

Putting a Value on the Ecosystem Services Provided by Forests in Canada: Case Studies on Natural Capital and Conservation



March 21, 2017

Prepared by TD Bank Group & the Nature Conservancy of Canada



About this Report

This report was prepared in collaboration between TD Bank Group (TD) and the Nature Conservancy of Canada (NCC), and builds on a white paper that was released in 2015, *The Natural Capital Value of Forest Habitat Conservation*: www.natureconservancy.ca/naturalcapital

Most of the case studies in this report include properties that were secured through a five-year collaboration between TD and NCC to conserve high priority forests across Canada, under the TD Forests program. This partnership has resulted in the conservation of over 16,000 ha in 25 forest conservation projects in Canada. In addition to the important natural values provided by these sites, including habitat for species at risk and corridors for wide-ranging mammals, these properties also provide ecological services to Canadians and their communities. The purpose of this report is to explore these ecological services and their natural capital values.

More information about the program can be found at www.natureconservancy.ca/forests

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Cover Photo: Kenauk property in Quebec. Protected through the forest conservation partnership of the TD Bank Group and the Nature Conservancy of Canada. Photo by Mike Dembeck.

Disclaimer

Information presented in this report is based on the most recent information and approaches to natural capital valuation. These values may change as new information and methods are developed. Natural capital values do not include all of the economic, social and ecological values associated with protected areas, and are solely intended to assess the values of ecological services and the projected costs to local communities and society if these services were to be lost or degraded.

Questions about this report?

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FOREWORD

Since 2012, the Nature Conservancy of Canada (NCC) and TD Bank Group (TD) have had the pleasure of collaborating through the TD Forests program to protect forests across Canada. The conservation results have been impressive. TD's support has helped NCC protect over 16,000 hectares of important forests from coast to coast, in seven of Canada's eight forest regions.

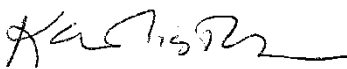
Over the course of this partnership, NCC and TD have further investigated how a charitable organization and financial institution can work together in innovative ways to contribute to the protection of our natural world. One of these innovations is this paper, which combines our respective expertise in ecology and economics to calculate the natural capital values of the ecosystem goods and services of properties across Canada that have been protected thanks to our partnership.

These forests, and countless others across the country, provide essential services to Canadians every day. They produce oxygen, filter the air we breathe, hold flood waters, clean our drinking water, regulate our climate and absorb atmospheric carbon dioxide. Until recently, the value of these services has seldom been calculated and communicated. As a result, the important ecological services that forests provide are often not included in decision-making.

NCC and TD first began a project to value the benefits of natural capital in 2015, with an analysis of three NCC properties protected with the support from the TD Forests program. Now, NCC and TD have expanded upon this initiative by calculating the natural capital values provided by forests representing each of Canada's eight forest regions

The environmental challenges facing our natural world are too big for one sector alone to overcome. NCC and TD's collaboration is an excellent model of how we can work together to protect Canada's most important natural spaces and create a sustainable future for our children. We hope that this analysis helps inspire both the private and public sectors to explore collaborative approaches to conservation, factor the natural capital values of Canada's forests into decision-making and continue to explore the myriad ways in which forests matter to all Canadians.

On behalf of NCC and TD, we are pleased to present the following case studies, which explore the natural capital benefits that forests provide to Canada and to the world. NCC and TD are proud to contribute to the important conversation about the value of Canada's natural places and the essential ecosystem services they provide to Canadians every day.



Karen Clarke-Whistler
Chief Environment Officer
TD Bank Group



John Lounds
President and CEO
Nature Conservancy of Canada

INTRODUCTION

Effective conservation protects and restores nature for species, including people. Conserving natural ecosystems such as forests, wetlands and grasslands helps to protect important species and habitats and maintain essential ecological processes. Conservation also provides a benchmark to monitor future environmental change.

There has been increasing recognition of the importance of protected areas to the quality of human life (Secretariat of the Convention on Biological Diversity, 2008). In addition to conserving important habitats and species, protected areas provide important ecosystem goods and services, also known as natural capital services, such as:

- water filtration
- flood control
- pollination
- climate regulation

In the past, these ecological benefits provided by nature have been largely taken for granted. One of the challenges with traditional economic tools is that nature is often treated as an externality; a variable that cannot be accounted for. But in a world where we are losing species and ecosystems, it is ever more critical to include nature in economic decision-making. The emerging field of natural capital valuation – which places a financial value on ecosystem goods and services – provides a framework for assigning economic values to these services.

The valuation of nature provides an opportunity to link conservation and economics. The important role of ecosystem goods and services in conservation has also been recognized in Canada's biodiversity goals and targets for 2020 (Government of Canada, 2015). By valuing the goods and services that nature provides, we can improve our understanding of the impacts of habitat loss and land conservation not only to nature, but to our economy and well-being. This provides decision-makers with valuable tools to support better conservation and sustainable development.

“Natural capital is the stock of natural resources (finite or renewable) and ecosystems that provide direct or indirect benefits to the economy, our society, and the world around us.”

TD Economics (2014)

This report focusses on properties conserved by NCC through the TD Forests program to calculate the natural capital value of forests. The report includes two main parts:

1. The first part provides general background on Canada's forests and approaches to natural capital valuation.
2. The second part presents case studies for each of Canada's eight forest regions. Each study provides an introduction to the forest region and explores the natural capital value of at least one conserved forest property.

Approach and key findings

Analysis of the natural capital value of the protected areas was undertaken using the defensive expenditures approach. Monetary valuation of the benefits used the latest Environment and Climate Change Canada values of the Social Cost of Carbon. Further details are provided in the technical notes (page 34).

Reflecting the diversity of forest types, densities and geographic features, a relatively broad range of natural capital values were calculated. The case study properties provide services valued at between \$5,800 to \$46,000 per hectare, per year in natural capital benefits, with an average benefit of \$26,382 per hectare per year.

The specific valuation depends on the type of forest and where it is located. For example, the ecological services of the maple-dominated forests of NCC's Kenauk property in the Great Lakes–St. Lawrence forest region of Quebec is valued at approximately \$20,000 per hectare per year. The lowland boreal forests in eastern Manitoba on the Kurian property have an annual value of \$26,800 per hectare, and demonstrate the importance of peatlands in storing and holding carbon. The big trees of the Gullchucks Estuary property in BC's coastal forest region provide over \$33,000 per hectare of ecological services each year.

AN INTRODUCTION TO NATURAL CAPITAL

Decision-makers, whether in politics, business or other realms, may not always incorporate environmental trade-offs into their thinking. When these trade-offs are ignored, unexpected costs and unanticipated consequences may occur. Consider the late 19th century factories that released untreated effluent into rivers and streams, affecting the health and livelihoods of people downstream: the downstream effects are what economists call externalities, when the actions of one party has consequences, and associated costs, that accrue to another.

Natural capital is a way of bringing externalities into the decision-making process. As TD Economics has defined it, "natural capital is the stock of both finite and renewable natural resources and ecosystems that provide benefits to our economy, society and the world around us." With the concept of natural capital comes natural capital services (sometimes referred to as ecosystem services).

The parallels with other forms of capital are clear: just as a piece of physical capital produces a product or service, or an investment provides income, natural capital also provides a yield in the form of natural capital services. For example, the ecological services provided by forests that benefit people include water purification, removing air pollution and regulating our climate by storing carbon dioxide.

Once these ecological services are taken into account, decision-making improves and becomes smarter. It may be more beneficial to a local community to protect a forest once the value of the clean air, habitat, biodiversity and other benefits are taken into account. If there is a decision to convert a forest to other land uses, natural capital can provide a framework to better understand and articulate the services that are being lost, and explore options to restore these benefits. In this way, the conservation and restoration of forests helps to ensure that these natural capital benefits continue to accumulate for generations to come.

For example, New York City has a watershed protection program that conserves lands around the reservoirs and tributaries that provide its drinking water. As a result of this watershed protection, residents avoid the need for costly filtration, a cost estimated at between \$8.0 to \$10.0 billion to construct the facility, and approximately \$1.0 million each day to operate and maintain the filtration plant. Protecting forests and other natural capital within these watersheds provides New York City's eight million residents with clean water, reduces their costs and protects lands that provide wildlife habitat recreational opportunities and other ecosystem services such as air filtration and climate regulation (New York Department of Environmental Conservation, 2017).

CANADA'S FORESTS

Canada is a country that is dominated by forested landscapes. More than one-third of the Canadian land base is covered with trees, and forests occur in every province and territory. Canada has nine per cent of all the world's forests and ranks third for total forest cover (behind Brazil and Russia). Canada also has some the largest and last areas of forested wilderness left on Earth. These mostly intact forests occur in a mosaic of lakes, rivers and wetlands in our northern boreal regions.

Forests have been central to many of Canada's indigenous peoples for centuries, and provided the foundation for Canada's emergence as a nation, our economic prosperity and our cultural identity. Forestry continues to play a key role in Canada's economy, particularly in northern communities, and provided more than 200,000 jobs in 2015 (NRCan, 2016). The forest industry has made significant progress in increasing sustainability, including the widespread adoption of certification programs. Forests also provide recreational opportunities for millions of Canadians and international visitors every year.

The vast forests of Canada are comprised of eight forest regions (Figure 1). These regions are distinct in their dominant tree species, wildlife, land use and conservation needs.

Canada's intact forest regions

The boreal forest is Canada's largest forest region. The northern reaches of the boreal includes some of the last large forested areas left on the planet. It extends from Newfoundland and Labrador, across central Canada into the Yukon. Regions in western Canada still have areas with intact forests that, in some places, continue to support the full diversity of large mammals that existed at the time of European settlement, such as grizzly bear and wolverine.

