A Value on the Priceless:

Ecological goods and services generated in the Seal River Watershed

IISD REPORT

Marina Puzyreva
Geoffrey Gunn
Joey Simoes

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Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org
Twitter: @IISD_news

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Cover photo: Josh Pearlman

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We greatly appreciate the guidance from our partners in this research project and are honoured to share several reflections of those with a strong bond with the Seal River Watershed. As an introduction to this report, these perspectives on the Seal River Watershed's past and future and its significance will add to our understanding of the true value of the watershed.

Why We Must Protect One of the Last Great Wild Spaces on Our Planet

By Ron Thiessen, Executive Director, Manitoba Chapter—Canadian Parks and Wilderness Society

It's hard for someone who's spent their life in cities—or even small towns—to fully comprehend what it feels like to breathe the air of true wilderness.

As I stood on the shore of Tadoule Lake, marvelling at its beauty and feeling deeply grateful for the privilege of being in Sayisi Dene First Nation, I tried to feel in my heart what I knew in my mind.

I felt that I was standing in one of the last places on earth where nature was still operating without the constraint and pollution of human development.

Every stream, lake, and river in the 50,000 km^2 Seal River Watershed was running free and running clean. There was nothing but this cozy community and a handful of lodges to potentially alter the path of caribou migrating through the watershed's forests, wetlands, and tundra. No roads. No hydro lines. No mines.

This is what most of the world looked like at the turn of the last century, when industrial development was rare, electric lighting was for city folk, and just 15% of the world's land area was used for agriculture (Goldewijk et al., 2011).

Staggering Loss of Wilderness

Today, a whopping 75% of the planet's land area has been altered by human activity (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019). Most of the natural spaces that remain are isolated and fragmented. If you were to parachute into the middle of 70% of the world's forests you'd land within one kilometre of the forest edge (Haddad et al., 2015).

The pace of wilderness loss is staggering. We lost 1.9 million square kilometres of wilderness—an area the size of Mexico—from 2000 to 2013 (Williams et al., 2020). We don't yet know how much wilderness has been lost since then. But we have little reason to hope that the pace has slowed.

Wilderness spaces are now so few and far between that a 10,000 km^2 area with "minimal" levels of development is classified as "globally significant" (Mittermeier et al., 2003). The Seal River Watershed is five times that size and is 99.97% intact.

Value of Large-Scale Wilderness

Canada is one of many nations that have recognized the need for conserving nature by vowing to protect 30% of its terrestrial lands and waters by 2030 (Government of Canada, 2021).

Our survival is dependent on the forests, wetlands, peatlands, and other natural areas that produce the oxygen we breathe, filter the water we drink, and capture the carbon we are emitting into the atmosphere.

It isn't enough, however, to conserve isolated pockets of nature in areas that are of low value for development. We need to permanently protect large-scale areas of high conservation value to help mitigate the impacts of climate change and to stem a devastating collapse of global biodiversity. And we need to establish meaningful conservation corridors that link protected areas to maximize their impacts.

Natural areas don't function as well when they are isolated and fragmented, according to an increasing body of research (Watson et al., 2018). Fragmented habitats lose more than half their species within 10 years and show drastic reductions in soil nutrients and biomass, long-term experiments conducted on different types of habitats in five continents determined (Haddad et al., 2015).

Large-scale wilderness areas are critical for protecting wildlife from mass extinction. According to the World Wildlife Fund, the world has lost around 60% of its mammals, birds, reptiles, amphibians, and fish in the past 40 years (World Wildlife Fund, 2018). Around a million species are at risk of extinction—many within decades—according to a 2019 UN report which found that a quarter of assessed plant and animal species are threatened (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019).

Canada is one of just a handful of countries with vast tracts of intact wilderness—places like the Seal River Watershed—where there is enough space for wildlife to thrive. We have a responsibility to safeguard these global treasures.

A Fleeting Glimpse of the Seal River Watershed's True Worth

I caught a fleeting glimpse of the immense value of the Seal River Watershed's land and water while camping under the Northern Lights in September 2019. Listening to the sounds of drums echoing across the lake, I knew its true worth could only be fully understood by the Dene, Cree, and Inuit Peoples who have stewarded the watershed for millennia. That is why the Canadian Parks and Wilderness Society is supporting the Seal River Watershed Alliance's efforts to establish an Indigenous Protected Area.

This ecological goods and services report is like that trip to Tadoule Lake.

It is a fleeting glimpse of the true worth of the Seal River Watershed. It is based on a Western science perspective, and it does not presume to share the deep knowledge of the elders and land users of the Seal River Watershed.

What it does instead is to demonstrate some of the watershed's value in terms many Westerners can understand.

One of the most impactful pieces of evidence that the excellent researchers at IISD produced was a map showing how humans have altered the flow of rivers and lakes in nearly every corner of the globe. There are few free-flowing places left beyond the far North and the major deserts.

The Seal remains unique even in the far North, where development has spread much farther than most Southerners realize. The IISD researchers found that most of the watersheds pouring into Hudson Bay—which stretches from Nunavut to Manitoba, Ontario, and Quebec—are affected by mining and dams.

The Dollar Value of Ecological "Assets"

What is fascinating about this report was how IISD was able to assign a dollar value to some of the watershed's "assets."

The carbon stored in the watershed's peatlands, wetlands, forests, and permafrost is worth a whopping CAD 314.5 billion (based on how much global economic damage would be caused if it were released.)

IISD was able to calculate the worth of three of the watershed's 261 species by looking at what people said they were "willing to pay" to conserve barren-ground caribou, belugas, and northern pintails: an impressive CAD 192 million a year.

They calculated the value of the barren-ground caribou harvest (CAD 1.5 million a year) and captured some of the ecotourism expenditures in the watershed (CAD 11 million a year.)

They even calculated the value of the mental health benefits to tourists who visit the watershed: CAD 9.6 million for 1,449 annual visitors.

Value of Large-Scale Conservation

Economics has not yet given us a way to measure the full value of conserving one of the few remaining intact watersheds of this scale as an Indigenous Protected Area.

We have seen governments and foundations invest tens of billions of dollars in conservation initiatives amid dire warnings about the impact of biodiversity loss.

We have seen even more massive investments in efforts to remediate environmental damages caused by oil spills, mining, and other industrial development.

We have seen studies showing that every dollar invested in Indigenous-led conservation in Canada leads to at least CAD 2.50 in social, economic, cultural, and environmental benefits (Dehcho First Nations, Lutsel K'e Dene First Nation, Indigenous Leadership Initiative & Tides Canada, 2016).

However, while we may never understand the total value, these fleeting glimpses of its true worth are more than enough to show us that the Seal River Watershed is worth protecting.

By Valérie Courtois, Indigenous Leadership Initiative

Dene, Cree, and Inuit Peoples have been stewards of the Seal River Watershed for millennia. The proposed Seal River Watershed Indigenous Protected Area will help carry on this stewardship knowledge and sustain the watershed's people, culture, and animals into the future.

It is also part of a national movement of Indigenous-led conservation. Across the country, Indigenous Nations are at the forefront of caring for lands and waters and addressing the dual crises of climate change and loss of biodiversity. Recent research confirms what many of us have known for generations: Indigenous stewardship is good for the land and for people.

The United Nations 2019 Global Assessment Report on Biodiversity and Ecosystem Services found that lands managed by Indigenous Peoples tend to be healthier and more vibrant than other areas (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019). A University of British Columbia study (Schuster et al., 2019) had similar conclusions. Researchers looked at land and species data from Canada, Australia, and Brazil and found that the Indigenous-managed lands supported more threatened mammals, birds, reptiles, amphibians, and fish than existing protected areas and non-protected areas.

Indigenous Nations in Canada are stewards of the largest intact forest left on the planet: the Boreal Forest. The boreal holds about 12% of the world's land-based carbon reserves—the equivalent of up to 36 years' worth of carbon emissions from global fossil fuels (Wells et al., 2020). Indigenous Nations are conserving lands that store this carbon, preventing it from escaping and making climate change worse. The proposed Seal River Watershed Indigenous Protected Area holds 1.7 billion tonnes of carbon—equivalent to 8 years' worth of greenhouse gas emissions in Canada (Ducks Unlimited Canada, 2021; Seal River Watershed Initiative, n.d.).

Indigenous stewardship succeeds because it honours the relationship between people and the land. It recognizes that caribou herds, songbird nesting grounds, and deep carbon storehouses benefit from respectful management. In Indigenous communities, that stewardship is guided by Indigenous law, generations of Traditional Knowledge, and cultural responsibility.

Sustaining healthy lands in this way helps support healthy people. Indigenous-led conservation initiatives like Guardians programs transform lives and strengthen communities. They help people connect to the land and teach the next generation to be healthy and rooted in their culture.

Researchers have documented the many benefits of Indigenous stewardship programs. In Australia, 118 teams of Indigenous Rangers manage the land on behalf of their communities. A study conducted for the Australian Prime Minister and Cabinet found that every dollar invested in combined Indigenous Ranger and Indigenous Protected Area programs generates up to 3 dollars in social, economic, and cultural benefits (Social Ventures Australia, 2016).

The same is true in Canada. A team of Australian researchers used the same evaluation methods in a study about the Lutsel K'e NiHat'ni Dene and the Dehcho K'ehodi programs, and they determined that Indigenous Guardians in the Northwest Territories are delivering similar results (Dehcho First Nations et al., 2016).

The analysis showed that Guardians benefit by gaining increased skills, higher income, better health and well-being, and greater pride and cultural knowledge. In addition, communities benefit by gaining more participation in self-governance, better management of cultural assets, more role models for young people, and reduced crime rates.

Indigenous Nations are delivering proven benefits for communities and all Canadians. This conservation leadership is helping revitalize culture, sustain biodiversity, and combat climate change. It reflects the teaching of the Elders: We take care of the land, and the land takes care of us.

By Ernesto Bussidor, former Sayisi Dene First Nation Chief and Senior Advisor to the Seal River Watershed Alliance

As a lifelong adventurist, I've had the pleasure of traversing through the whole of the watershed—either on foot or snowshoes, on snowmobiles, or canoes. I am fully amazed and still in awe of the beauty, ruggedness, and pristineness of this territory. An abundance of wildlife that use this amazing river as its home can best be witnessed in the summer evenings when travelling by canoe.

I shall report on these journeys, what I witnessed, and what ecological value they may provide for future stewardship and management of this area.

The Area Between Lac Brochet and Tadoule—Cochrane River/Seal River Watersheds (Canoe Trip June/July 1976)

- 18 portages between Lac Brochet and Maria Lake, beautiful trapline trail along the creeks with pine, birch, and spruce groves. Plenty of fish, waterfowl, and moose.
- One of these small lakes is a special medicinal lake—with clear, almost blue, water. One can see the whole bottom of the lake and the fish.
- Maria Lake is an ancient community site that goes back many generations. Sandy esker country.
- Johnson Lake has a small cabin used by trappers, from where the canoe/trapline trail goes north to Jackfish Lake. Black bear country. Low boggy creek en route.

- From Jackfish Lake, trail goes over high hill that goes east to Dean Lake, where the North Seal River flows southeast. Trout, grayling, pike, and whitefish are plentiful.
- From Dean Lake to Nicklin Lake, a smooth-flowing river connects the many large lakes in the area. Caribou country.
- Bain Lake, along with Nicklin Lake has lodges and outpost cabins owned by the Ganglers now. Sandy esker country, old highways for the Dene.
- Many species of large and small animals inhabit this area—moose, caribou, black bears, martens, beaver, otters, muskrat, wolverines.
- East of Bain are Copeland and Stoney lakes—Precambrian country lots of ancient boulders and rocky outcrops. Deep lakes teeming with lake trout. Caribou and moose country. Good trapping area.
- Tadoule Lake, esker community. White caribou moss all along the route from Lac Brochet to Tadoule.
- Trapline trails connect these lakes, and in recent historical times people travelled this route to reach Little Duck Lake to the northeast.

The Area Between South Indian Lake and Tadoule Lake (1986 Canoe Trip, 1978 Line Cutting for Winter Road Trail)

- The lake was flooded in 1975 when the control structure was built on the Churchill River at Missi Falls and saturated the ground, rendering all shorelines soaked and making for poor camping grounds 50 feet inland on all shores. This exists to about halfway up the Little Sand River. The Moose family have a family trapline cabin at the north end of Little Sand Lake. Fires ravaged the territory about a decade ago, and the regrowth is prime moose hunting country. Caribou also winter here sometimes. White moss, eskers, and pristine lakes. Much migrating waterfowl in the spring.
- Once Mountain Portage is climbed over at Little Sand Lake, and one hits the South Seal River, the flood zone disappears, and the pristine waters of the river are evident with much fish and wildlife.
- There is a winter trail that connects South Indian Lake to Tadoule Lake through the smaller lakes west of the Seal River. Moose hunting and trapping area, regrowth area ravaged by fires decades ago.
- Elder Lazarus Linklater from South Indian Lake had a trapline cabin at Davenport Lake along the Seal, which burnt down decades ago. Good moose hunting country, as the Tadoule boys often harvest moose from the river in this area.
- The only troublesome part of this river is at the mouth of the Seal River to Tadoule Lake: boulder fields in the river make navigating tricky, but navigable during high water.
- Good fishing along the South Seal River—trout, pickerel, whitefish, pike.

