extractive activities led to a rearrangement of the population of different tree species. The recomposition of the forest cover affected the availability of certain species and the size of certain specimens, prompting changes in the timber trade between the Laurentian Valley and Great Britain. For example, tall pine trees were more difficult to find, and the 1875 annual timber circular of Bell Forsyth noticed a supply problem: 'The manufacturers of all kinds of

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[65] S. Dupuis *Reconstitution de la composition des forêts préindustrielles du sud-est du Québec à partir des archives d'arpentage (1846-1949)*, Rimouski, 2009; S. Dupuis, D. Arseneault and L. Sirois, «Change from pre-settlement to present-day forest composition reconstructed from early land survey records in eastern Québec, Canada», *Journal of Vegetation Science* 22 (2011): 564—575.

[66] M. Barrette and L. Bélanger, Reconstitution historique du paysage pré-industriel de la région écologique des hautes collines du Bas-Saint-Maurice, *Canadian Journal of Forest Research* 37 (2007) 1147—1160.

[67] Dupuis, Arseneault and Sirois, Change from pre-settlement to present-day forest composition reconstructed from early land survey records in eastern Québec, Canada 565; J. Fortin, *Histoire du Bas-Saint-Laurent*, Quebec City, 1996, 158.

[68] Y. Boucher, D. Arseneault and L. Sirois, La forêt préindustrielle du Bas-Saint-Laurent et sa transformation (1820—2000): implications pour l'aménagement écosystémique, *Le Naturaliste canadien* 133 (2009), 61.

Timber find it an impossibility to produce the same class of wood they were able to do some years ago, the trees are more scattered, the new ones which are most inaccessible'.[69] A shift from hewn timber to sawn lumber in the export of white pine in the second half of the nineteenth century partly resulted from the scarcity of good-sized specimens to be shipped as square timber, although the British market experienced its own transformations, with a stronger inclination toward the imports of deals, battens, and boards. However, even for the production of pine deals, the transportation of logs to the Port of Quebec became more expensive because lumber camps needed to be constantly relocated to reach the trees that were still available upstream on the Ottawa River.[70] The commercial potential of spruce deals sourced from nearby forests east of the Port of Quebec increased, even in British ports of the east coast like Hull and Sunderland, closer to large providers of whitewood deals from the Gulf of Bothnia and the White Sea. Over time, housebuilders valued the structural properties of spruce such as lightness, strength and elasticity and extended its use "into frames of buildings, covering, roof-boards, flooring, finish, sheathing and even mouldings."[71] Modifications in the transatlantic timber trade therefore reflected the new composition of the Laurentian forests, but they also resulted from fundamental changes in British preferences for sawn lumber.

Conclusion

Far from being intangible, ghost acres of British industrialization had ecological foundations. The forest cover of the Laurentian Valley changed materially since the Napoleonic blockade initiated a long era of timber trade between Great Britain and its North American colonies. Because of the scarcity of specific tree species, the extraction and transportation of certain wood products from the Laurentian forests became too prohibitive to compete on the international market. Different trees and wood products gained market share in Britain and encouraged timber merchants to rely on new sections of the colonial territory that they drew into the imperial trade.

Unlike current studies which abstractly described the process of extraterritorial extraction of natural resources, our data enabled us to characterize the British ghost forest by dividing the hypothetical and aggregate surface area into peculiar ecologies and geographies. We distinguish how

[69] Forsyth Timber Circular, *The Morning Chronicle*, 18 December 1875.
[70] S.J. Gillis, *The Timber Trade in the Ottawa Valley, 1806-54*, Ottawa, 1975, 93.
[71] T. Laslett, *Timber and Timber Trees and Foreign*, London, 1875, 338; Spruce, *Timber Trades Journal*, 12 June 1886; The trees of commerce, *Timber Trades Journal*, 16 April 1887.

different ecosystems were specifically impacted by the imperial timber trade, thus providing a richer historical analysis of the environmental transformations of Britain's industrialization. In fact, the ecological ghost acres of the imperial timber trade rested on the exploitation of distinct wooded areas across the St. Lawrence-Great Lakes drainage basin, whose tributaries and watersheds did not offer the same forest possibilities.

Rather than limiting our understanding of ghost acres to the calculation of a surface area, we operationalize this notion by identifying environmental changes at the extraction site and the spatial dynamics of logging in the Province of Canada. The interplay between the requirements of the British industries and the ecological conditions of the Laurentian forests shaped the geography of the timber trade. Logging teams went great distances to supply red pine from the upper Ottawa Valley, while other timber merchants focused on exporting the more abundant, but less valued white pine. High-end builders started to value white pine for interior applications where the softness proved useful for finishing carpentry. When the extraction and transportation of pines to the Port of Quebec became more costly for forest operators in the Upper Ottawa, the commercial potential of eastern Quebec spruce lumber increased, along with a changing appreciation of this wood product species by the British construction industry.[72] Growing quantities imported from Quebec suggest this inferior construction wood found its way into many homes in the fast-growing neighbourhoods of simple two-up two-down row houses throughout Britain. Free trade in timber did not end exports of pine and spruce from the Laurentian Valley, even after they were surpassed by the contributions of Sweden and Russia. The availability of certain tree species thus took on both ecological and geographical dimensions, and the impact of selective logging was felt both in the Laurentian forests and in the British buildings.

British timber consumption throughout the nineteenth century changed, from shipbuilding construction to the railway industry. Subsequently, urbanization intensified the need for residential buildings and therefore for construction lumber. Indeed, in his seminal work, Pomeranz refers three times to the four Malthusian necessities, but his research focuses on food, clothing, and energy, and sets aside housing — the fourth necessity.[73] Revealing the dynamics of the housebuilding industry would enable us to appreciate the synchronicity of environmental changes throughout the British

[72] Timber trade reports—London, *Timber Trades Journal*, 23 January 1875.
[73] Pomeranz, *The Great Divergence*, 19, 56, 219.

Empire, by linking the forest landscape transformations of the Laurentian Valley with those of the urban landscapes of Great Britain. By knowing, for different periods and different regions, the volumes of exported tree species, the reconstitution and the description of the ghost acres would lead us to present how the ecology of peripheral ghost acres in the Laurentian forests impacted on metropolitan urban landscapes according to the availability of specific wood products.