Southern Canada's threatened forests

These forest regions stand in contrast to most of southern Canada, where much of the original forest cover has been lost or is highly altered. For example:

- The Carolinian forest region has lost more forest cover than other places that have come to exemplify global deforestation, such as Haiti or Indonesia. The Acadian and Great Lakes–St. Lawrence forest regions are now mostly second-growth, with few areas of original old-growth remaining.

Forests in southern Canada, including the southern regions of the boreal forest, are increasingly facing the threats of resource extraction, fragmentation, loss of old-growth, invasive species and conversion to farms and cities. Climate change is also altering the composition of native forests.

Despite this loss, the forests of southern Canada remain vital for the 85 per cent of Canadians who live within 150 kilometres of the U.S. border. These forests provide important recreational opportunities and habitat for many of Canada's most endangered species. Their ecological services support the health and well-being of communities across the country.

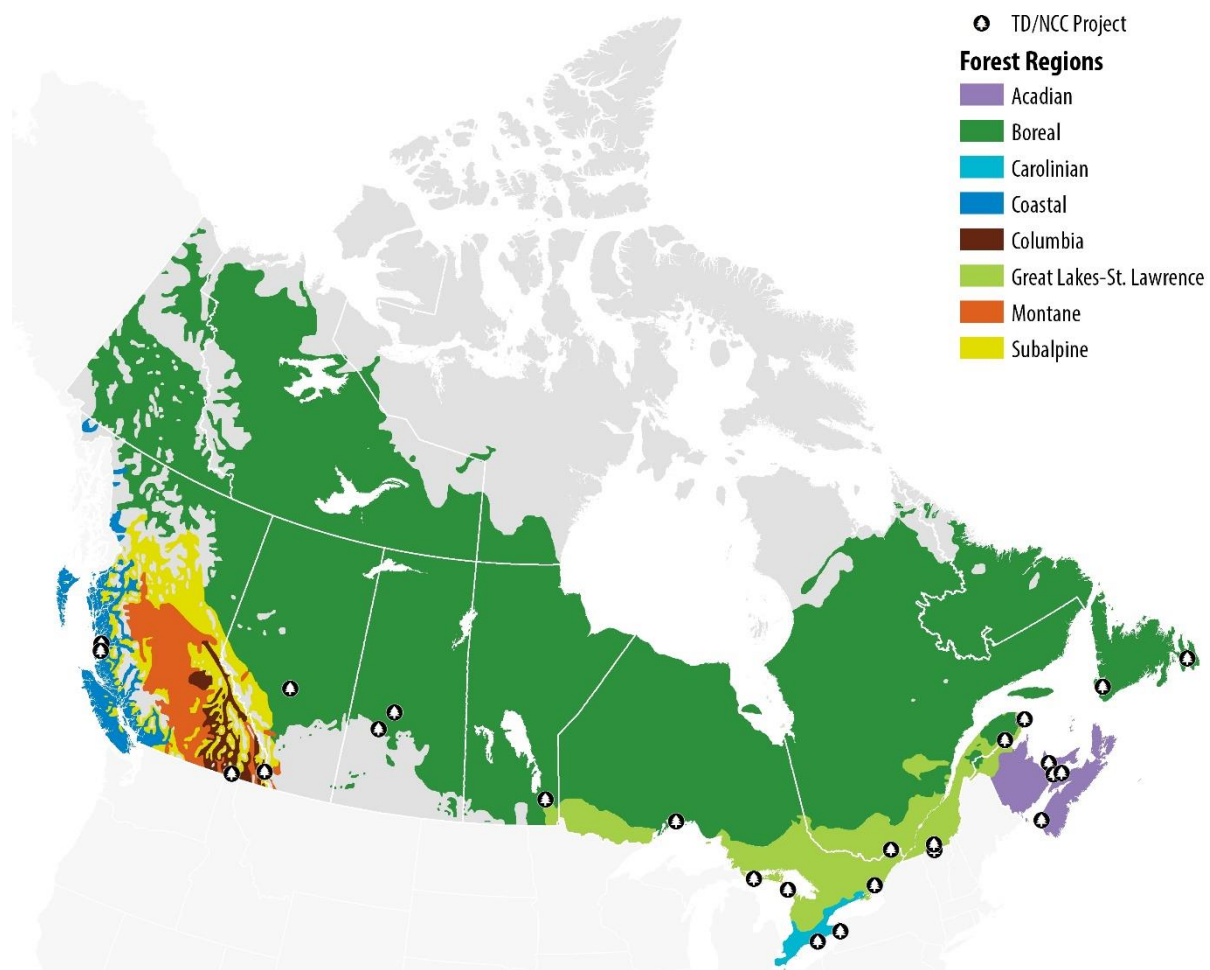


Figure 1: Forest regions of Canada and TD Forests conservation projects, 2012-2016.

Forest Region	Location	Common Tree Species
Acadian	New Brunswick, Nova Scotia, Prince Edward Island	balsam fir, red spruce, yellow birch
Boreal	Northern Canada, from Newfoundland and Labrador to the Yukon	white spruce, black spruce, balsam fir, jack pine, white birch, trembling aspen, tamarack, willow
Carolinian (deciduous)	Southwestern Ontario	American beech, hickory, oak, sugar maple
Coastal	British Columbia	Douglas-fir, Sitka spruce, western hemlock, western red cedar
Columbia	British Columbia	Douglas-fir, western hemlock, western red cedar
Great Lakes–St Lawrence	Central Ontario and southern Quebec	Eastern hemlock, eastern white pine, eastern hemlock, red oak, red pine, sugar maple, yellow birch
Montane	British Columbia and Alberta	Douglas-fir, lodgepole pine, ponderosa pine, trembling aspen
Subalpine	British Columbia and Alberta	Engelmann spruce, lodgepole pine, subalpine fir

NATURAL CAPITAL VALUES OF FORESTS

Forests provide a broad range of ecological services that support community infrastructure and the well-being of Canadians (Box 1). Relying on the defensive expenditures method, which effectively calculates the cost to society of replacing the services provided by forest regions, the values of these services calculated in the case studies in this report range from \$5,800 to \$46,000 per hectare per year of ecological services (Figure 2). We note, as we are only able to focus on a narrow slice of benefits due to data and methodological limitations, the values presented in this report should be considered lower end estimates of the benefits provided by these regions. Quantification of all benefits shown in Box 1 would undoubtedly increase the quantified value.

Approximately half of the natural capital values of forests are related to carbon sequestration and storage in both trees and soils. Forests in wetlands, particularly in bogs and fens, store a larger amount of carbon than forests in upland areas, because the carbon is stored in peat. It has been estimated that the forested peatlands of Interlake region of eastern Manitoba provide \$128 million/year of goods and services annually (Voora, Swystun, Dohan, & Thrift, 2013). The case study on the Kurian property in Manitoba (page 15) highlights the particular importance of these peatlands in carbon storage. Overall, Canada's peatlands hold approximately 147 gigatons of carbon (the equivalent of one-fifth of all the carbon in the atmosphere today) and are one of the largest national storehouses of land carbon in the world. The degree to which Canada conserves its peatlands is the degree to which Canada will sustain its global leadership in the sequestration of carbon by natural ecosystems, an essential contribution to the global carbon budget.

The other half of the natural capital values are driven by ecological services related to air purification, water quality and water storage. This natural capital has a direct link to human health in local communities, and contributes to green infrastructure that supports well-being and economic prosperity. Additional notes on the methods and limitations are provided at the end of the report (page 34).

Box 1: Ecological services provided by forests

- carbon storage*
- carbon sequestration*
- disease regulation
- water filtration and purification *
- flood control*
- pollinator habitat
- nutrient recycling
- pest control
- soil erosion prevention
- recreation and exercise
- air filtration *
- shade and cooling
- soil formation
- wildlife habitat
- opportunities for wildlife viewing