- Most of the trapline cabins along the South Seal River were destroyed by fire. Trappers from Tadoule Lake and South Indian Lake often share this area for trapping—marten, mink, otters, beaver, muskrat.
- Hunters from South Indian Lake and Nisichawayasihk Cree Nation used to come as far as Tadoule in recent times to harvest caribou with help from the local hunters who took them north of Tadoule to harvest.
- South Seal River from Otter Lake to Tadoule is smooth with little rapids, just a fast-moving wide river 100-ft wide.
- Young spring goose hunting area along the South Indian Lake inland flyway. Many species of edible waterfowl harvested by the hunters—geese, swans, cranes, ducks.
- Ancient Dene camp at Chipewyan Lake—during the Spanish Flu epidemic a clan of Dene retreated south to this lake. They were visited by hunters from South Indian Lake who offered them food and assisted them in harvesting fish. They came back numerous years to camp there in the spring and made lasting friendships with the Cree from South Indian Lake.
- O-Pipon-Na-Piwin Cree Nation owns a fishing and hunting lodge at Big Sand Lake, upriver 20 miles from Otter Lake (along the South Seal)

Seal River Main, From Shethanei Lake to Hudson Bay Estuary (Canoe Trip With Youth in 2017) North Channel (From Great Island)

- The last known famous medicine man is buried on Dufferin Lake, just northeast of Shethanei Lake. His name was K'ali Dye.
- East from Tadoule, through Negassi Lake, the elevation drops significantly, and the Seal flows into Shethanei Lake (ancient Dene camping area at the esker that gives this lake its name). Canoes were built here, so the Dene could canoe across the Seal en route to Churchill. Arctic grayling plentiful in the river starting right at Negassi Lake.
- It is at the famous esker on the north shore of Shethanei Lake that harbour seals become visible in large numbers. All the full distance from Shethanei Lake esker to the coast the river is teeming with harbour seals.
- The power of the river and the mass amount of water flowing into the river is evident east of the esker. The current is so fast that it is impossible to find good camping spots along the river unless you have quick reflexes.
- The first noticeable feature you pass by is the Wolverine River as it hits the Seal approximately 15 miles east of the mouth of the river. The river is so fast, it is hard to see the features away from the river until you reach Great Island. It is a massive sandy hill that splits the river in half, majestic in appearance. According to Dene elders, medicine grows on the island, a very rare special flower that heals many ailments.

- The beauty of the river and its majesty is all in view on the north channel with small to medium rapids that are navigable.
- Moose are also visible, eating along the shoreline, especially around Great Island. The north channel is rugged, rocky with ancient rocks that are carved out by the power of the river.
- The Hudson Bay lowlands area is almost featureless as you join up with the south channel and onward to the coast.
- The Great Prayer Rock is visible there and is a historical landmark for the Dene. Legends and historical stories are passed on through the generations about the significance of this huge boulder sitting on the open tundra. Items such as ornaments, tobacco, ammunition, and other items are left in the cracks by everyone who passes by this rock.
- Polar bears are evident as you get closer to the coast, along the lowlands. Their dens are usually on islands, and they become numerous at the mouth of the river.
- Another even more famous medicine Man is also known to be buried at the mouth of the Seal River coast. The man's name was "Enetha," and he is buried on the island known as "Theely Nua."
- Polar bears, beluga whales, Arctic char, harbour seals, and thousands of nesting waterfowl at the coast of Hudson Bay. Belugas give birth to their young in the fresh water of the Seal River.

The Heart of the Watershed, Winter Road From Lynn Lake to Tadoule Lake (Overland Winter Road Project 1996–2000)

- A wonderful view of this huge territory within the Seal River Watershed can be seen by travelling the long winding winter road from Lynn Lake to Tadoule. Once you get away from the exploration areas south of the watershed, the pristineness and beauty of this ridge of land can be best seen during day travel. Rolling hills and lakes with no human footprints other than our ancestors who used the Robertson Esker for travel routes for trade many generations ago. This esker is one of the longest eskers in the north, reaching all the way to Hurwitz Lake, Nunavut, from Reindeer Lake.
- There are many large lakes en route but the road is strictly overland. Some of the larger lakes have outpost camps, owned mostly by the Ganglers. Lakes such as Sprott Lake, Kiask Lake, Big Sand Lake, Cheyne Lake, Marantz Lake, Madison Lake.
- By snowshoeing 40 miles southeast from Tadoule Lake, we found an old-growth forest approximately 20 miles west of Tadoule. Ancient trees standing 30–40 feet high, 3 feet in diameter. Lots of porcupine in this area.
- Cherry Lake, just south of Madison Lake, is a small lake no more than a mile in diameter, but it boasts at least seven beaver lodges. A remote city of beavers.

- Beautiful pristine hills, also home to the barren-ground caribou. They often winter within this great vast land where there are no humans or development of any kind other than a seasonal winter road.
- 335 kilometres from the south end of the road to Tadoule, and all within the watershed of the Seal River.

Photo: Ernie Bussidor

Executive Summary

Wilderness areas support biodiversity, provide clean water and air, regulate our climate, and ensure the availability of traditional foods and medicines. They also educate people about the importance of nature for our everyday well-being and enhance people's mental and physical health through recreation and spiritual connection to the land.

Despite the significance of wild areas for many communities and some awareness of their benefits, the world has been losing these intact ecosystems at a staggering rate. In just 13 years, the world lost a total wilderness area of the size of Mexico: a whopping 1.9 million square kilometres of wilderness was lost to agriculture, urban sprawl, and industrial development from 2000 to 2013 (Williams et al., 2020). The global loss of large-scale wilderness and habitat integrity means that more than 500,000 terrestrial species have insufficient habitat for long-term survival and are driven to extinction (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019). Land conversion also erodes the natural infrastructure that cleans our air, filters our water, stores carbon, and lessens the impacts of climate change. As fewer wilderness areas remain, sparsely populated and intact areas larger than 10,000 km^2 are regarded as "globally significant" (Mittermeier et al., 2003). To stop and reverse the devastating biodiversity loss and limit climate warming, it is crucial to protect the world's few remaining ecologically intact regions.

The Seal River Watershed is a pristine region located in Northern Manitoba that drains over 50,000 km^2 in the traditional lands of Sayisi Dene First Nation, Northlands Denesuline First Nation, Barren Lands First Nation, O-Pipon-Na-Piwin Cree Nation, and the Inuit of the Kivalliq region. The Seal River Watershed is 99.97% intact and is five times larger than the minimum threshold for the "globally significant" wilderness areas. There are no mining or permanent roads in the watershed. The Seal River is also one of the few major rivers globally that are not impacted by dams or hydrological development.

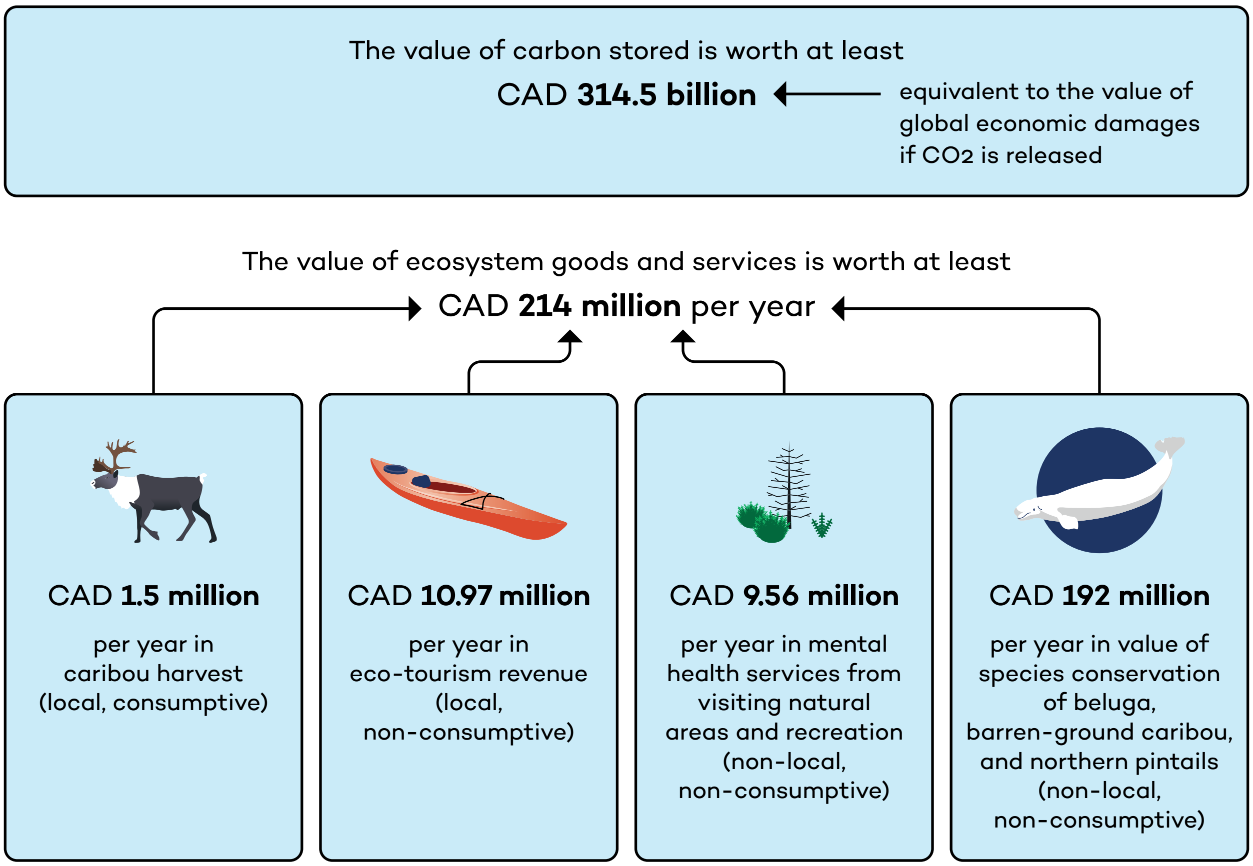
The Seal River Watershed is located in Northern Manitoba, Canada, and it is 99.97% intact.

Among its many benefits, the Seal River Watershed regulates the marine environment of the Hudson Bay, stores significant amounts of carbon, provides habitat for abundant wildlife, and attracts visitors for its unique hunting and fishing experiences. Efforts are already well under way to protect the entire watershed as an Indigenous Protected Area (IPA). Highlighting and communicating the value of many benefits of the Seal River Watershed is critical so that the decision-makers can take action to empower local Indigenous communities to manage these areas sustainably for the well-being of future generations. To support the case for conservation, this study produced a partial assessment of the ecosystem goods and services (EGS) in the watershed to help planners, governments, and the public better understand the value of this intact ecosystem in monetary terms.

We found that the Seal River Watershed provides at minimum **CAD 214 million worth of EGS annually** comprised of values of caribou harvest, ecotourism, health benefits from visiting natural areas, and willingness to pay for conservation of beluga whales, barren-ground caribou, and northern pintails. Most of the annual EGS value is outside the market and is associated with the non-use aspect of biodiversity or the willingness to pay for species conservation.

The value of carbon dioxide (CO_2) contained in the Seal River Watershed is worth at least CAD 314.5 billion, which is more than four times the GDP of Manitoba.

Figure ES1. The value of carbon stored and annual flow of EGS, CAD 2020



We acknowledge that the ecosystem functioning is complex, and there are many ways that the ecosystems benefit human populations. With the available data and valuation methods, **we were able to make only a partial assessment of the value** of the Seal River Watershed. However, even by partially capturing the value of the EGS benefits, we can demonstrate the significant value of this intact area, especially for climate change mitigation, conserving species habitat, and supporting Indigenous cultures and livelihoods. Conserving this area and protecting it from future development under Indigenous stewardship means that these vital benefits will be preserved for future generations of people and wildlife. The demand for the EGS of the Seal River Watershed and their importance will likely increase as we are faced with the global decline of intact forest ecosystems and the global decline in biodiversity, which reinforces the need for its protection.

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1.0 Introduction

Photo: Josh Pearlman

In this study, we assessed the monetary value of some of the ecosystem goods and services (EGS) provided by natural systems of the Seal River Watershed.

The Seal River drains a basin measuring 50,000 km^2—about the size of Nova Scotia—nearly a tenth of the province of Manitoba. It is situated on a transitional landscape called the Taiga Shield between Canada's Boreal Forest and the Arctic Tundra. Beneath this land is the southern limit of permafrost—the soil that in the past remained frozen throughout the year but now is threatened by a changing climate.