* Ecological services that are included in the case study valuations

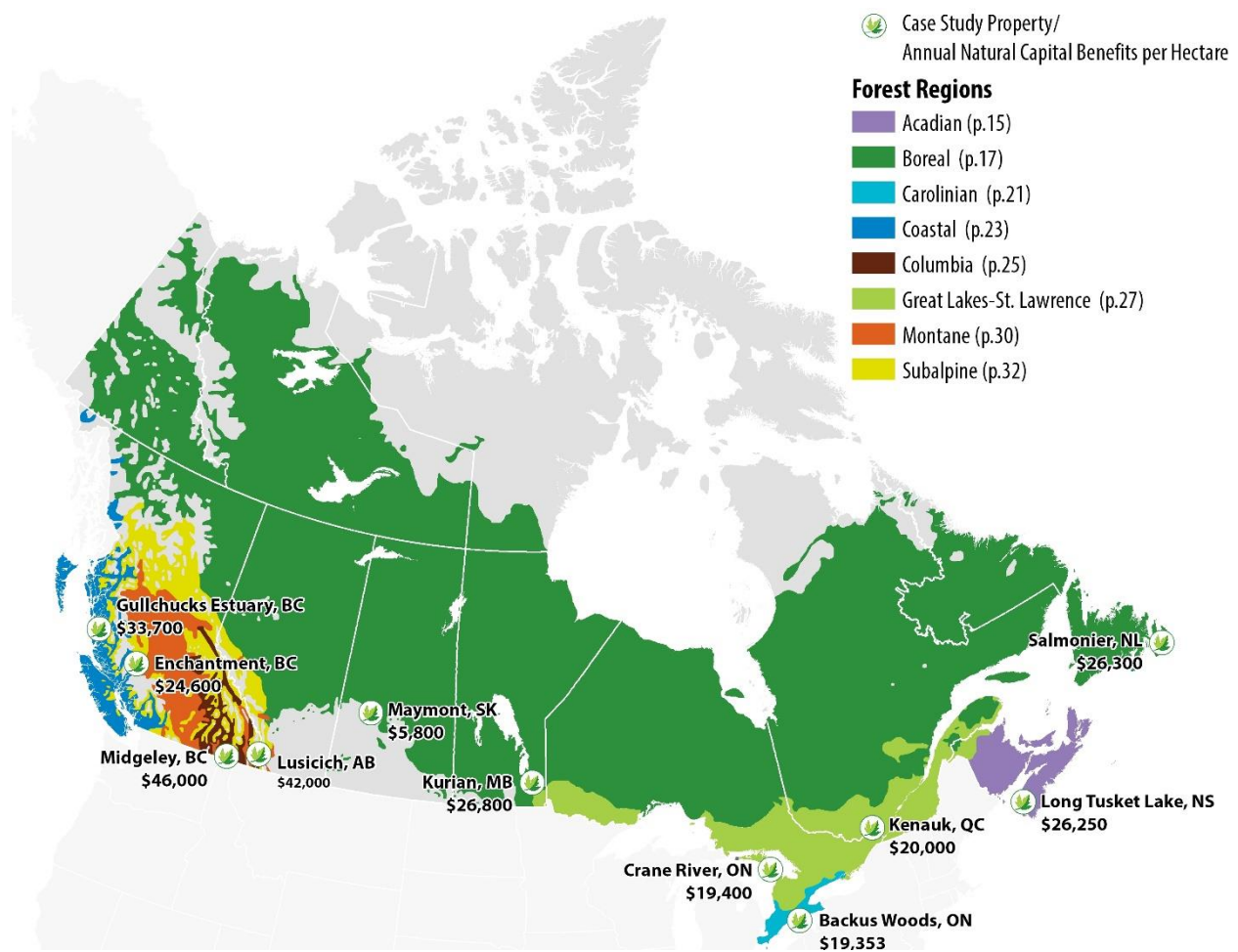


Figure 2: Natural Capital Case Study Properties

OTHER ECONOMIC AND SOCIAL VALUES OF PROTECTED FORESTS

In addition to ecological services, forests provide a wide range of other benefits, such as opportunities for recreation and the conservation of biodiversity. Forests may also be the location of culturally important places and practices. Although it can be difficult to assign specific dollar values for many of these at a property scale because of lack of data, and they are not included in the valuation presented in this paper, their importance should not be underestimated.

Protected forests provide space for ecotourism activities such as hiking, picnicking and bird-watching. The opportunity to engage in these activities is clearly important to Canadians, as three in four of us reported participating in nature-based recreation in 2012 (Federal, Provincial, and Territorial Governments, 2014). Each year, Canadians spend more than \$14 billion on equipment, travel, lodging and other expenses to observe wildlife – activities that clearly would not take place if this wildlife and their habitat was no longer present (Scott and Callahan, 2000). Moreover, these expenditures often take place in more remote parts of Canada, helping distribute income geographically, including to indigenous and northern communities.

Canada's forests, including those protected through TD and NCC's collaborative efforts under the TD Forests program, protect important areas that maintain the diversity of Canada's wildlife and habitats, and help to protect species at risk. For many Canadians there is a deep sense of the intrinsic values of these places and their associated wildlife, and our obligation to protect them for future generations.

Other benefits of protected forests that are difficult to value, but are no less important, include their cultural value, particularly for indigenous peoples. Many Canadian places and Canadians are defined by wild places and wildlife.

All of these values contribute to the worth of protected lands, regardless of whether a dollar value can be explicitly assigned.

INTRODUCTION TO THE CASE STUDIES

The natural capital values of Canada's forests varies across the country, depending on location, habitat types and landscape context. The following 11 case studies review the natural capital values of forests from each of Canada's eight forest regions (NRCan 2015). All of the case study properties, with the exception of one, were acquired as part of the TD Forests program¹. For the larger forest regions (i.e. Boreal and Great Lakes-St. Lawrence), more than one case study was done to provide representation of natural capital values.

Each case study consists of two parts. The first part provides an overview of the forest region, including statistics on the overall area, number of federal species at risk, size of protected areas and number of NCC projects. Table 2 provides a summary of the information that is provided for each forest region, data sources and how the information should be interpreted. This is followed by a description of the forest region, which outlines the characteristic trees species, biodiversity, land use and conservation challenges.

The second part of the case study provides a description of the case study property, including the types of forests and other habitats, wildlife and why it was conserved. The case study then outlines the total natural capital values and explains the underlying ecological services that are driving these values. The description of the property is based on inventories, ecological land classification and timber cruises.

¹ An existing NCC project was added to the case studies to provide an example from the subalpine forest region.

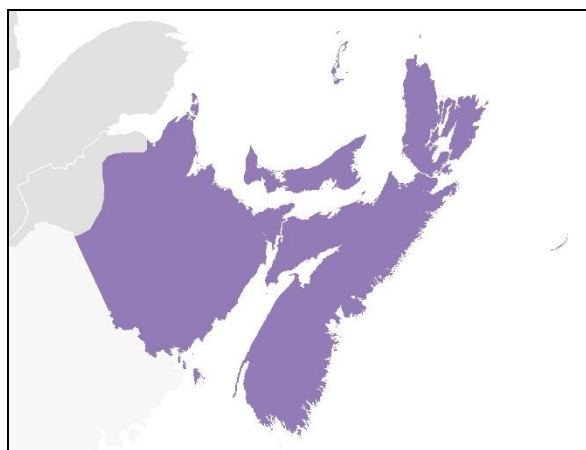
Table 2: Summary of the information provided for each forest region in the case studies.

Information	Explanation/ Data Source
Total Area (km ²)	Total area of forest region, includes water. Forest region boundaries based on NRCan <i>Forest Regions Map of Canada</i> (n.d.) available http://www.NRCan.gc.ca/forests/measuring-reporting/classification/13179 .
Forested Area (km ²)	Total area of all forest types. Based on land cover data circa 2011 from NRCan 2012.
Natural Cover (%)	Total area for all natural cover types. Excludes cropland and urban. Based on land cover data circa 2011 from NRCan 2012.
Amount of Protected Area (%)	Includes national parks, provincial parks and lands owned by the Nature Conservancy of Canada. Based on CARTS data CCEA 2015, Quebec's Protected Areas Network data from MDDELCC and MFFP 2014.
Intact Landscapes (%)	Based on Human Access to Canada's Landscape from Global Forest Water Canada 2014.
Conservation Risk	A ratio of habitat converted : habitat protected. Higher numbers indicate a greater risk. The global average is 4.7 for temperate broadleaf and mixed forests, 0.5 for temperate conifer forests and 0.3 for boreal/taiga. Based on Hoekstra et al. 2005.
Number of NCC Projects	Total number of Nature Conservancy of Canada (NCC) land protection projects. Current to December 2016 within the forest region.
Estimate Population (million)	Population based on Stats Canada (2011) dissemination units.
Number of Tree Species	Number of species based on range maps of trees. Based on Digital Representation of " <i>Atlas of United States Trees</i> " by Elbert L. Little, Jr. by the USGS 1999.
Number of Bird Species	Number of species based on range maps of birds. Based on <i>Bird Species Distribution Maps of the World</i> from BirdLife International and NatureServe 2014.
Number of Mammal Species	Number of species based on range maps of mammals. Based on <i>Distribution Maps of the IUCN Red List of Threatened Species</i> (Mammals) IUCN 2014 and <i>Digital Distribution Maps of the Mammals of the Western Hemisphere</i> by Patterson et al. 2007.
Number of Species at Risk	Number of species that have been assessed as endangered, threatened or special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Based on information available from NatureServe Canada and associated Conservation Data Centres. This information is current as of 2015.

Acadian Forest Region

New Brunswick, Nova Scotia, Prince Edward Island

Total Area (km²)	119,373
Forested Area (km²)	99,693
Natural Cover (%)	94.7
Amount of Protected Area (%)	8.0
Intact Landscapes (%)	19.5
Conservation Risk	0.7
Number of NCC Projects	322
Estimate Population (million)	1.7
Number of Tree Species	61
Number of Bird Species	220
Number of Mammal Species	83
Number of Species at Risk	87



The Acadian forest region occurs in Nova Scotia, Prince Edward Island and a large portion of New Brunswick. This region is influenced by the Atlantic Ocean, resulting in cooler summers and warmer winters. This forest region has abundant rain and snowfall, especially near the coastal areas. There is a rich diversity of native trees: more than 60 species, including yellow birch, red spruce, American beech and sugar maple, may be found here. This mixed wood forest ecosystem provides habitat for wide-ranging mammals such as Canada lynx. Moose are common in the eastern part of this forest region, but endangered in Nova Scotia.

Despite significant human development in the area, this region remains dominated by forests, particularly in the more rugged uplands. Most of the agriculture and settlement in this region occurs within the coastal lowlands and long river valleys. Acadian forests have a long history of human use, and forestry is important for many local economies. Most of the forests have been harvested several times, and less than one per cent of original old-growth remains today.



Parks and protected areas cover approximately eight per cent of the Acadian forest region. Some of the largest parks include: Tobeatic Wilderness Area, Kejimikujik National Park and Spednic Lake Provincial Park. The Nature Conservancy of Canada is working in several areas of this forest ecoregion, such as the Meduxnekeag Watershed, Chignecto Isthmus, Southwest Nova and the headwaters of the Tusket River. These projects are protecting examples of old-growth forests and creating ecological corridors for wildlife.