The Seal River Watershed is home to spectacular wildlife, including beluga whales, polar bears, and barren-ground caribou, and is notable for one of the highest concentrations of ancient glacial eskers in the world—long ridges of sand and gravel deposited by glacial meltwater. The watershed also stores large amounts of carbon in its soils, fens, bogs, and open water. Dene, Cree, and Inuit people have lived in the Seal River Watershed for millennia; the land, water, and wildlife sustained them and shaped their identities. Today, the Seal River is one of the largest remaining free-flowing (undammed) drainage basins in Canada and represents a valuable but threatened unique habitat.

One way of highlighting why an ecosystem should be protected is making the benefits of nature clear in monetary terms and allowing the benefits to be compared to other aspects of the economy by both local users and distant decision-makers. Direct supply of marketable products like traditional foods and medicine, provision of a clean and consistent water supply, or intangible benefits such as spiritual fulfillment and historical understanding are integral to our everyday well-being.

Places that are closest to their natural state, otherwise called "pristine" or "wild," are especially valuable. For a long time, this value was not recognized: the colonial viewpoint was that these lands were wastelands or barren because they were not yet "developed" (Hippert, 2019; Innis, 1999; Weston, 2021). Throughout the 20th century, the value of northern Canada was seen by provincial and federal officials only in terms of raw resources, such as forestry and furs, uranium, heavy metals, and large hydroelectric projects, that supported and shaped Canada's economy (Innis, 1999). Now, in the 21st century, we recognize that landscapes themselves can and do deliver economic values beyond raw resources and energy. We can realize significant value by preserving large regions and by placing them under local and traditional stewardship.

Our economic system has commonly prioritized produced[1] and human[2] capital over natural capital and failed to properly integrate values of natural assets in decision making (Dasgupta, 2021). The regulating and non-material contributions of nature have been especially undervalued (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019). This resulted in an imbalance between human demands placed on nature and nature's ability to

[1] Produced capital refers to "physical assets generated by applying human productive activities to natural capital and capable of providing a flow of goods or services" (Goodwin, 2003, p. 1).

[2] Human capital refers to "productive capacities of an individual, both inherited and acquired through education and training" (Goodwin, 2003, p. 1).

supply desired goods and services (Dasgupta, 2021). Now we are faced with the rapid loss of wild areas and biodiversity decline all over the world. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019, pp. 238–239) reports that "it is probable that at least a million animal and plant species—more than one in eight—already face global extinction." The same report also states that 75% of the land surface has been significantly altered to date, and over 85% of wetland area has been lost globally. The pace of land conversion is also startling, with serious implications for biodiversity and ecosystem services. Through a mapping exercise, Williams et al. (2020) found that between 2000 and 2013, about 1.9 million km^2 of land in the world that was previously intact—an area the size of Mexico—became highly modified. As for intact forest loss, Heino et al. (2015) estimated that between 2000 and 2012, Canada lost over 100,000 km^2 (5%) of its intact forests—and the current rate of loss of wild areas outpaces the rate of their protection (Watson et al., 2016).

Nevertheless, there is a growing realization that nature is extremely valuable for our long-term well-being as a species, and we need to sustainably manage our natural areas and conserve the last remaining wilderness regions. This is backed up by government commitments, such as Canada's commitment to protecting 25% of the country's land and waters by 2025, and 30% by 2030 (Government of Canada, 2021).

Steps have already been taken to protect the Seal River Watershed for future generations. The Sayisi Dene First Nation partnered with Northlands Denesuline First Nation, Barren Lands First Nation, O-Pipon-Na-Piwin Cree Nation in an alliance to conserve the Seal River Watershed as an Indigenous Protected Area (Seal River Watershed and Ancestral Lands Protected Area Cooperative Relationship Memorandum of Intent [MOI], 2019). The Government of Canada has also invested CAD 3.2 million in the Seal River Watershed Indigenous Protected Area Initiative (Environment and Climate Change Canada, 2020b). The proposed conservation model allows the local communities to chart their own path based on local and Traditional Knowledge and thus help the federal government meet the commitments outlined in the *Final Report of the Truth and Reconciliation Commission* toward repairing damages done by colonial policies (Truth and Reconciliation Commission of Canada, 2015). Indigenous Guardians working in Indigenous Protected Areas to care for their traditional lands and the communities they live in experienced many social, economic, cultural, and environmental benefits, such as increased skills and income, reduced crime, better health, and improved well-being (Dehcho First Nations, Lutsel K'e Dene First Nation, Indigenous Leadership Initiative & Tides Canada, 2016; Indigenous Leadership Initiative, n.d.a). Protection of the Seal River Watershed for future generations also contributes to the Aichi Biodiversity Targets put forward by the UN Convention on Biological Diversity as part of the Strategic Plan for Biodiversity 2011–2020[3] and the Sustainable Development Goals (Goal

[3] See Target 11—Conserved Areas; Target 12—Threatened Species; Target 18—Traditional Knowledge. For national targets, please see https://www.cbd.int/nbsap/targets/.

13: Climate Action,[4] Goal 15: Life on Land[5]) for the benefit of communities at local, national, and global scales.

To support the case for conservation of the Seal River Watershed, we have reviewed the EGS provided by the watershed and, where existing data and research were available, estimated the value of those services. This valuation was informed by the publicly available datasets and EGS literature, research by Ducks Unlimited Canada, CPAWS Manitoba, and communication with several tour operators in the watershed. This economic valuation is a preliminary EGS assessment that, from the Western science perspective, captures the value of the watershed in monetary terms and strengthens the case for conservation. Like all EGS assessments, it is not complete and total. However, it already demonstrates the significant value of this intact area, especially for climate change mitigation, conserving species habitat, and supporting Indigenous cultures and livelihoods.

This report will first describe the physical and biological features of the Seal River Watershed, followed by a discussion of the uniqueness of watershed in the global context. Next, the report will introduce the concepts behind EGS, identify a range of EGS that the watershed provides, and select appropriate methods to capture the value of what may be counted. The report will then present the values of what was calculated. Lastly, hypothetical development scenarios in the watershed will be discussed along with how the EGS values may be affected.

[4] https://www.un.org/sustainabledevelopment/climate-change/

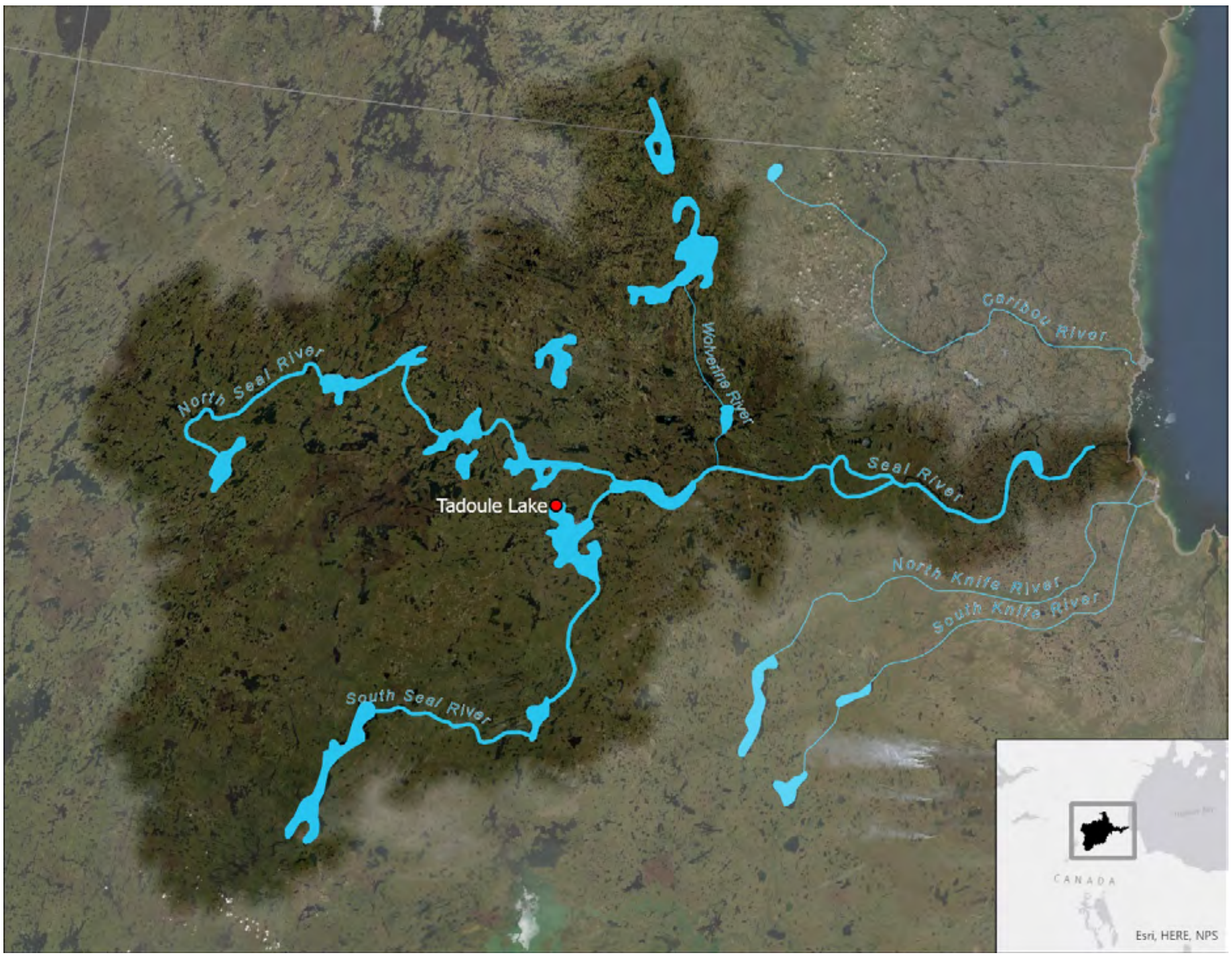
[5] https://www.un.org/sustainabledevelopment/biodiversity/

2.0
What Are the Physical and Biological Characteristics of the Seal River Ecosystem?

Photo: Josh Pearlman

The Seal River Watershed is Manitoba's largest ecologically intact watershed and has very little observable development—99.97% of the watershed area remains in its natural, wild state (Figure 3). The Seal River Watershed drains over 50,000 km² in the traditional lands of Sayisi Dene First Nation, Northlands Denesuline First Nation, Barren Lands First Nation, O-Pipon-Na-Piwin Cree Nation, and the Inuit of the Kivalliq region. This basin has only one permanent community—Tadoule Lake, which has a population of 325 (Statistics Canada, 2018)—and is accessible only by air (year round) and by ice road in winter months (Figure 1; Table 1).

Figure 1. Seal River and principal tributaries



Source: Author diagram.

The Seal River proper is 260 km long, beginning at Shethanei Lake and terminating at Hudson Bay. The Wolverine River feeds the Seal downstream of Shethanei Lake, while principal tributaries are the North Seal and South Seal Rivers. As the largest river in Northern Manitoba without any existing flow regulation, the Seal is one of 39 rivers with a designation in the prestigious Canadian

Heritage Rivers System, holding this title since 1992. Seal River ranks 12th in drainage area and 21st in discharge among Canada's major ocean-contributing rivers (Déry et al., 2016).

The landscape of the Seal River basin marks the transition between Canada's Boreal Forests and the Arctic bogs and tundra, and includes forest, tundra, and coastal wetlands. This transition becomes more Arctic to the north and west. Hudson Bay influences local climate toward a more polar trend than the latitude would otherwise suggest.

Natural processes in the watershed store significant amounts of carbon, provide habitat for rich and abundant wildlife, regulate the marine environment of Hudson Bay, and provide infrastructure that people on the land have used for thousands of years.

2.1 Land Cover

Land cover in the basin is largely composed of natural flora including forests (70%), mixed herbaceous plants (6%), and shrubs (6%), with surface waters occupying the remaining region (18%). The landcover change information is available in Appendix A.