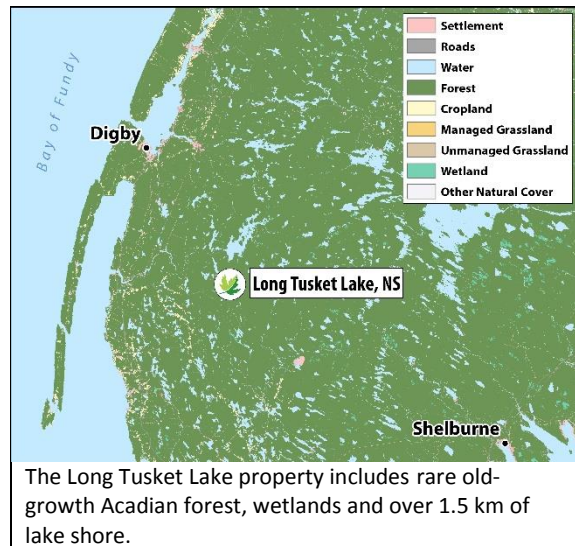
The Acadian Forest region has a high amount of forest cover, but old-growth stages are becoming increasingly rare.
NCC Long Tusket Lake property, Nova Scotia (Photo by Mike Dembeck)

Acadian Forest Region

Natural Capital Case Study: Long Tusk Lake, Nova Scotia

Valuation: \$26,250 per hectare per year

Located southeast of Digby in southwest Nova Scotia, Long Tusk Lake and the extensive mixed-wood Acadian forest surrounding it are an iconic part of the woodlands of the region. The 202-hectare property is dominated by mature conifer forests of red spruce and eastern hemlock, with scattered occurrences of balsam fir, white pine and black spruce. On well-drained hummocks, several large, structurally diverse hardwood stands containing sugar maple, red maple, yellow birch and American beech are found. A bog-fen system includes areas of open water suitable for waterfowl nesting, and scattered riparian (riverbank) wetlands are located on the shores of Long Tusk Lake.



The property has notable conservation values associated with its size, forest and riparian ecosystems, as well as extensive lake shoreline within a headwaters region. The older-growth forests found on the property are increasingly rare in the Acadian forest region. These forests also protect barred owl, northern saw-whet owl and a remnant moose population, which is endangered in Nova Scotia.

Natural capital valuation

Long Tusk Lake provides an excellent example of the many societal benefits provided by the Acadian forest. Significant carbon storage and sequestration is provided by the mix of hardwood and softwood forests. Nitrogen dioxide, ozone and other non-carbon atmospheric pollutants are also significantly reduced, while the wetlands within the property help provide flood control for downstream communities.

As a result, the Acadian forest is found to be one of the more valuable forest types from a natural capital perspective, providing approximately \$26,250 in annual benefits per hectare per year (based on the Long Tusk Lake property).

This case study is presented as part of a report by TD Bank Group and the Nature Conservancy of Canada on the natural capital values of conserved forests. The data and results presented may change as new information becomes available. Project background and information on methods and data can be found in the full report.

Boreal Forest Region

Alberta, British Columbia, Quebec, Manitoba, Newfoundland & Labrador, Northwest Territories, Nunavut, Ontario, Saskatchewan, Yukon

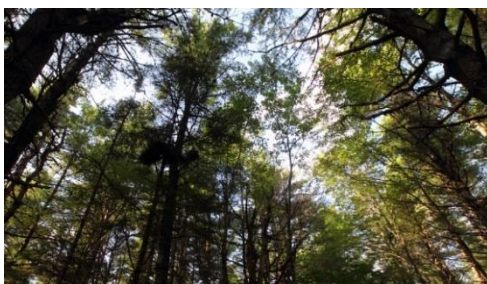
Total Area (km²)	5,255,824
Forested Area (km²)	2,489,423
Natural Cover (%)	95.4
Amount of Protected Area (%)	8.3
Intact Landscapes (%)	75.9
Conservation Risk	0.5
Number of NCC Projects	407
Estimate Population (million)	4.8
Number of Tree Species	90
Number of Bird Species	346
Number of Mammal Species	153
Number of Species at Risk	125



Canada's forests are dominated by the vast swath of boreal forest that extends from Newfoundland to the Yukon. This forest region covers about 30 per cent of Canada and is very diverse. Northern regions are characterized by taiga, where trees are smaller and interspersed with plains and wetlands. The southern region of the boreal along the edge of the prairies is often referred to as parklands and is dominated by trembling aspen that become increasingly sparse as the forest transitions into grassland.

Most of the boreal forest is dominated by white spruce, black spruce, jack pine, balsam fir, tamarack, white birch and trembling aspen. On the Canadian Shield, these forests are interspersed with hundreds of thousands of lakes. In the boreal plains region, which stretches from Manitoba into northern British Columbia, lowland forests and wetlands are abundant. Characteristic species of the boreal include moose, woodland caribou, black bear and Canada lynx. The boreal forest has been referred to as North America's songbird nursery and provides critical breeding habitat for more than 300 species. An estimated five billion birds migrate south from the boreal each fall.

Canada's boreal forest represents 28 per cent of the world's boreal forests, and includes some of the most intact forested landscapes left on Earth. Although forestry, mining, energy and hydroelectric development have impacted parts of the boreal, most of this forest region remains intact. The boreal forest is subject to regular large-scale natural disturbances such as fire and insect outbreaks. Many indigenous peoples who live in the boreal rely on the forest for their food and livelihood.



The boreal covers an area larger than the country of India. NCC Kurian property, Manitoba (Photo by Mike Dembeck)

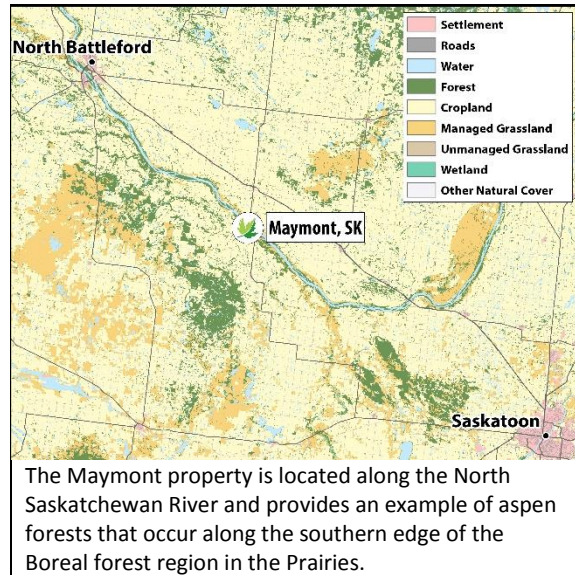
Protected areas cover approximately eight per cent of the boreal forest region. Several provinces have committed to protecting most of the boreal forest with additional protected areas and resource management areas. NCC is working in the southern boreal forest to protect sites with important species and habitats, and is working with partners to develop a nature atlas for the boreal plains region.

Boreal Forest Region

Natural Capital Case Study: Maymont Property, Saskatchewan

Valuation: \$5,800 per hectare per year

The 55-hectare Maymont property is situated along the North Saskatchewan River approximately 110 kilometres northwest of Saskatoon. It is located in the parkland region of the boreal, and typifies the transition between forest and prairie. The rolling property includes aspen parkland, open fescue grasslands and 500 metres of river frontage. Aspen parkland forests are under increasing threat from conversion to croplands. These diverse habitats on the property provide habitat for a variety of mammals, waterfowl and grassland birds. The Maymont property builds on NCC's work in the western parklands, which have been heavily impacted by habitat conversion to agriculture. It also helps to secure an ecological corridor along the North Saskatchewan River.



Natural capital valuation

With grasslands making up a large share of the property, the natural capital benefits provided by Maymont are somewhat lower relative to other properties considered in this study. This is because of the lesser role that grasslands play in removing atmospheric pollutants.

Nevertheless, the property plays an important role in improving air quality, and filters out many harmful pollutants. The large amount of carbon sequestered in the area also matters to help mitigate the impacts of climate change, while the wetlands help to both control flooding downstream, and to serve as a miniature water treatment facility of sorts, filtering out phosphorus and nitrogen that results from agricultural run-off.

Based on the Maymont property, natural capital benefits of approximately \$5,800 per hectare per year are estimated for this region of the boreal.

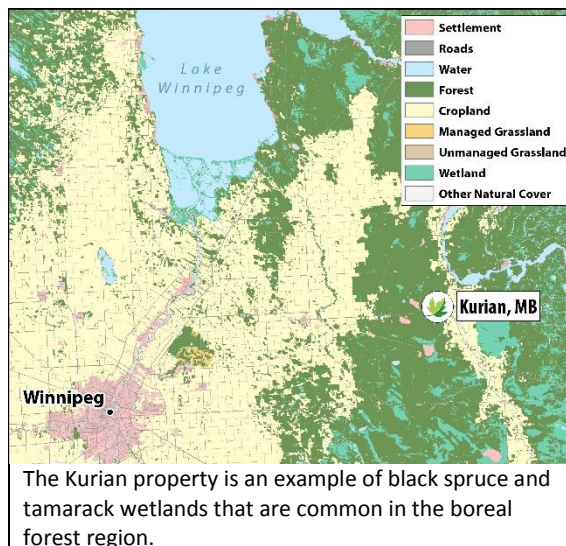
This case study is presented as part of a report by TD Bank Group and the Nature Conservancy of Canada on the natural capital values of conserved forests. The data and results presented may change as new information becomes available. Project background and information on methods and data can be found in the full report.