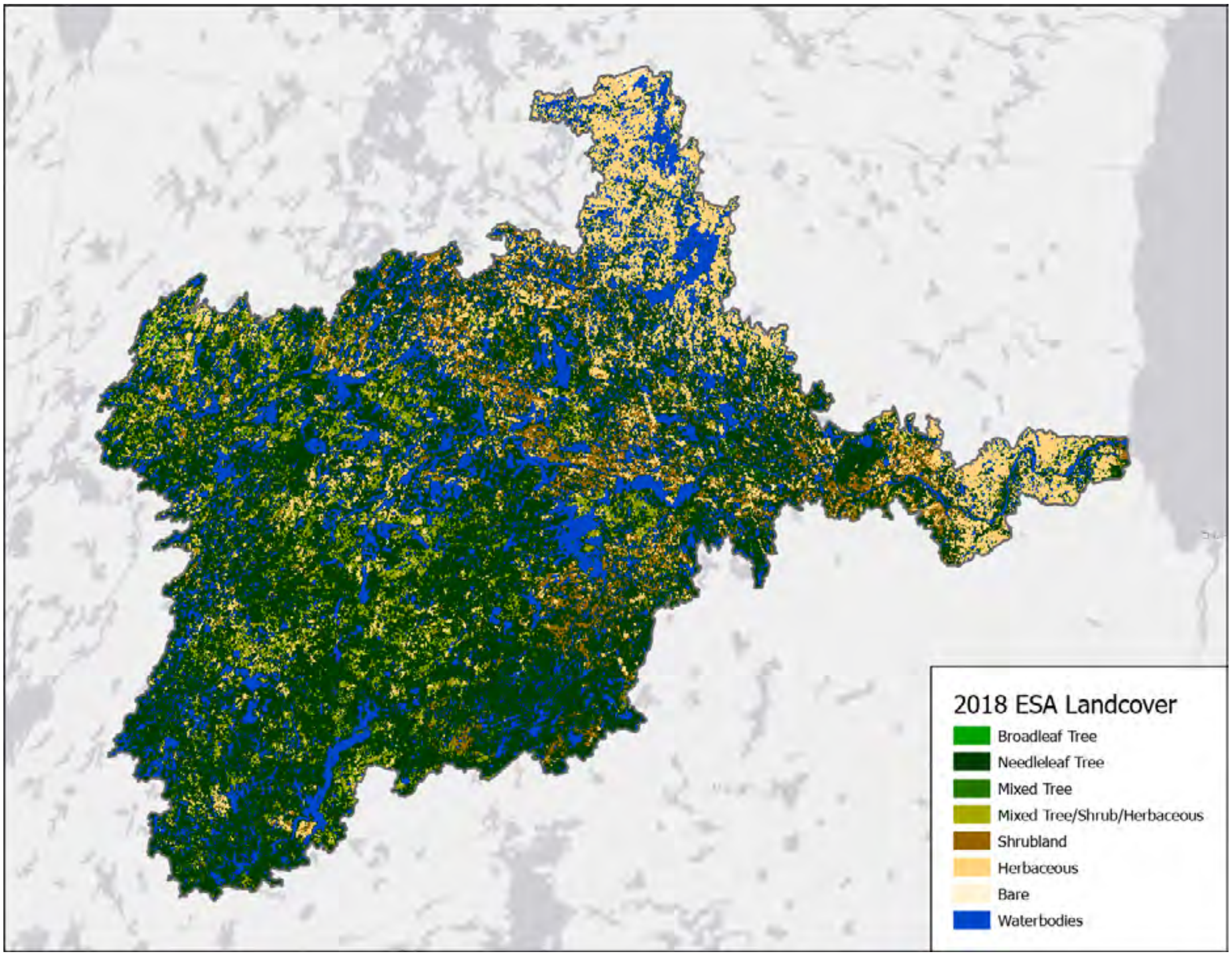
Table 1. Physical summary of the Seal River Watershed

Total area	50,689 km^2
Forested area	12,019 km^2
River length (reach)	486 km
Existing protected area	13.32%
Intact landscape	99.97%
Population (2016 estimate)	325[6]

Land cover (Figure 3) shows the influence of a north-south climatic gradient, with the south covered by mostly needleleaf forests and the north and east transitioning to open forest, shrubland, and bare ground. These floral regions reflect and influence the distribution of animal biodiversity in the watershed.

[6] Statistics Canada (2018).

Figure 2. Land cover of the Seal River Watershed



Source: Author diagram, based on data from European Space Agency Climate Change Initiative (ESA CCI), 2019.

2.2 Biodiversity

The Arctic marine environment at the mouth of the Seal River hosts large mammals such as ringed seals, beluga whales, and polar bears. Inland, barren-ground caribou migrate through the watershed in large numbers to winter near the Seal River. The Seal River Estuary is also designated as an Important Bird Area with an abundance of bird species; many of them are shorebirds such as various types of sandpipers and passerines (IBA Canada, n.d.).

In total, there are 261 known species[7] in the Seal River Watershed, of which 20 are species at risk (Swan, 2022) (Appendix B). According to Swan (2022), 261 species is a gross underestimate.

[7] 117 bird species, 17 fish species, 2 frog species, 5 insect species, 19 mammal species, and 100 plant species.

The watershed is also a habitat for five species threatened with global extinction under the International Union for Conservation of Nature (IUCN) Red List[8] including barren-ground caribou, polar bear, and rusty blackbird (BirdLife International, 2018; Gunn, 2016; Swan, 2022; Wiig et al., 2015) and seven near-threatened bird species such as the olive-sided flycatcher and buff-breasted sandpiper (BirdLife International, 2017a, 2017b; Swan, 2022).

2.3 Carbon Storage

Figure 3. Observable development in the Seal River Watershed

Source: Author diagram.

Large stocks of organic carbon are locked in roots, soils, and freshwater ecosystems. Ducks Unlimited Canada estimated that the Seal River Watershed stores approximately 1.7 billion tonnes of carbon or 6.2 billion tonnes CO_2 in its fens, bogs, upland, open water, and freshwater

[8] Vulnerable (VU) under IUCN classification.

mineral (Ducks Unlimited Canada, 2021; Seal River Watershed Initiative, n.d.). This is equivalent to 8 years' worth of total greenhouse gas (GHG) emissions in Canada as reported in 2018 or 69 years of annual emissions from passenger cars and light trucks in Canada based on 2018 levels (Environment and Climate Change Canada, 2021; Seal River Watershed Initiative, n.d.).

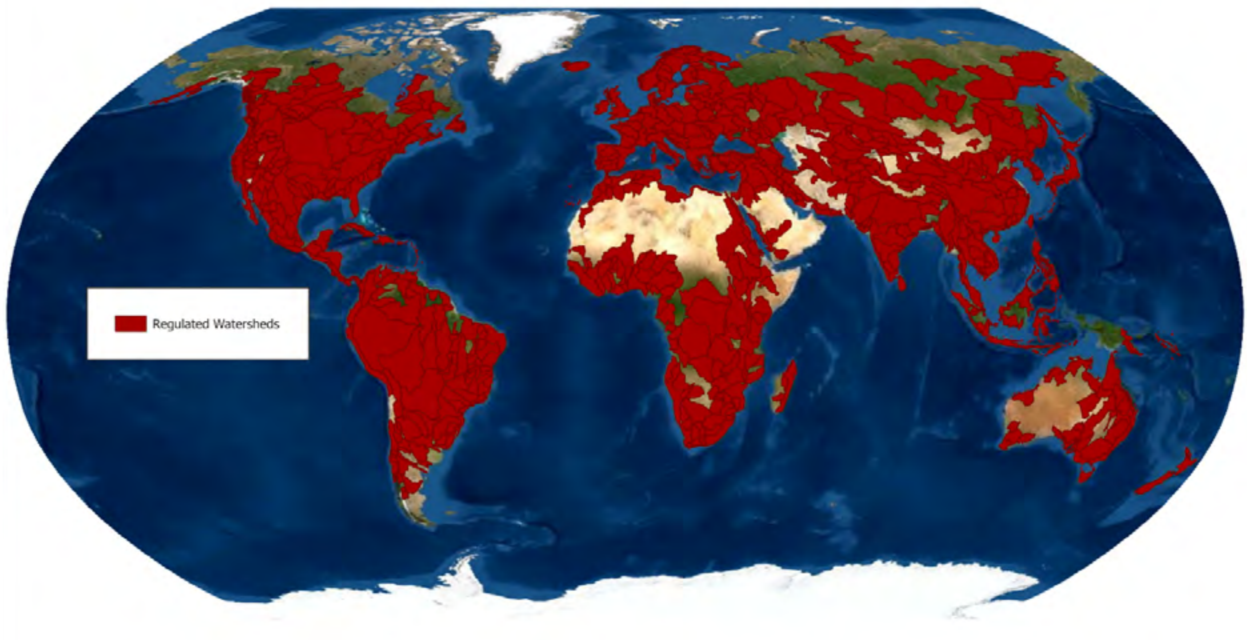
More physical and biological characteristics such as temperature, precipitation, and discharge are presented in Appendix A.

3.0
The Seal River Watershed in a Global Context

Photo: Ernie Bussidor

3.1 Wild Rivers and the Importance of the Fresh Water/Ocean Connection

Figure 4. Dammed watersheds in the world



Source: Author diagram, based on data from Mulligan et al., 2020.

Every second, 1.2 million cubic metres of water spill off continental landmasses and into the global ocean (Schanze et al., 2010). This water carries life-sustaining nutrients and minerals to the ocean while bridging fresh water and saltwater—a refuge for spawning salmon and a smorgasbord for whales, seals, and polar bears. These connections enable natural cycles through seasonal and annual changes and are essential for a healthy biosphere.

However, most rivers no longer flow naturally. To generate electricity or improve agriculture, humans have constructed dams on rivers ranging from small dikes to massive hydroelectric facilities. We have built ponds to condition tailings from mines. We have rerouted entire rivers from one drainage basin to another to increase flows and engineered completely artificial reservoirs to hold back water.

In holding back and controlling water, the river loses its "wild" character. The temperate seasonal cycles of a freshet—the torrent of water in the springtime—followed by gradually declining flow into the summer and fall are systems that plants, animals, and even plankton have evolved to thrive in. These stresses will be amplified in aquatic ecosystems as climate change alters these flows even in wild rivers making them more important as the last refuges of not only species at risk but the plants and animals that may be at risk in the next decade.

Human industrial systems disrupt not only the water but the land as well: forests are turned into reservoirs, bogs, and peatlands are drained, affecting seasonal and year-round habitats. This makes life challenging at higher latitudes where species need larger ranges to meet dietary and breeding needs. Caribou, northern pintails, and beluga whales are all species that need large and diverse ranges to meet their own survival needs.

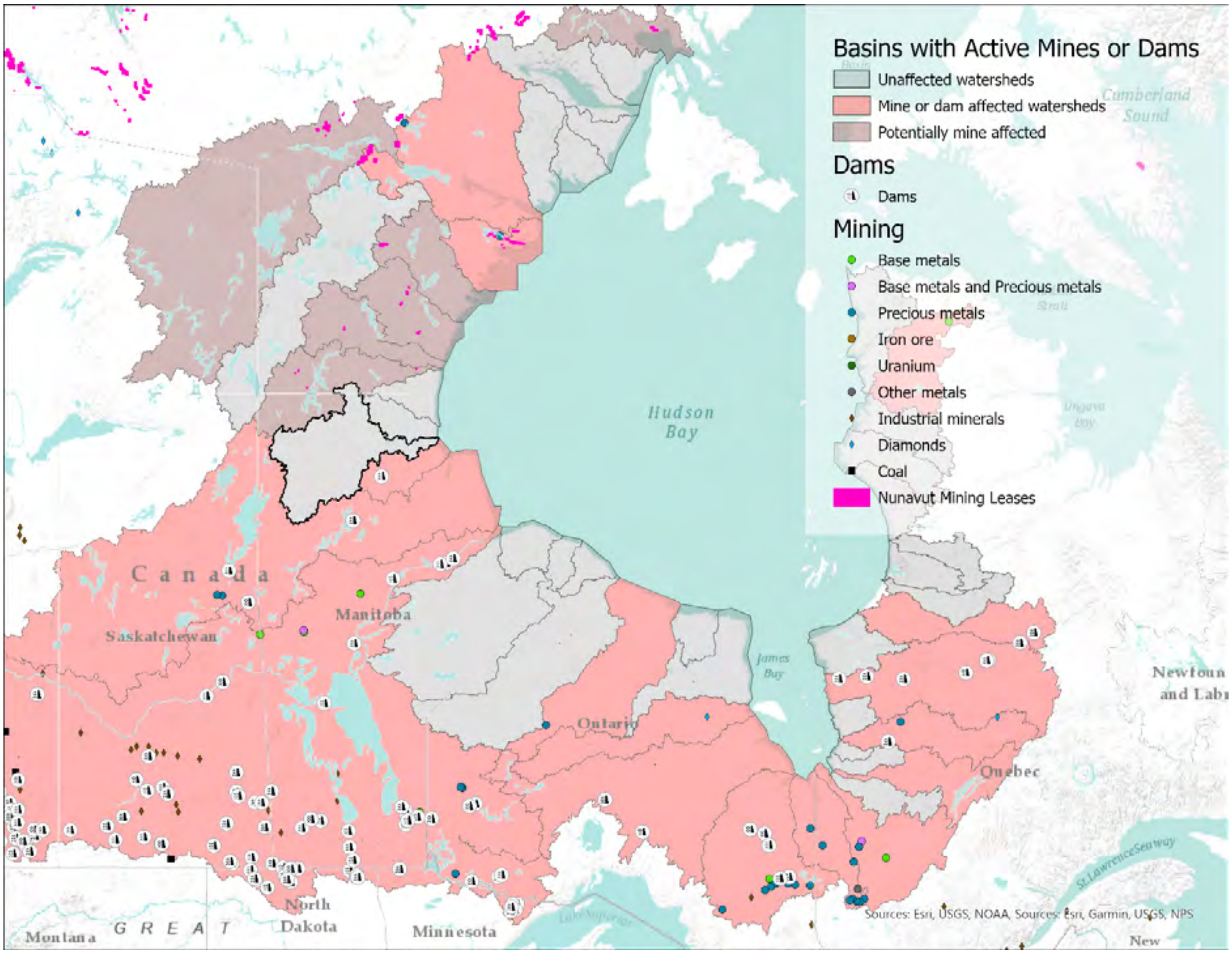
According to data from Global Dam Watch (n.d.), there are over 38,000 dams or human-created impediments to natural flow around the world (Figure 5). They affect drainage basins throughout the world, with the only non-polar exceptions located in places such as the Sahara Desert, Arabian Peninsula, and the Australian Outback. The dam-affected watersheds cover just under two thirds of the total land surface of Earth.

3.2 The Last Wild Rivers in the Hudson Bay Basin

Part of the Seal River's unique global position is in its connection to the Hudson Bay Marine Complex (Figure 5). This system, composed of Hudson Bay, James Bay, and the Hudson Strait, is a southerly Arctic projection and one of the world's largest inland seas as well as one of the few subject to complete winter ice cover and complete summer open water (MacDonald & Kuzyk, 2011). More than half of the rivers draining into the Hudson Bay are affected by dams or mines, including major rivers like the Churchill River, Nelson River, and La Grande River.

Figure 5 shows the few remaining drainage basins that remain hydrologically unaffected by dams or mines. The Seal River Watershed, at the boreal/tundra transition, is one of the largest watersheds within the Hudson Bay basin without current or prospective developments.

Figure 5. Watersheds affected by industrial development draining into Hudson Bay



Source: Author diagram.

4.0 Identifying and Valuing the EGS in the Seal River Watershed

Photo: Ernie Bussidor

For the assessment, we first discussed the concept of EGS, identified the EGS that the Seal River Watershed provides, and reviewed appropriate economic valuation methods. Second, we estimated values of EGS that could be monetized. The EGS were identified based on the biophysical analysis, interviews with key informants, and review of the published studies on the forest ecosystems and natural infrastructure. These EGS demonstrate that the importance of ecosystems to humans has many dimensions.

4.1 What Are Ecosystem Goods and Services?

Ecosystem (or ecological) goods and services (EGS) are direct and indirect benefits to both local and global communities from ecological characteristics, functions, or processes of the ecosystems. For an ecosystem function to be viewed as an ecosystem service, there needs to be a recognition of its connection to human well-being and the ecosystem or biophysical function needs to be valued by people (Costanza et al., 2017; Paul et al., 2020). Examples of EGS include regulation of local and global climates, food for harvest, clean drinking water, protection from floods and droughts, and opportunities for recreation and spiritual fulfillment.

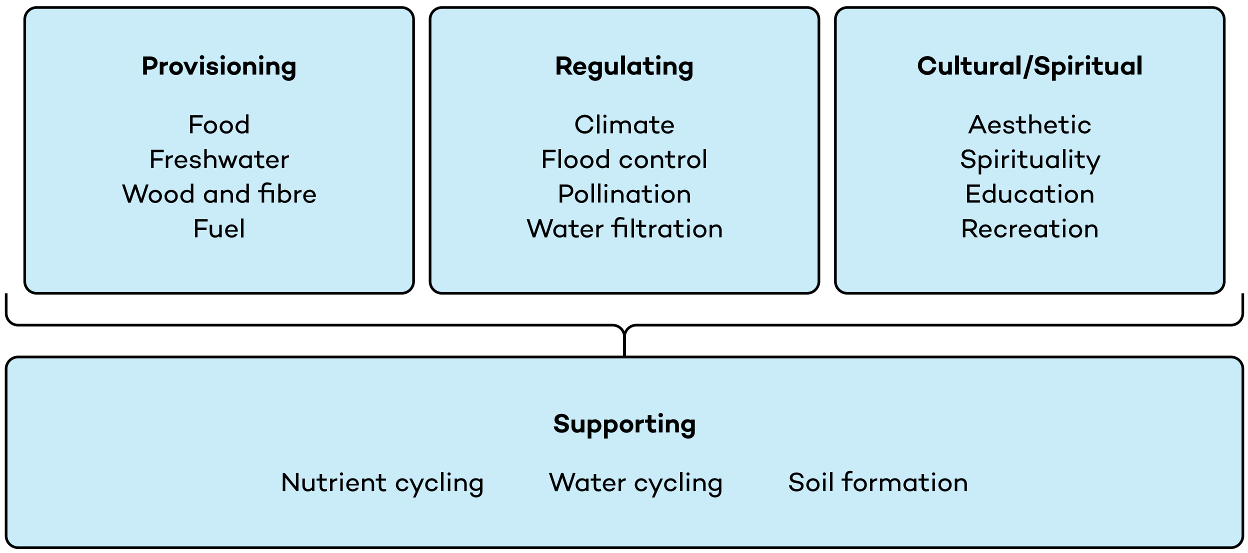
There is a distinction between natural capital/ecosystem assets as stocks of resources and the flows of EGS. To help understand the difference, it is worth examining the internationally accepted definitions. Natural capital refers to "**the stock of renewable and non-renewable resources** (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people" (United Nations, n.d., emphasis added). This concept considers nature not only as a source of raw materials for production but extends to encompass the role of the environment and ecosystems in human well-being through the supply of critical services such as clean water and fertile soils (United Nations, n.d.). Similar to natural capital, ecosystem assets are assets that provide ecosystem services to people. They are defined by a spatial area, for example, wetlands within a specific territory (United Nations, 2019). In contrast to stocks of natural capital or ecosystem assets, ecosystem services are the **flows of services** that the ecosystem asset provides to either economic units, including businesses and households, or the flow of services between ecosystem assets, as defined by the United Nation's System of Environmental Economic Accounting Experimental Ecosystem Accounting (SEEA EEA) (United Nations, 2019).

The most well-known classification of the EGS by the Millennium Ecosystem Assessment (2005) groups the EGS into four major categories:

1. **Provisioning** services relate to products derived from the ecosystems such as clean drinking water, food, and biomass.
2. **Regulating** services refer to the regulating processes such as flood, erosion, and disease control.
3. **Cultural** services encompass the non-material benefits of ecosystems, such as spirituality, education, and recreation.

4. **Supporting** services are fundamental services that support habitats and make more direct benefits available to humans, such as nutrient cycling, soil formation, and the water cycle. In Figure 6, they are shown at the bottom as foundational to the provision of other types of services.

Figure 6. Classification of EGS



Source: Author's diagram adapted from Millennium Ecosystem Assessment, 2005.

The United Nation's SEEA EEA statistical framework groups ecosystem services into three categories: provisioning services, cultural services, and regulating services. These could be said to represent material, non-material, and regulating nature's contributions to people, respectively (Hein, 2018).

The EGS concept is explicitly human centred, based on the global understanding of *Sustainable Development*, and the calculation methods compromise with the predominant economic system. While presenting monetary value for the EGS may be challenging—especially for services that are not typically traded in markets—there are nonetheless significant advantages to doing so. When an industrial proponent advocates for a resource development project, they will present benefits to regulators and the public, such as jobs or economic impact. By using EGS assessment, land stewards can also show measurable benefits of existing natural systems, compare land management scenarios, and predict costs to communities in the future, such as remediation or relocation.

EGS are also important from a land-planning and stewardship perspective. By monitoring and understanding goods and services, land stewards can track the changes in the EGS over time and help the public and policy-makers make more informed decisions around the watershed's management. The EGS assessments can also highlight data gaps and incentivize monitoring and measurement of the services while building a long-term plan for the Seal River Watershed.

With the EGS approach, those working to conserve landscapes are telling compelling stories to public policy audiences and the wider public about tangible benefits from these regions and their value in monetary terms. Waldron et al. (2020) estimated that expanding protected areas to 30% of the planet would generate an additional USD 64 billion–USD 454 billion per year in direct output, such as revenues, by 2050 for fisheries, agriculture, nature tourism, and forestry compared to the non-expansion scenario. Therefore, expanding protected areas does not, in fact, lower the level of economic output in these sectors, which is a first concern regarding establishing protected areas (Waldron et al., 2020). Moreover, expanding protected areas would help avoid significant damages associated with the degradation of nature for an *additional* economic benefit of USD 170–USD 534 billion per year by 2050 (Waldron et al., 2020). This includes avoided flood, climate change, soil-loss costs, and costs associated with coastal storm-surge damage. For more studies with similar valuations, see Wilson (2008) and the Task Force on Economic Benefits of Protected Areas of the World Commission on Protected Areas of IUCN in collaboration with the Economics Service Unit of IUCN (1998).

For remote areas like the Seal River Watershed, data availability and low population levels make it more challenging to estimate the value of the EGS. The most straightforward approach to capturing the EGS values is to monetize the direct use of goods and services by taking the prices from the existing markets, such as the value of hunting and gathering and clean water provision to local communities. However, since remote regions are less populated and difficult to access, these values may not be high. For example, Bullock (2018) notes "values are likely to be higher where there are more people. This means that wilderness areas could be valued less unless their existence is very well-known and they have a high non-use value" (p. 18).

To further understand the role of the non-use values in the economic valuation of the remote ecosystems, we need to consider the complex ecosystem functioning and how it affects communities located far from these ecosystems and their values. For example, by supplying fresh water, the Seal River Watershed supports downstream marine circulation and the sea ice habitat in Hudson Bay. This function helps ensure a healthy habitat for species like polar bears and beluga whales. In turn, polar bears and beluga whales are valued by local and distant communities. There is local and global demand for ensuring that these species are sustained for future generations (Government of Canada, 2012; Joint Secretariat, 2015; Tyrrell, 2008; National Oceanic and Atmospheric Administration [NOAA], n.d.). Capturing the non-use values of many people who do not live close to the watershed in this case is possible with the use of contingent valuation or stated preference methods that usually ask people in surveys about how much they would be willing to pay to preserve a species' habitat. The advantages and limitations of this are discussed in Appendix C. Unfortunately, such contingent valuation studies are often not readily available for many ecosystems and the EGS under investigation, so new research into people's values is required.

Another example of an EGS that is valued globally is the carbon storage. All around the world, communities are interested in preventing further releases of CO_2 from terrestrial ecosystems and slowing down the pace of climate change. It is possible to capture this value using a social value of carbon or a carbon price.

Overall, it is important to remember that the pathways in which many ecosystem benefits reach people are complex and vary spatially and temporally (Claes et al., 2020; Sutherland et al., 2018). Considering this complexity, we can only make a partial assessment of the EGS in the Seal River Watershed with the economic tools and data available to us. The methodological challenges and remoteness, however, should not prevent us from considering the benefits of these large intact regions and improving existing frameworks to provide more accurate estimates of the EGS in the future. We also need to acknowledge the intrinsic values of the wilderness areas, that is, the value of wilderness area in and of itself, irrespective of human beings (Bullock, 2018, p. iv).

4.2 What Are Some of the EGS That the Seal River Watershed Provides to Local and Distant Communities?

Carbon Storage

Ducks Unlimited Canada estimated that the Seal River Watershed stores approximately 1.7 billion tonnes of carbon (6.2 billion tonnes of CO_2) in its wetlands and surface waters (Ducks Unlimited Canada, 2021; Seal River Watershed Initiative, n.d.). Storing this carbon in the soils, plants, and water ensures it is not released into the atmosphere, contributing to our efforts to combat climate change.

Regulation of the Hudson Bay Marine Environment

Fresh water delivered to Hudson Bay from the Seal River Watershed has a crucial role in marine circulation and maintenance of the seasonal ice cover. This regulation of the marine environment of the Hudson Bay by the Seal River supports a healthy habitat for species such as polar bears and beluga whales, which has a direct impact on the ecotourism industry that may be able to attract distant communities. Thus, keeping the river flow undisturbed supports the availability of nutrients and biological productivity in Hudson Bay.

Clean Air and Clean Drinking Water

Wetlands and riparian forests play a key role in water purification. Plants, roots, and microbes filter water by removing heavy metals and other pollutants and transforming toxic elements into non-toxic ones. Available clean water not only sustains human life but also animal and plant life. Similarly, the wetlands, forests, and soil filter many pollutants from the air for the benefit of humans and animals.

Harvest of Local Foods

The natural abundance of the Seal River Watershed provides a key source of healthful and fresh traditional food. Indigenous people in the area have long been harvesting seals, caribou, and polar bears for food, clothing, shelter, heating, and other uses essential for their livelihood. Harvest of local foods has a cultural value connecting local Indigenous people to their history, language, and identity (e.g., through collective hunting). It also has a health value, reducing reliance on purchased and imported foods.