Boreal Forest Region

Natural Capital Case Study: Kurian Property, Manitoba

Valuation: \$26,800 per hectare per year

The 130-hectare Kurian property is located east of Winnipeg in the lowland boreal forests and wetlands that characterize southeastern Manitoba, where glacial Lake Agassiz once occurred. The property is dominated by black spruce swamps, tamarack swamps and open fens that have deep peat soils. In some places on the property these peat soils are over two metres in depth. More than 40 bird species have been recorded on the property, including ovenbird and rose-breasted grosbeak. Conservation of this property protects and restores important wetland habitats, and builds on existing conservation lands.



Natural Capital Valuation

The Kurian property is an outstanding example of the power of the boreal forest to sequester and store carbon, and the role it plays in mitigating the impacts of climate change. With its extensive peatlands, the property stores nearly 250,000 tonnes of carbon, with more added each year – serving as an important sink for atmospheric carbon, thereby helping reduce the impacts of climate change.

With natural capital benefits valued at \$26,800 per hectare, the Kurian property demonstrates the importance of Canada's boreal forests.

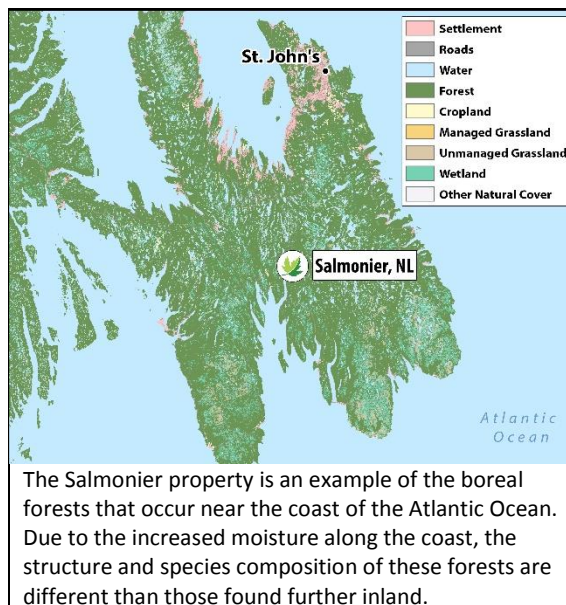
This case study is presented as part of a report by TD Bank Group and the Nature Conservancy of Canada on the natural capital values of conserved forests. The data and results presented may change as new information becomes available. Project background and information on methods and data can be found in the full report.

Boreal Forest Region

Natural Capital Case Study: Salmonier Conservation Project, Newfoundland & Labrador

Valuation: \$26,300 per hectare per year

The 64-hectare Salmonier property is located on the Avalon Peninsula in Newfoundland and Labrador. The forests on the property are dominated by mixed balsam fir, black spruce and yellow birch. The forest provides habitat for species at risk, including blue felt lichen. The forest could also provide important habitat for other species not found on the property but known to occur in the area, such as red crossbill. The property is nestled between the Salmonier River on the northwest boundary and a mosaic of bog wetlands on the southeast boundary and acts as a protective ecological buffer for both. The Salmonier River is a well-known migration route for the threatened South Newfoundland Atlantic salmon population.



Natural capital valuation

The Salmonier property provides a multitude of natural capital benefits year after year. The fir, spruce and birch forests that make up the majority of the land provide significant atmospheric benefits, by reducing airborne pollutants and storing significant amounts of carbon. The wetlands and riparian (riverbank) zones on the property further provide flood control benefits to communities downstream.

Overall, an estimated \$26,300 per hectare per year of natural capital benefits are provided by the property. The true value is likely much higher, as the significant biodiversity value of these lands is not included in our estimates, due to methodological limitations (as discussed in the technical notes on page 34).

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Carolinian Forest Region

Ontario

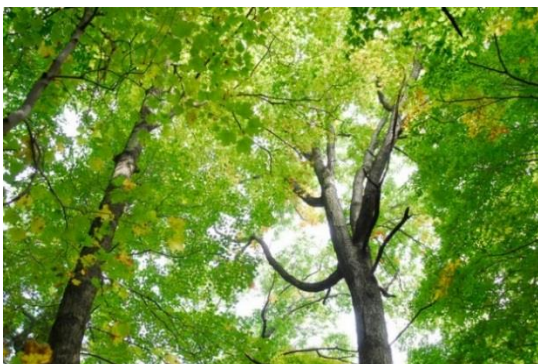
Total Area (km²)	29,711
Forested Area (km²)	5,468
Natural Cover (%)	22.3
Amount of Protected Area (%)	0.8
Intact Landscapes (%)	0.9
Conservation Risk	96.1
Number of NCC Projects	170
Estimate Population (million)	8.5
Number of Tree Species	102
Number of Bird Species	216
Number of Mammal Species	57
Number of Species at Risk	136



Canada's smallest forest region is restricted to the extreme southern part of Ontario and extends from the north shore of Lake Ontario to the southeast shore of Lake Huron. This southernmost region of Canada has a climate that is moderated by the lower Great Lakes.

The warmer, year-round temperatures and lower latitudes of the Carolinian forest region foster a very high level of species richness, including the largest number of native trees found in any forest region. In addition to species such as sugar maple, American beech and red oak that occur in other forest regions, there are many trees that reach their northern range limit in the Carolinian region, including cucumber tree, black gum, Kentucky coffeetree and sassafras. Covering just one per cent of Canada's landmass, the Carolinian forest region supports almost 20 per cent of the country's species at risk, including Acadian flycatcher and blue ash.

The Carolinian forest region is the most heavily impacted forest region in Canada. Most of the forest has been lost to urban development and agriculture. Remaining forests often occur in small isolated woodlots. Many birds and mammals that require larger forested habitats are now very rare in this region. Trees would have grown here for hundreds of years, but most of the forests have been selectively harvested several times and old-growth habitats are very rare.



The Carolinian forest region has lost more cover than any other region in Canada. NCC Backus Woods property, Ontario (Photo by Mike Dembeck)

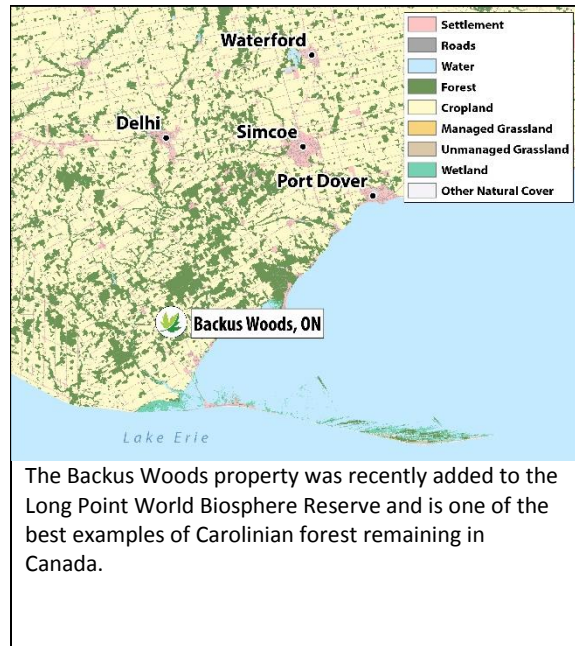
The vast majority of the Carolinian forest region is privately owned and only a small amount is in protected areas. In addition to nationally and provincially protected areas (less than one per cent), lands owned by conservation authorities and other organizations make an important contribution to the protected areas network. The Nature Conservancy of Canada has protected and restored forest habitats in several areas of the Carolinian forest region, including sites near Long Point in Essex County, the southwestern coast of Lake Huron and on Pelee Island.

Carolinian Forest Region

Natural Capital Case Study: Backus Woods, Ontario

Valuation: \$19,353 per hectare per year

The 730-hectare Backus Woods property is one of the highest quality old-growth forests in all of Ontario and the best remaining example of Carolinian forest in the region. Backus Woods was secured in 2010 by NCC with the support of The W. Garfield Weston Foundation. NCC has continued to secure core properties around Backus Woods, including the Smith property in 2012 as part of the TD Forests program. Backus supports a mosaic of Carolinian forest types, including mature deciduous forests and hardwood swamps. Most of the successional meadows within this property will eventually return to forest, increasing the area and connectivity of Backus Woods. More than 25 Canadian species at risk have been documented here, including American chestnut, flowering dogwood, cerulean warbler and wood thrush. The Backus property were recently added to the core of the Long Point World Biosphere Reserve.



Natural capital valuation

The Backus Woods property, with its mix of both old-growth forest and old fields that are being restored to forest, as well as extensive wetlands (266 hectares), provides significant natural capital benefits. Stored carbon is the largest benefit, followed by non-carbon atmospheric pollutant reduction. Sizeable wetland coverage provides additional benefits in the form of flood control.

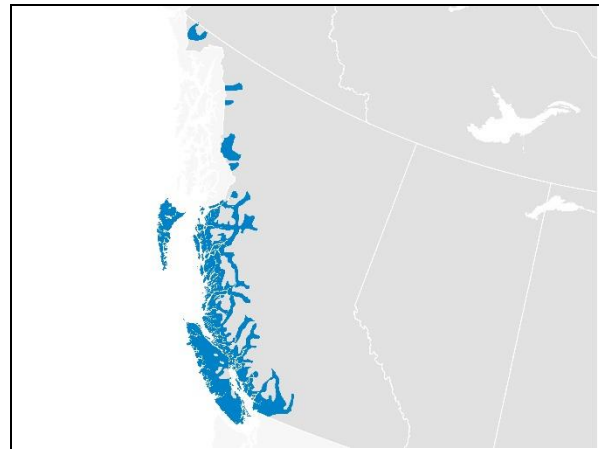
The benefits provided by the property are the equivalent of roughly \$19,353 per hectare per year. For the Backus Woods property in particular, it should be noted that this valuation is very conservative, given the relatively limited number of benefits considered as a result of data and methodological limitations. The Carolinian forest in Canada supports an extremely high level of biodiversity which, were it to be properly accounted for, would yield a true natural capital value significantly higher than reported here.