Tourism

The recreational value of the Seal River is tied to its remote and largely undeveloped subarctic environment, which can provide visitors with a unique connection with nature. The Seal River Watershed offers spectacular canoeing, fishing, hiking, and wildlife watching experiences. Four commercial lodges are located in the watershed:

1. Gangler's North Seal River Lodge, located on the North Seal River toward the western edge of the watershed.
2. Churchill Wild's Seal River Heritage Lodge, located near the Seal River Estuary on the shores of the Hudson Bay.
3. O-Pipon-Na-Piwin's Big Sand Lake Lodge, located in Sand Lakes Provincial Park at the southern end of the watershed.
4. The Lodge at Little Duck, located in the northern end of the watershed near the border with Nunavut.

Around 1,449 visitors fly to Gangler's North Seal River Lodge, Churchill Wild's Seal River Heritage Lodge and O-Pipon-Na-Piwin's Big Sand Lake Lodge each year to to fish, hunt, watch wildlife, and learn about the ecosystem and the Indigenous cultures. These businesses also bring substantial local benefits such as income for First Nation members, and opportunities to share culture and build relationships with visitors. For additional details on these operations, see Appendix C.

In addition, five commercial operators offer excursions into the Seal River Watershed: Monroe Lake Lodge (located north of the watershed); Churchill-based Lazy Bear Expeditions and Hudson Bay Helicopters; and paddling excursion operators Black Feather and Wilderness Spirit. The Seal River Watershed also contributes to the significant ecotourism industry in Churchill, Manitoba, by providing habitat for key migratory attractions like polar bears and beluga whales.

Health Services

Visits to nature improve both physical and mental well-being (Bratman et al., 2019; Frumkin et al., 2017). Nature's benefits for health are being increasingly recognized in the health care system, and medical professionals are even encouraged to prescribe nature, for example, see PaRx, Canada's first national nature prescription program[9] (Kliem, 2021). Visits to the remote Seal River Watershed to connect with nature improves mental well-being for more than 1,449 tourists annually, which translates into reduced treatments, reduced caregiver costs, improved workplace productivity, and improved overall well-being.

Education

The surrounding environment and biodiversity provide plenty of educational opportunities related to boreal forest ecosystems, sustainable harvest of local foods, and Indigenous culture and heritage. This educational potential can continue to be realized if the Seal River Watershed becomes a protected area and is further supported by the Indigenous Guardians programs[10] (Indigenous Leadership Initiative, n.d.b; Government of Canada, 2020). Local Indigenous people will be able to build capacity and skills as land stewards, monitor wildlife and water quality, and educate researchers, visitors, and the broader public about the Seal River Watershed. Also, ecotourism provides opportunities for relationship building around knowledge exchange. Visitors who have taken ecotours for many years have developed relationships with Indigenous guides, and over time these guides share more about the land, history, and traditional activities with the visitors whom they trust (B. Kotak, personal communication, December 18, 2020).

Cultural Value

The cultural value of the Seal River Watershed is inevitably linked to the watershed's clean air and water, rich and abundant wildlife, and opportunities to collectively engage in traditional activities like hunting and fishing. Cultural and spiritual values associated with biodiversity, especially with caribou, are integral to the Indigenous communities. Caribou from the Qamanirjuaq herd have sustained Indigenous people in the Seal River Watershed for generations. As a vital part of the ecosystem, caribou are not only a source of food and sustenance but also identity. Local Indigenous people pass down Traditional Knowledge and bond as a community while hunting caribou.[11]

Impacts of Indigenous Guardians programs

There are numerous potential future socio-economic benefits from establishing an Indigenous Guardians Program to support the stewardship of the Seal River Watershed. This program is designed to provide training and create jobs for Indigenous Guardians to steward their traditional lands and waters (Indigenous Guardians Toolkit, n.d.; Indigenous Leadership Initiative, n.d.-a). The activities of Indigenous Guardians typically include environmental monitoring, maintaining cultural sites, interacting with visitors, and sharing culture and knowledge with younger

[9] https://www.parkprescriptions.ca/

[10] https://www.indigenousguardianstoolkit.ca/

[11] Caribou populations, however, have been declining (Beverly and Qamanirjuaq Caribou Management Board [BQCMB], 2019). Climate change will further affect species habitat (through wildfires [Walker et al., 2019], shifts in ecozones, changes in animal and plant ranges, and other connected stressors [Allen (2017]) and the Indigenous culture tied to it, including ability to practice traditional ways of being.

generations (Indigenous Guardians Toolkit, n.d.; Indigenous Leadership Initiative, n.d.a). This participation will create meaningful employment, build skills, and improve community well-being. The evidence from across the country demonstrates that the Indigenous Guardians programs result in positive socio-economic change in Indigenous communities and create value for the investments made (Indigenous Leadership Initiative, n.d.a). For example, the Dehcho First Nations, Lutsel K'e Dene First Nation, Indigenous Leadership Initiative and Tides Canada (2016) reported that the Guardians programs in the Lutsel K'e and Dehcho regions of the Northwest Territories had generated CAD 11.1 million in social, economic, cultural, and environmental value for an initial investment of CAD 4.5 million. The positive outcomes included increased access to traditional foods, improved work ethic, increased confidence, and better overall health and well-being (Dehcho First Nations, Lutsel K'e Dene First Nation, Indigenous Leadership Initiative & Tides Canada, 2016).

4.3 Who Are the Beneficiaries of These EGS at Different Scales?

These EGS benefit both local and distant communities. Today, members of five Indigenous communities—Sayisi Dene First Nation, Northlands Denesuline First Nation, Barren Lands First Nation, O-Pipon-Na-Piwin Cree Nation, and the Inuit of Kivalliq—interact directly with the watershed, engage in subsistence harvesting, derive benefits from clean water and air, and maintain a connection to their culture and identity.[12] Tourists who visit the watershed to watch wildlife and partake in sport fishing, paddling, and other activities also directly benefit from the Seal River Watershed's EGS.[13] Distant communities that do not interact with the watershed directly may also care about its benefits, for example, climate regulation, carbon storage, habitat for endangered species, educational opportunities, and preserving natural heritage for future generations.

4.4 How Can We Capture the Value of EGS Using a Common Monetary Unit?

The value attributed to these services results from either the direct interaction between humans and ecosystems (**use value**) or when communities do not directly interact with the watershed (**non-use**, such as existence value and bequest value). Direct use values may be "consumptive," e.g., drinking water, or "non-consumptive," e.g., ecotourism, observation. Non-use values occur, for example, when a larger group of individuals care about the existence of individual animal

[12] The four First Nations–Sayisi Dene First Nation, Northlands Denesuline First Nation, Barren Lands First Nation and O-Pipon-Na-Piwin Cree Nation – have a combined on-reserve population of 2,922 people and 1,971 off-reserve members, many of whom return regularly and maintain connection to the land (Indigenous Services Canada, 2021). We were unable to assess how many Inuit people interact directly with the watershed.

[13] More than 1,449 visitors annually.

species even if they will never see one in the wild. They may derive utility from knowing that certain species are conserved (Hanley & Perrings, 2019).

The monetary evaluation is most straightforward if the goods and services are traded in markets and thus have a recognized monetary value, for example, ecotours or the commercial harvesting and selling of caribou meat. For many services, the monetary values are not readily available—people do not directly pay for certain services, either in this watershed or in general. However, people still benefit from these services, for example, climate regulation, regulation of the marine environment of Hudson Bay, and spiritual fulfillment. There are a variety of well-established techniques to estimate the value for the EGS when there is no direct payment for them.

Some non-market economic valuation methods are:

- **Avoided cost:** We can capture the value of a certain non-tradable service indirectly through costs that society would have incurred in the absence of these services. For example, wetlands provide protection against floods and help avoid costs of property damage; connecting with nature in ecotourism and fishing trips improves mental and physical well-being and potentially avoids costs of medical treatment and the cost of reduced workplace productivity associated with health issues.
- **Replacement cost:** This approach calculates the value based on the costs that would be incurred if we were to replace the ecosystem services with human-made alternatives. For example, we can estimate how much the water treatment services provided naturally by wetlands are worth by comparing them to the cost of water treatment in built wastewater treatment facilities.
- **Net factor income:** This method is used when the ecosystem services are contributing to the production of commercially marketed goods and services. For example, the regulation of the marine environment of Hudson Bay through a free-flowing river system supports polar bear and beluga whale populations, which is reflected in the revenues of the ecotourism sector.
- **Travel cost:** This method considers people paying for travel to access certain services (e.g., wildlife watching) so that a service value (e.g., biodiversity value) is somewhat reflected in the travel costs people are willing to incur.
- **Hedonic pricing:** This method assumes that the demand for certain ecosystem services is reflected in the prices of associated goods. For example, property values along the coast often exceed the values of inland houses, reflecting the intangible benefit of enjoyment from certain landscapes/ecosystems.
- **Contingent valuation:** This method involves administering surveys with alternative land-use scenarios to understand people's preferences and values. This method is often used to estimate non-use values, for example, the benefits of wildlife abundance. In hypothetical scenarios, people can be asked how much they are willing to pay for the conservation of a particular species (i.e., the "willingness to pay" [WTP] method).

These methods have their limitations. Nonetheless, they allow us to apply a common metric to understand the value of rich and abundant ecosystems to many beneficiaries. All these methods are commonly applied in the calculation of the use values, and contingent valuation is particularly useful in assessing the non-use values of the EGS. To calculate the values for a particular region, it is important to know the demand for certain goods and services both locally and from people not living in the watershed, for example, country food consumption by the people living in the watershed and the number of tourists flying to the Seal River Watershed to partake in the recreation activities. We were able to obtain some of this information; for those services where the local data is not available, we relied on existing studies in similar regions that applied the above-mentioned economic valuation methods to estimate the EGS values.

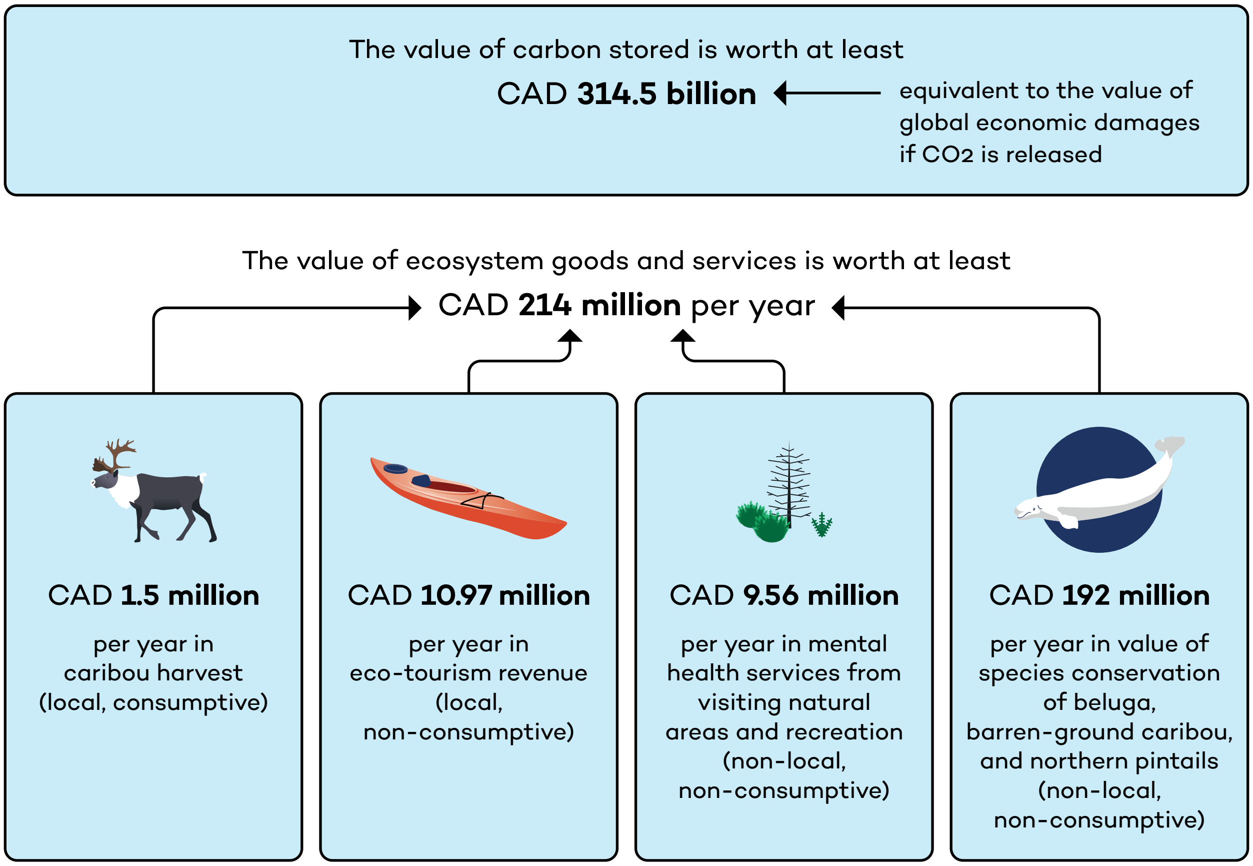
4.5 Estimating the Values of What May Be Counted

The following presents the monetary values for some of the EGS identified earlier. We acknowledge that ecosystem functioning is complex, and there are many ways that ecosystems benefit people. With the available data and economic tools, we were able to make a partial assessment of the value of the Seal River Watershed.