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Coastal Forest Region

British Columbia

Total Area (km²)	129,575
Forested Area (km²)	96,823
Natural Cover (%)	98.8
Amount of Protected Area (%)	21.4
Intact Landscapes (%)	65
Conservation Risk	0.1
Number of NCC Projects	93
Estimate Population (million)	3.3
Number of Tree Species	77
Number of Bird Species	306
Number of Mammal Species	130
Number of Species at Risk	92



British Columbia's coastal rainforests are highly productive, due to a warm, wet maritime climate and a steady source of marine-based nitrogen that is transferred to the land from fish such as salmon, which swim upriver to spawn and die. It is a place of exceptional biological richness, comprised of an intricate mosaic of intact coastal temperate rainforest, islands, inlets, valleys, marine waters, estuaries and freshwater systems.

The coastal temperate rainforests found here are globally rare, occurring on less than one-fifth of one per cent of the Earth's surface. These forests are renowned for their trees, which grow to almost 100 metres in height, and contain more living biomass per hectare than any other ecosystem in the world. Characteristic species are western hemlock, Douglas-fir, western red cedar and Sitka spruce. Coastal forest wildlife includes grizzly bear, black-tailed deer and the rare white Kermode black bear. Globally rare Garry oak savannah habitats exist in a small part of this region near Victoria, in the rain shadow of the Vancouver Island mountain ranges.

Although parts of the coastal forest have been impacted by forestry and mining, much of the forest region remains intact, including areas that are some of the last true wilderness regions of the planet where intact natural systems function at a large scale.



The coastal forest region has Canada's largest trees and is closely linked to coastal and marine ecosystems. NCC Gullchucks property, B.C. (Photo by Tim Ennis)

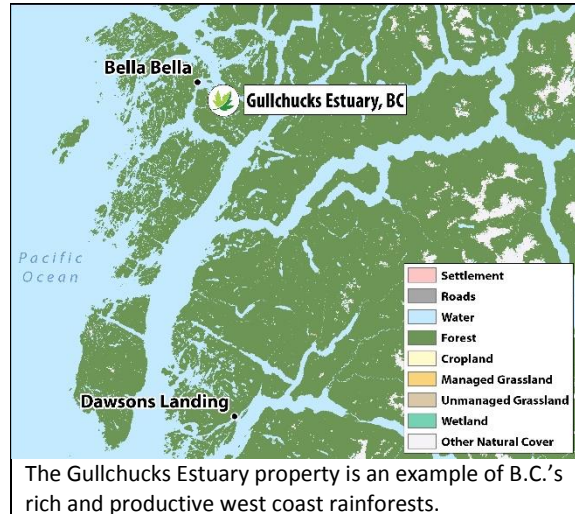
Over 20 per cent of this forest region has been protected in provincial and national parks. In 2016, First Nations, environmentalists, industry and governments announced the Great Bear Rainforest Agreement, which redefines land use and protects 85 per cent of this region. Well-known protected areas include Gwaii Haanas National Park Reserve and Haida Heritage Site, Strathcona Provincial Park and Pacific Rim National Park Reserve. NCC has completed land securement and stewardship projects at Haida Gwaii, Clayoquot Sound and the Salish Sea. Many of these projects involve protecting places where the forest and coast meet.

Coastal Forest Region

Natural Capital Case Study: Gullchucks Estuary, British Columbia

Valuation: \$33,700 per hectare per year

The 20-hectare Gullchucks Estuary lies in the heart of the Great Bear Rainforest, near Bella Bella on Denny Island. The property is dominated by coastal western hemlock and western red cedar forests, including some old-growth trees. In addition to forests, the property includes the estuary of the Gullchucks River and riparian (riverbank) habitats, and supports nearshore communities. These coastal forests and associated habitats support wolves, Kermode bears and bald eagles. The Gullchucks River supports four species of Pacific salmon (Coho, chum, pink and sockeye), and the river provides as much as 25 per cent of the salmon harvested each year by the Heiltsuk First Nation from nearby Bella Bella.



Natural capital valuation

With the Gullchucks Estuary used as our case study, it is not difficult to see why the coastal forest region provides the one of the highest estimated natural capital benefit value per hectare of the major Canadian forest types. Old-growth forests provide the bulk of the annual benefits, acting as a carbon sink while also reducing other atmospheric pollutants.

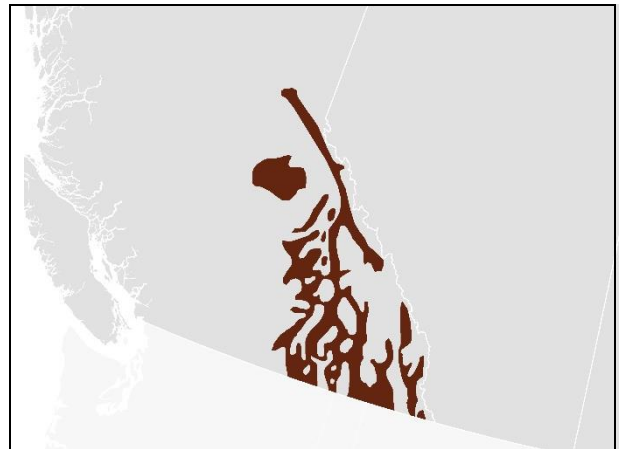
A value of approximately \$33,700 per hectare per year is assigned to these benefits. Although difficult to value and thus not included, the other natural capital benefits that this property provides should be acknowledged. These include the cultural value assigned by First Nations and others in the area, as well as biodiversity and other benefits. As a result, the true value of the services provided by the property is undoubtedly higher than what has been estimated.

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Columbia Forest Region

British Columbia

Total Area (km²)	58,397
Forested Area (km²)	42,223
Natural Cover (%)	99.5
Amount of Protected Area (%)	15.4
Intact Landscapes (%)	50.3
Conservation Risk	0.0
Number of NCC Projects	31
Estimate Population (million)	0.1
Number of Tree Species	49
Number of Bird Species	213
Number of Mammal Species	84
Number of Species at Risk	40



The Columbia forest region occurs in the wet belt of southern eastern British Columbia, between the central plateau and the Rocky Mountains. This forest region occurs at lower elevations along river valleys and is interspersed with subalpine and montane forests. A mix of western red cedar and western hemlock with Douglas-fir grows throughout the region. The southern part of the forest region includes western white pine, western larch, grand fir and western yew. This forest type often referred to as inland rainforests and its global range is almost entirely restricted to British Columbia. Located more than 500 kilometres from the coast, inland rainforests closely resemble coastal forests in their composition and structure, but rarely attain the same age structure due to more frequent disturbances from fire, insects and avalanches. Characteristic wildlife include mountain goat, grizzly and black bear, with moose mostly found in the north and American elk in the south. These forests are particularly important for mountain caribou that find winter cover in these dense mountain forests.

Most of this region remains dominated by forests, although forestry, mining and agriculture have influenced about half of the landscape. Most human settlement and agriculture occurs along river valleys. Western red cedar and western hemlock have high economic values, and in much of this region there is a history of forestry.



The Columbia Forest region includes trees that are more typical of the coastal region due to higher amounts of rainfall. NCC Midgeley property, B.C. (Photo by Steve Ogle)

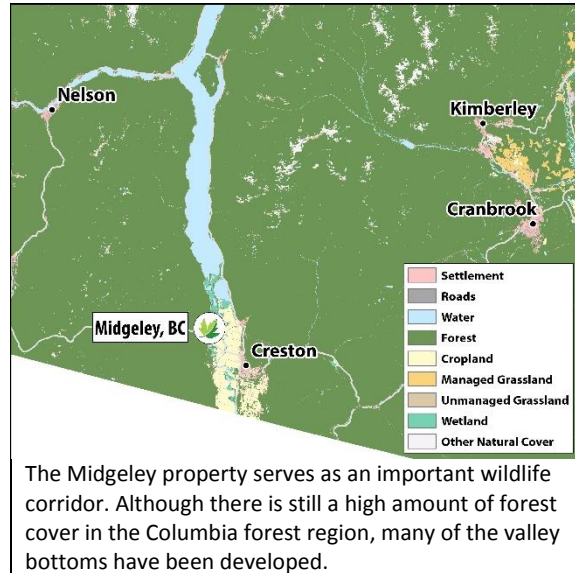
Parks and protected areas cover approximately 15 per cent of this region. Excellent examples of Columbia forest can be found in Glacier National Park and the newly created Ancient Forest/Chun T'oh Whuduju Provincial Park. The Nature Conservancy of Canada is working in the southern part of the forest region, including in the South Selkirks Natural Area. NCC's Darkwoods property includes old-growth Columbia forest that provides important habitat for the South Selkirk herd of mountain caribou.

Columbia Forest Region

Natural Capital Case Study: Midgeley, British Columbia

Valuation: \$46,000 per hectare per year

The Midgeley property (66 hectares) is located at the southern end of Kootenay Lake near Creston, British Columbia, and builds on an existing network of protected areas. The forests are dominated by ponderosa pine and Douglas-fir, with stands of western red cedar. The forests on the Midgeley property have the highest diversity of tree species in British Columbia. The valley wetlands have been recognized by the Ramsar Convention on Wetlands as being of international importance and in Canada as Important Bird Areas. In addition to providing habitat for the at-risk western population of the grizzly bear, the property forms part of an important linkage area that supports the movements of grizzly bears and other mammals that have large home ranges.