We have estimated that the Seal River Watershed provides CAD 214 million worth of EGS annually comprised of the values of caribou harvest, ecotourism, health services, and households' WTP for conservation of beluga whales, barren-ground caribou, and northern pintails. Most of the annual value (94%) is associated with non-use aspect of biodiversity, i.e., WTP for species conservation. The stock value of CO_2 contained in Seal River Watershed is worth at least CAD 314.5 billion, which is more than four times the GDP of Manitoba (Government of Manitoba, 2020). For the full description of our methods and data sources, please refer to Appendix C.

The EGS provided by the Seal River Watershed and their value will likely change over time as climate change impacts increase and as the number of intact forest ecosystems declines (Chen, 2020; United States Environmental Protection Agency, n.d.): this will alter the supply of and demand for the EGS. Climate change will affect the supply of the EGS—for example, a decline in animal species that may affect food provision. At the same time, the global loss of the remaining intact ecosystems to development will likely increase the demand for certain EGS and the value that people attribute to these ecosystems because they will become the last remaining buffers to slow down (and mitigate) climate change, maintain clean air, and preserve clean water for human well-being.

Figure 7. The value of carbon stored and annual flow of EGS, CAD 2020



Source: Authors' diagram.

Conserving the area and protecting it from future development under Indigenous stewardship will create additional local benefits. Indigenous Guardians will be trained and make a living by monitoring the land, which will yield multiple benefits to local communities: it will reduce their reliance on social services, help pass on Traditional Knowledge, history, and culture to youth, and build skills and capacity. Ecotourism can be expanded with new activities, such as rafting and bringing visitors to traplines—this could attract more tourists while acknowledging that growth in tourism is limited by the area's remoteness.

5.0
Potential Development and Impact on EGS Values

This EGS evaluation exercise not only allows us to understand the value of the watershed and assess potential future values, but it also allows us to analyze what could happen if certain development takes place. The values generated by intact watershed ecosystems like the Seal River—including values of stored carbon, fish for food and recreation, ecotourism, clean water, and regulation of larger systems—could be lost with mining or hydroelectricity. EGS assessments can capture important changes in the EGS values and help make more informed decisions about the future management of the watershed as part of the cost–benefit analyses of the development projects. In such analyses, the loss of the EGS from development will need to be considered alongside economic benefits of employment, for example from road construction and maintenance, transportation cost savings, etc. The following describes the hypothetical development scenarios in the Seal River Watershed and their likely implications without presenting changes in monetary values.

Potential Risk: All-weather road

An all-weather road connecting Churchill (Manitoba) to Rankin Inlet (Nunavut) has been proposed over the years (MacLean, 2017). If constructed, this road would pass through the Seal River Watershed. Nishi-Khon SNC-Lavalin Limited (2010) presented a business case for constructing this highway. The report mentioned the following environmental risks associated with road construction (p. 38):

- Increased risk of boreal forest and tundra wildfires
- Increased hunting and fishing as well as loss of human life and wildlife through road collisions
- Risk of accidental spills of hazardous fuels and materials
- Disturbance of barren-ground caribou calving areas and migration routes
- Risk of disturbing archaeological sites, sacred sites, and cultural artifacts.

The construction of an all-weather road through the watershed could also increase the likelihood of hydrological or mining development by significantly decreasing transportation and construction costs.

Potential Risk: Mining

Mining activities often produce long-lasting effects on the environment and the health of local Indigenous communities. In the northern regions of Canada, the adverse effects of mining activities undertaken without Indigenous knowledge and participation have been documented in the past, such as uranium mining around Wollaston Lake, Saskatchewan, and the negative and long-lasting impacts on the Lac La Hache First Nation. Uranium mining produces a variety of contaminants, such as radionuclides, heavy metals, and chemical compounds. Many spills have been documented, including a major spill in 1989 at the Rabbit Lake Mine when around

2 million litres of fluids containing high concentrations of arsenic and radium-226 burst into Collins creek, which flows into Wollaston Lake (Green & Bonacci, 2016). Releases of high concentrations of contaminants into air and water from uranium mine tailings at various times of the mine's operation had a direct negative effect on the aquatic environment, abundance of fish and wildlife, country food consumption, and Indigenous people's health (Elias et al., 1997). In the absence of mining, the Seal River Watershed does not contribute human-created contaminants, such as methylmercury, beyond background levels and thus does not put the health of local communities and animals at risk.

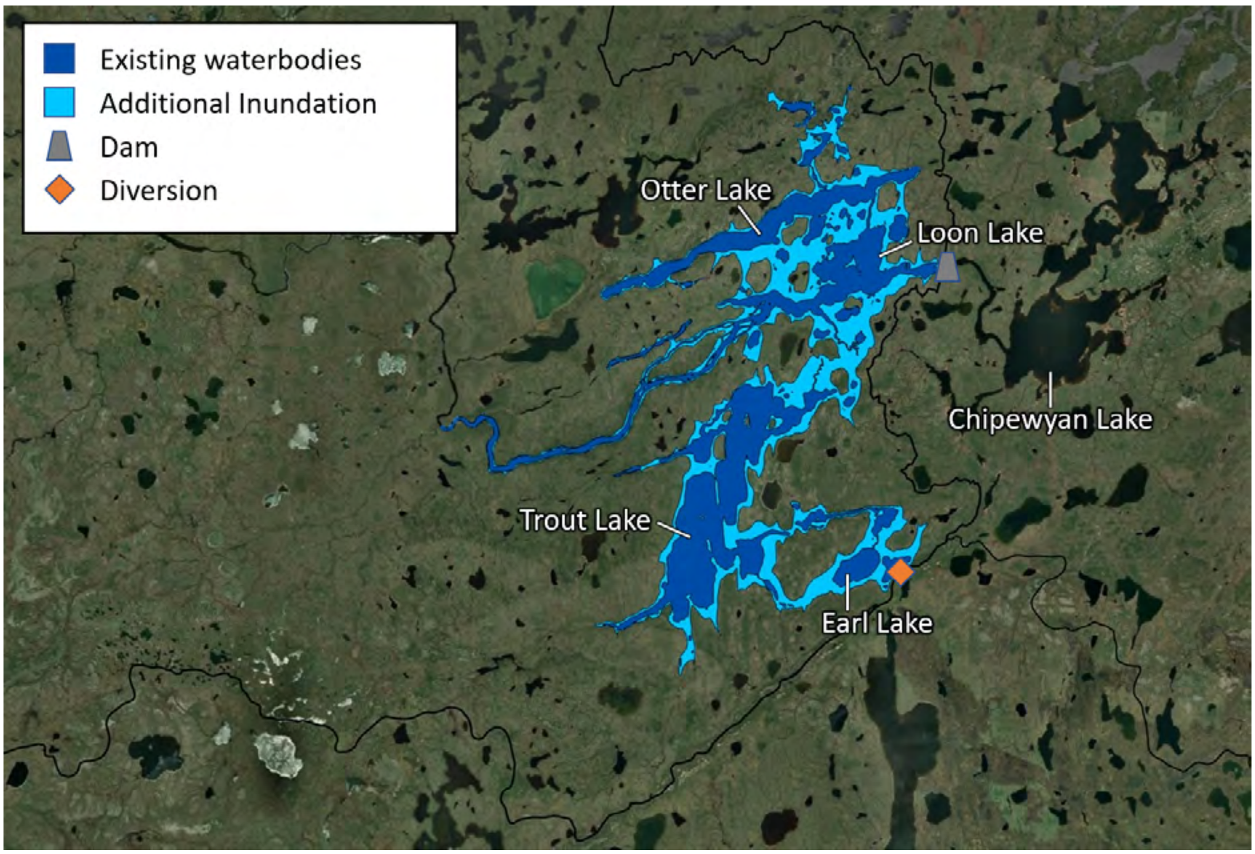
Potential Risk: Water diversion

Hydroelectric development is another risk to the EGS of the watershed. There have been hydroelectric projects built in the surrounding watersheds in the past few decades that had devastating consequences for the local Indigenous communities like South Indian Lake/O-Pipon-Na-Piwin Cree Nation (a partner in the Seal River Watershed Alliance.) In the 1970s, Manitoba Hydro diverted the Churchill River into the Nelson River to increase its rate of flow using South Indian Lake as a water reservoir (Wa Ni Ska Tan, n.d.; Know History Inc., 2015). This project was meant to increase the power supply for the rest of the province. However, raising the levels of South Indian Lake also meant the Indigenous community of South Indian Lake had to relocate because of flooding, and the surrounding land was permanently altered (Know History Inc., 2015). The community was forced to relocate to the other side of the lake, and the project ultimately had many negative impacts on wildlife and the health of the community. Some of impacts were fluctuating water levels that made travel unsafe, destabilized shorelines, caused erosion, disrupted the fish cycle, and had adverse effects on whitefish fishery and trapping (Wa Ni Ska Tan, n.d.; Dysart, 2013). A community that had previously been self-sufficient lost a vital source of sustenance and a sense of identity (Wa Ni Ska Tan, n.d.; Dysart, 2013). The community was provided with poor housing and infrastructure and started to be reliant on government services (Dysart, 2013). The effects of such modifications to the land are long lasting for wildlife and people, and the disturbed balance is extremely difficult to restore.

While Manitoba Hydro publicly stated in 2014 that there are no development plans for the Seal River (Province of Manitoba, 2014), that could change should capacity at major generating stations fail to meet demand. However, a more likely scenario is that Manitoba Hydro would first begin development at one of many from a long list of preferred locations of undeveloped hydroelectric potential locations such as the Conawapa generating station or pursue alternative energy sources such as solar or wind (Manitoba Hydro, 2013).

We developed a hypothetical scenario to understand changes to the EGS as the result of water diversion to generate electricity. A theoretical flow regulation between the Loon and Chipewyan Lake in the southwest part of the basin could divert runoff from up to 11,088 km^2 or 22% of contributing area from the Seal River toward Little Sand Lake and the Churchill Diversion. An additional area of up to 39 km^2 could be flooded as a result, mostly replacing forest (other land cover types in the flood area amount to less the 0.2% of the total). Much of the stored carbon lost would be in the form of methane, a gas that is 44 times more damaging to the climate than carbon dioxide. Estimates assuming a level water surface profile show evidence that Otter, Loon, Trout, and Earl lakes would act as a single reservoir under this operating scenario, potentially disrupting natural ecosystems and the services they provide. EGS could be used to assess the damages and costs of this scenario to communities in monetary terms.

Figure 8. Inundated area resulting from a theoretical flow diversion between Loon and Chipewyan Lakes



Source: Author diagram.

6.0 Conclusion

Photo: Josh Pearlman

This study was a first step to understand, in monetary terms, the value of EGS in the Seal River Watershed. Situated within the Hudson Bay complex, this watershed is one of the few remaining undammed watersheds in the polar region. As one of the last truly wild places remaining in Canada, the Seal River Watershed is an important ecosystem to conserve due to its unique biodiversity and significant contributions to human prosperity on both local and global scales.

There are limitations to capturing interactions that people have with the watershed and the values they place on the natural systems in monetary terms, mostly due to the lack of local data on goods and services and people's preferences. Monetary values should also not be the only drivers for decision making. At the same time, such estimations allow us to better capture previously overlooked values of pristine areas and understand how humans depend on them using common units and economic approaches. In the past, the value proposition for nature was limited to extracting resources like minerals and lumber or as a transportation route to global markets.[14] We must start to recognize other values of these landscapes. By using Western economic and scientific approaches to take stock of nature's assets and evaluate EGS, we can better understand how a community interacts with and depends on a landscape and track changes over time, which will ultimately improve conservation outcomes and watershed stewardship.

We have estimated that the Seal River Watershed provides **CAD 214 million worth of EGS annually** consisting of values of caribou harvest, ecotourism, health benefits from travelling to natural areas, and willingness to pay for conservation of beluga whales, barren-ground caribou, and northern pintails. Most of the annual value exists outside the market—94% of this value is associated with the non-use aspect of biodiversity or willingness to pay for species conservation by distant households. **The stock value of CO_2 contained in the Seal River Watershed is worth at least CAD 314.5 billion**, which is more than four times the GDP of Manitoba.

It is important to note that this estimate is just a portion of the total economic value of this remote and intact ecosystem. Due to methodological limitations and a lack of locally relevant values, we have only placed a dollar value on a handful of the hundreds of benefits the watershed provides. For instance, we have not estimated the value of carbon sequestration or of dozens of species that rely on the watershed's pristine habitat. It is also important to remember that spiritual connection with nature, Indigenous culture, community bonding, education, and many other significant benefits could not be translated into economic terms. The identified gaps, however, offer opportunities for measurement through surveys/interviews to account for people's values, community-based monitoring, improved satellite/remote sensing products such as improved estimates of biomass, topography, and rare plant surveys and strengthening local data collection under the framework of community data ownership, control, access, and possession (OCAP®). Indigenous Guardians programs can play a role by providing opportunities for capacity building, including in education and monitoring.[15]

[14] Whether from the time of the 17th century fur trade to 20th century development of the Port of Churchill.