Natural capital valuation

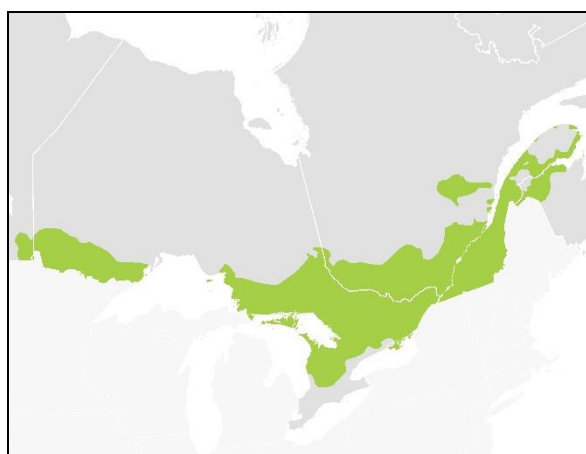
At more than \$46,000 per hectare per year, the forest habitat represented by the Midgeley property has the highest natural capital service value per hectare of the major Canadian forest types. The bulk of the annual service value stems from the large amount of carbon stored in the trees, bushes, grasses and other vegetation, as well as the additional carbon sequestered each year. The removal of atmospheric pollutants, such as sulfur oxides and nitrogen oxides, are the next largest contribution, while water-oriented services provide only minor annual benefits. However, given the importance of the wetlands of the property for the bird population, the biodiversity benefits of the property, were they to be included, would push the estimated value even higher.

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Great Lakes – St. Lawrence Forest Region

Quebec, Manitoba, New Brunswick, Ontario

Total Area (km²)	408,748
Forested Area (km²)	306,552
Natural Cover (%)	86.8
Amount of Protected Area (%)	9.6
Intact Landscapes (%)	30.6
Conservation Risk	1.4
Number of NCC Projects	691
Estimate Population (million)	12
Number of Tree Species	101
Number of Bird Species	270
Number of Mammal Species	99
Number of Species at Risk	132



Second in size in Canada to the boreal forest, the Great Lakes-St. Lawrence forest region stretches from southeastern Manitoba to the Gaspé Peninsula in Quebec, with a gap where the boreal forest extends to the north coast of Lake Superior. This is a mixed forest region that grows between the conifer-dominated boreal forests to the north and the deciduous forests in the south. Characteristic species include sugar maple, American beech, yellow birch, red maple, eastern white pine, red pine and eastern hemlock. Wetter areas support red maple, black ash, white spruce, black spruce, tamarack and eastern white cedar. Moose and black bear are common in the central and northern parts of this region, with white-tail deer more common in the south. It is the only region in the world that supports a population of the threatened eastern wolf.

The land cover of this region is split between the rich, deeper soils in the south, and the shallow bedrock of the Canadian Shield in the north. Most of the settlement and agricultural land occurs along the St. Lawrence Valley and southern portion of this forest region in Ontario. Regions on the Canadian Shield are a mosaic of forest, lakes and rock. Forestry and tourism are important industries in this part of the Great Lakes-St. Lawrence forest region. While forests still dominate this region, there is far less forest cover than there was even a century ago, as much of this region has been influenced by human activity.



Part of the Great Lakes–St. Lawrence Forest region occurs on the Canadian Shield and is interspersed with many lakes. NCC Kenauk property, Quebec (Photo by Mike Dembeck)

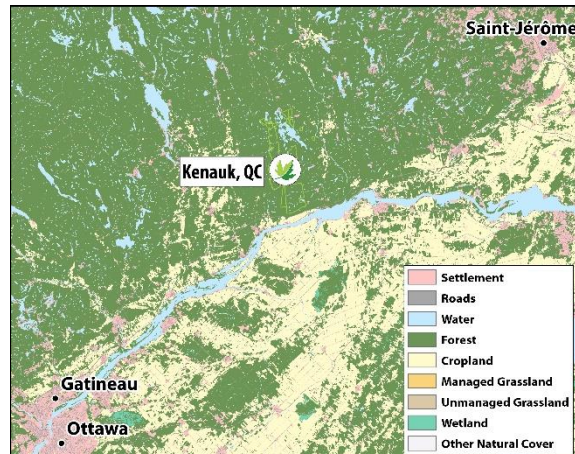
Almost 10 per cent of the Great Lakes-St. Lawrence forest region is protected in national and provincial parks, including Algonquin Park, Ontario's oldest provincial park. The Nature Conservancy of Canada is working in a large number of areas in this forest region, including on the Bruce Peninsula, Lake Superior coast, Ottawa Valley and Upper St. Lawrence. NCC projects in the Frontenac Arch and Green Mountains areas protect important forests and contribute to the conservation of important continental linkages that extend into the U.S.

Great Lakes-St. Lawrence Forest Region

Natural Capital Case Study: Kenauk, Quebec

Valuation: \$20,000 per hectare per year

The 4,068-hectare Kenauk property is located in Quebec, just north of the Ottawa River. The property lies at the southern limits of the Canadian Shield, in a landscape dominated by rolling deciduous forests that are characterized by maple-dominated forests with mixed forest, as well as stands of birch and aspen. It also includes wetlands and open rock barrens. Lakes and streams on the property provide habitat for brook trout. More than 30 provincially and nationally rare species have been documented on the property, including Canada warbler. This property is located in one of the last regions in southern Quebec that is relatively intact.



The Kenauk property occurs along the southern edge of the Canadian Shield and provides a linkage to other protected areas.

The large, connected forests provide habitat for wide-ranging mammals such as black bear, Canada lynx, moose and the threatened eastern wolf. The property is also part of an important wildlife corridor that extends from the Adirondacks to Mount Tremblant region.

Natural capital valuation

At roughly \$20,000 per hectare per year of natural capital benefits, the property underscores the importance of the Great Lakes-St. Lawrence forests in providing ecological services. Moreover, the size of the property translates into significant carbon sequestration: more than half-a-million tonnes of carbon are estimated to be stored within the property itself, with nearly 10,000 more tonnes captured each year.

There are also significant wetlands within the property, which help mitigate storm water for surrounding communities, and act as a purifier by removing many tonnes of phosphorous and nitrogen from the water system each year, thereby reducing pollutants for water users farther down the watershed. The Kenauk property is located upstream from the town of Montebello's municipal water intake.

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Great Lakes-St. Lawrence Forest Region

Natural Capital Case Study: Crane River, Ontario

Valuation: \$19,400 per hectare per year

The 596-hectare Crane River property is a striking example of the large and well-connected forest habitats that are found on the Bruce Peninsula. Over 90 per cent of the property is forested. Mature eastern white cedar, red pine, white spruce and jack pine intermingle with white birch, trembling aspen and red maple. Small pockets of wetland and open limestone barrens also occur. The rare dwarf lake iris and Massasauga rattlesnake can be found on the property. The Crane River property builds on a network of protected areas, including Bruce Peninsula National Park. The property is part of a wildlife corridor that is important for the survival of black bears and fishers. The Bruce Peninsula's bear population, which has become genetically distinct, requires large, connected habitats for its long-term survival.



Natural capital valuation

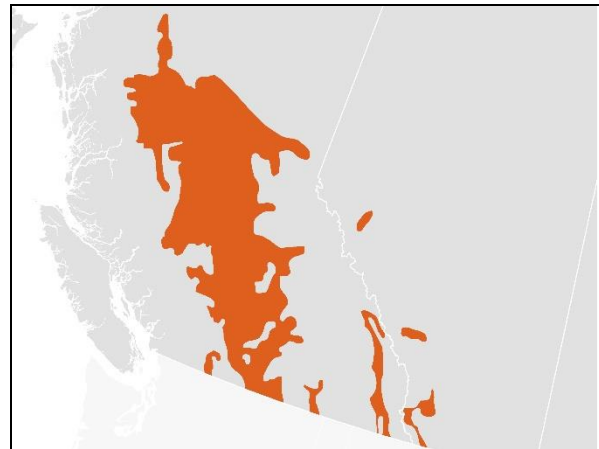
Dominated by softwood forests, the Crane River property in the Great Lakes-St. Lawrence forest region provides an important carbon sink; an important role in mitigating the effects of climate change. Indeed, the bulk of the estimated annual natural capital benefits of \$19,400 per hectare per year are from the carbon stored within the region's biomass. Further to this however are important air purification benefits, as well as the flood control assistance provided by wetlands on the property. Forested watersheds are also important for maintaining water quality and quantity in the Crane River.

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Montane Forest Region

Alberta, British Columbia

Total Area (km²)	172,743
Forested Area (km²)	108,569
Natural Cover (%)	98.4
Amount of Protected Area (%)	10.4
Intact Landscapes (%)	39.3
Conservation Risk	0.2
Number of NCC Projects	130
Estimate Population (million)	0.7
Number of Tree Species	65
Number of Bird Species	252
Number of Mammal Species	106
Number of Species at Risk	65



The montane forest region of central British Columbia and western Alberta is one of the warmest and driest ecoregions in Canada. This forest region consists of a large region in central British Columbia and scattered pockets in the rain shadows of the Rocky Mountains. Elevation, aspect and fire play an important role in shaping these forests, often resulting in an open, park-like setting. Characteristic species include Douglas-fir, lodgepole pine and trembling aspen. White spruce occurs in cooler microclimates in valley bottoms. Ponderosa pine is more common in the region's southern limits, while Engelmann spruce and alpine fir grow in the north. Common large mammals include mule deer, elk, grizzly bear, black bear and gray wolf.

Most of this region remains in natural cover, although much of the region, particularly in the south, has been influenced by human activities such as forestry, mining and roads. The open character of the forests and the interspersed grasslands has attracted cattle ranching as a primary land use activity. In some of the southern regions with fertile soils such as the Okanagan Valley, much of the region is dominated by settlements, orchards and crops.



Montane forests occur in the drier regions of B.C. and Alberta and can have an open, park-like setting. NCC Lusicich property, Alberta (Photo by NCC)

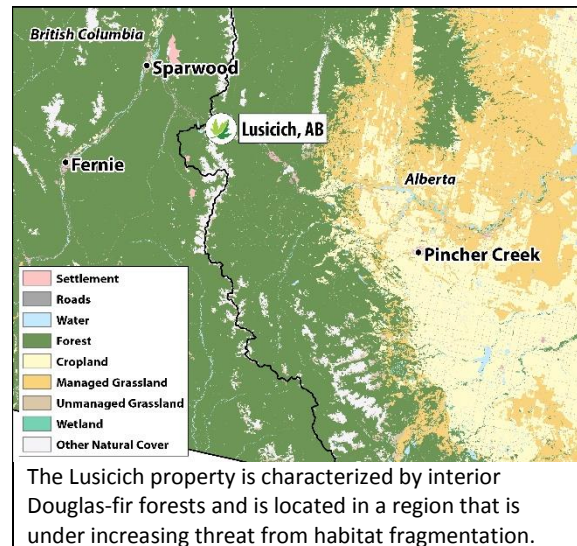
Approximately 10 per cent of the montane forest region is protected. While well-known national parks such as Banff and Jasper have examples of montane forest, much larger areas of montane forest have been protected in the British Columbia interior. The Nature Conservancy of Canada is working in many areas of the montane forest region, including the South Okanagan Similkameen, Heritage Grasslands and West Chilcotin natural areas. The Nature Conservancy of Canada's Tatlayoko Ranch has some of the best remaining stands of old-growth Douglas-fir in British Columbia.

Montane Forest Region

Natural Capital Case Study: Lusich, Alberta

Valuation: \$42,000 per hectare per year

The Lusich property (106 hectares) is located in the Crowsnest Pass in southwest Alberta. The property is characterized by Douglas-fir and trembling aspen forests interspersed with montane grasslands. In addition to its significant habitat values, the property provides important connectivity for wildlife, including grizzly bear, elk and gray wolf. The Crowsnest Pass is the lowest elevation passage through the Rockies, and is a critical area for the movement of wildlife between Alberta and British Columbia, and along the north-south mountain corridor. As this region becomes increasingly fragmented by transportation corridors and the loss of natural habitats, protected areas such as the Lusich property provide critical refuge and linkage for wildlife.



Natural Capital Valuation

The Lusich property in the montane forest region has one of the highest annual natural capital service values of the case studies. The large amount of carbon stored within the region's biomass provides the majority of the natural capital benefits, and highlights the importance of the region in storing carbon.

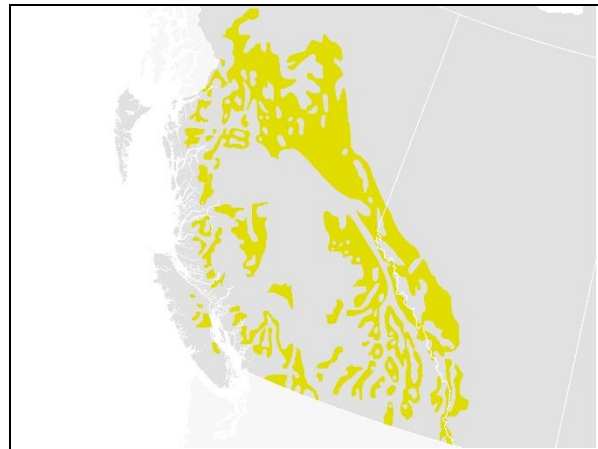
The Lusich property is estimated to provide \$42,000 in natural capital benefits per hectare per year.

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Subalpine Forest Region

Alberta, British Columbia

Total Area (km²)	245,606
Forested Area (km²)	166,972
Natural Cover (%)	99.7
Amount of Protected Area (%)	18.8
Intact Landscapes (%)	70.4
Conservation Risk	0.0
Number of NCC Projects	39
Estimate Population (million)	0.2
Number of Tree Species	67
Number of Bird Species	301
Number of Mammal Species	138
Number of Species at Risk	75



Stretching from the coast of British Columbia to southeastern Alberta's high elevation habitats, the subalpine forest region is located in the transition zone between forests and alpine habitats that are too cold for large trees to grow. This is Canada's third-largest forest region. It dominates north-central B.C. and occurs at high elevations throughout the mountain ranges of western Canada. Characteristic tree species are Engelmann spruce, subalpine fir and lodgepole pine, with western larch, whitebark pine and limber pine. Avalanches play an important role in this forest's diversity and disturbance, and forests in this region are often interspersed with open meadows. Mammals such as pine marten, mountain goat, mountain caribou and American pika occur here.

The high elevation of this forest region has helped to maintain much of its original character. Almost all of this region remains in natural cover and more than 70 per cent has low human influence. Accessible and more fertile areas of this forest region are used for forestry and grazing.



The high elevation subalpine forests are often interspersed with open meadows. NCC Enchantment property, B.C. (Photo by NCC)

Almost 20 per cent of this forest region is protected in provincial and national parks. The high elevation forests of Canada's most well-known national parks such as Banff and Jasper are dominated by subalpine forests. The Nature Conservancy of Canada has conserved several projects in the subalpine forest region, including in the Selkirk Mountains.

Subalpine Forest Region

Natural Capital Case Study: Enchantment Property, British Columbia

Valuation: \$24,600 per hectare per year

The 122-hectare Enchantment property is a hanging subalpine valley located in the headwaters of the Ottarasko Creek in the Niut Range, near the southwest end of Tatlayoko Lake. The flat-bottomed valley provides excellent high elevation habitat, which supports mature and old-growth forests of Engelmann spruce, alpine fir and lodgepole pine that intermingle with wet meadow and fen ecosystems. This remote property is true wilderness and supports all of the large mammals that would have historically occurred in the subalpine forest region. A viable population of grizzly bears occurs in the area, along with wolverine, mountain goat, wolf and many other wide-ranging species.



Natural capital valuation

Enchantment features a wide variety of land types, including temperate forests, grasslands, wetlands and riparian (riverbank) zones. As a result, natural capital values derive not just from atmospheric pollution reduction and climate change mitigation, but also from the purification of water provided by its wetlands (in addition to other benefits such as biodiversity that we are currently unable to properly value).

The benefits provided by the subalpine forest, as represented by the Enchantment property, are estimated at \$24,600 per hectare per year, making this forest type among the most valuable found in Canada, for the ecological services that were included in the valuation.

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TECHNICAL NOTES

Land sizes and ground coverage types are the outcome of independent assessment of the properties and are based on inventories, ecological land classification and timber cruises (timber cruises identify and measure trees to estimate standing timber).

Non-carbon atmospheric pollutants and water pollutant removal coefficients are adapted from Wilson (2010) and Wilson (2012). Carbon storage rates are based on Kulshreshtha et. al (2000).

Values for non-carbon atmospheric pollutants are those reported in Nowak et. al (2008). We use abatement costs for these pollutants as consensus social costs have not yet emerged in the literature.

A social cost of carbon is used, based on the Technical Update to Environment and Climate Change Canada's Social Cost of Greenhouse Gas Estimates (2016). The report uses 95th percentile values at a three per cent discount rate. The 95th percentile is used to reflect a number of criticisms of models of the social cost of carbon, which suggest that the values arising from each model may be too low (see for instance Revesz et. al (2014)).

The value of phosphorus removal is based on the lowest reported cost in Jiang et. al. (2005), while the value of removed nitrogen is based on the lowest reported value in Wilson (2012).

In practical terms, the valuations were conducted by first determining carbon and carbon-equivalent sequestration and storage by applying coefficients from Kulshreshtha et. al to land cover classifications reported from the independent assessment, yielding measures of annual CO₂ sequestration/storage on a by-property, per-hectare per-year basis. The natural capital value is then calculated by applying the social cost of carbon to these values. As noted above, for non-carbon pollutant abatement, abatement costs, as reported in Nowak et. al (updated to current Canadian dollar terms) are applied, reflecting the what the cost to society of removing these pollutants would be absent the protected area.

For water systems, the volume of nitrogen and phosphorus removed is calculated using a combination of the benefit transfer and defensive expenditure methodology: Removal rates as reported in Wilson (2012) are applied to those properties with wetlands, streams, or other notable (and applicable) water features, yielding estimates of the volume of these chemicals removed on an annual basis. As with non-carbon atmospheric pollutants, abatement costs (from Jiang et. al (2005) and Wilson (2012), as noted above) are utilized to produce a dollar estimate of these benefits. This figure represents the additional cost to downstream communities of water purification were these wetlands/water systems to no longer exist.

A note on methodological limitations

The science and economics of natural capital valuation continues to make advances, allowing for the quantification of an expanding universe of benefits. Unfortunately, many of these methods have significant data requirements, or are not yet at the fully developed stage. For instance, methods of valuing the recreational benefits of protected lands are well established, but require detailed information on the number of visitors, distance travelled, activities completed, and others, which are currently not available. On the other end of the spectrum, the importance to biodiversity of protected lands has been well established, but methods of quantifying this importance in natural capital terms are not fully established. Owing to these and other limitations, this report focuses only on the natural capital values that can be quantified by well-established methods given the data at hand. Other

benefits, such as cultural value, recreation value, biodiversity, etc. are tremendously important, and should not be ignored. The current difficulty in incorporating these values in the natural capital valuation thus mean that the estimates provided should be considered lower end figures. Clearly, an accounting that included the full sweep of natural capital benefits provided by protected lands would result in valuations much higher than those presented here.

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