[15] For the examples of the types of monitoring, see Chapter 10 in Indigenous Guardians Toolkit (n.d.).

Road construction and associated developments could compromise the continuous flow of EGS for present and future generations in the Seal River environment and lead to a reduction in important values, including the values of stored carbon, fish for food and recreation, ecotourism, clean water, and regulation of larger systems.

The demand for the EGS of the Seal River Watershed and their importance will likely increase as we are faced with a global decline of intact forests ecosystems and a global decline in biodiversity. A fully functioning, ecologically intact watershed that is sustainably managed and monitored by Indigenous stewards will help contribute to our action on climate mitigation, resiliency, and biodiversity conservation in the face of these climate and development threats.

Conserving this area and protecting it from future development under Indigenous stewardship means that these vital benefits will be preserved for future generations of people and wildlife. The EGS approach can further be improved with better monitoring and local data to understand the range of EGS in monetary terms and compare the outcomes of management decisions. By attempting to value the priceless, we can better communicate and track important changes in this unique landscape.

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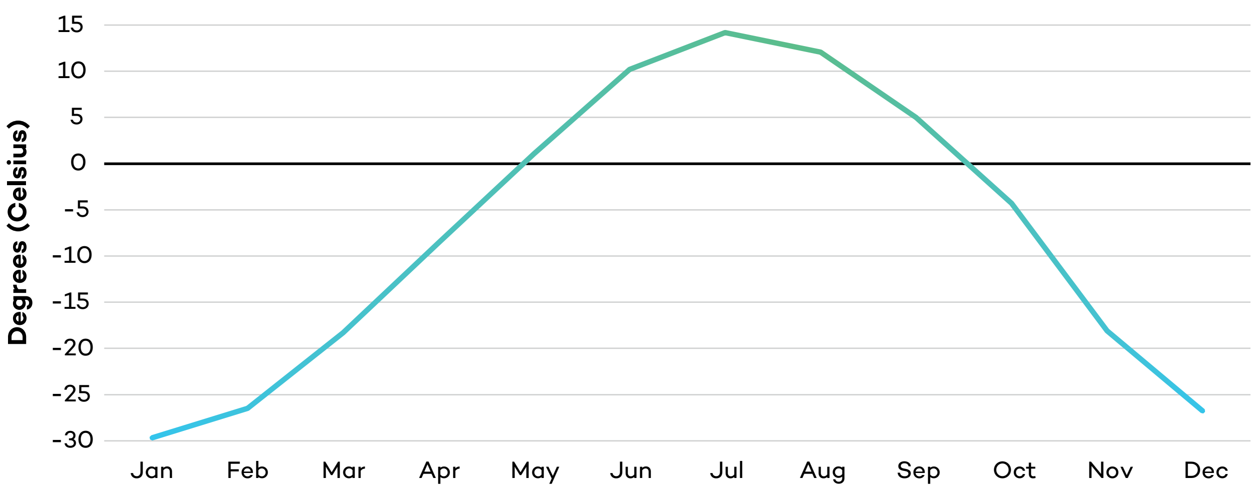
Appendix A. The Physical and Biological Characteristics of the Seal River Ecosystem

In preparation for evaluating the EGS generated in the Seal River Watershed, we created an inventory for some of its key physical and biological characteristics. Although not all of the data presented has been used for the provided estimates of ecological goods and services, the collection of this data within a single document is expected to be useful for future assessments and to help better understand gaps within the available monitoring records and other existing data sets. This inventory includes climate data, such as air temperature and precipitation, discharge, and hydrologic statistics, as well as the surface and sub-surface characteristics of the watershed.

Air Temperature

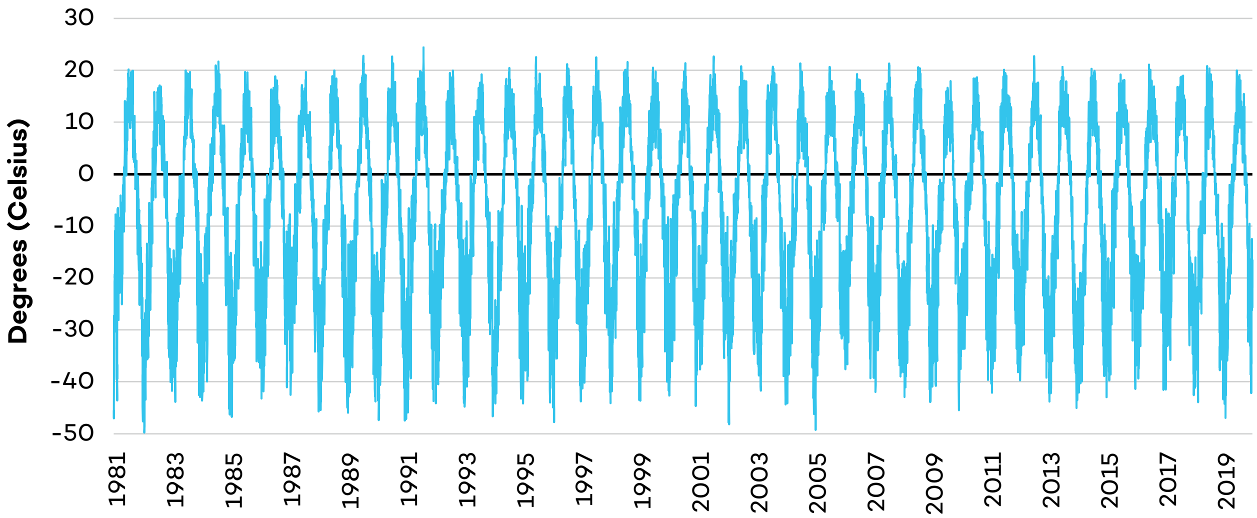
As a result of the Seal River Basin's northern geography, air temperatures at Tadoule Lake are generally low, with the lowest and highest average monthly air temperatures in January being -29.7°C and 14.2°C in July. Over the longer term, air temperatures appear to be increasing by approximately 0.23°C per decade.

Figure A1. Monthly average air temperature at Tadoule Lake



Source: Authors' diagram based on data from NASA, 2020.

Figure A2. Daily average air temperature at Tadoule Lake

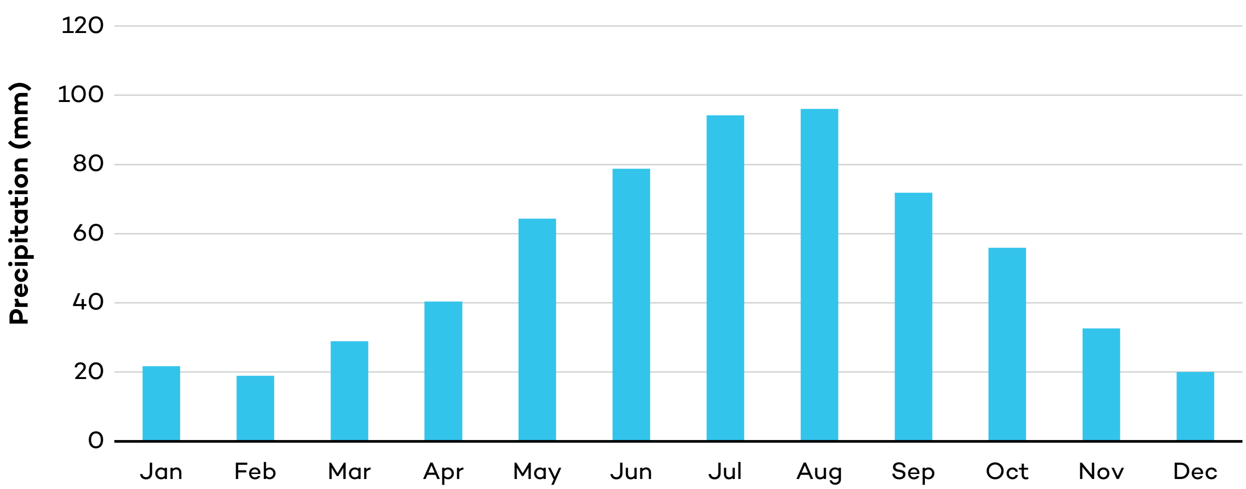


Source: Authors' diagram based on data from NASA, 2020.

Precipitation

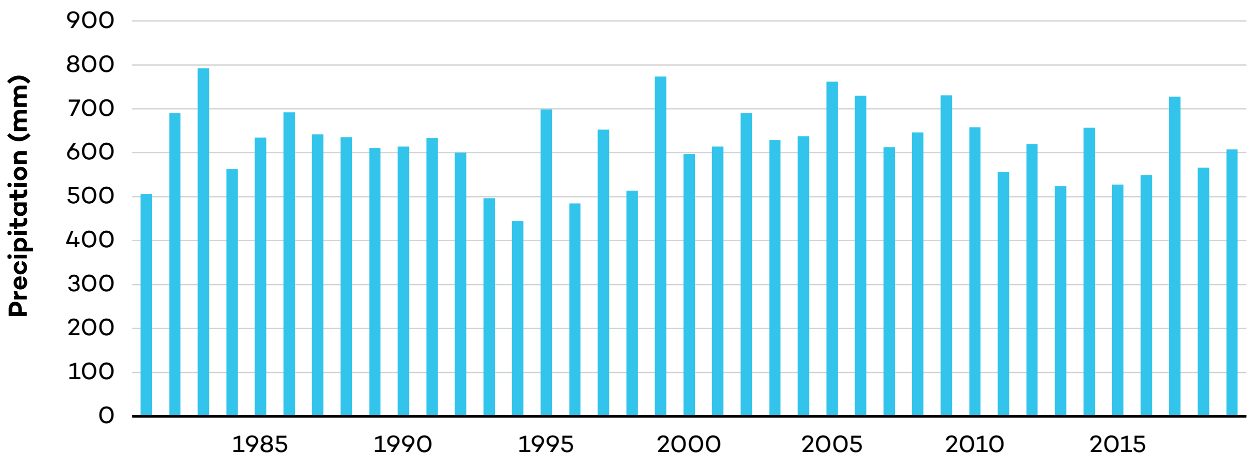
The lowest and highest monthly average cumulative precipitation occurs in February with 19 mm (snow water equivalent) and August, with 96 mm, which is similar in timing with the lowest and highest average monthly temperatures. Average yearly total precipitation for the watershed is estimated to be approximately 624 mm based on historical data.

Figure A3. Monthly average precipitation at Tadoule Lake



Source: Authors' diagram based on data from NASA, 2020.

Figure A4. Yearly precipitation at Tadoule Lake

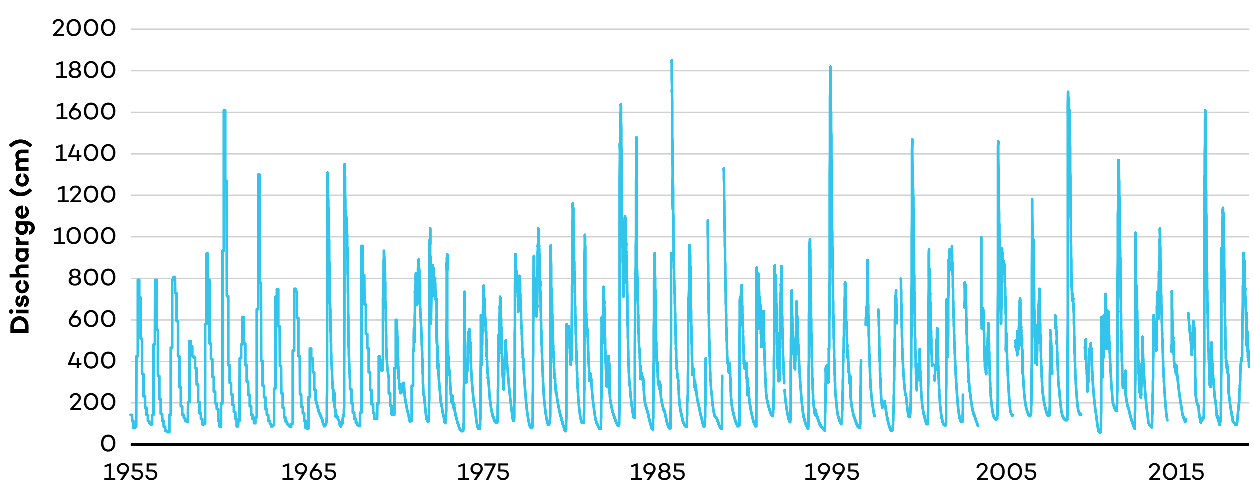


Source: Authors' diagram based on data from NASA, 2020.

Discharge

Based on flow records obtained from the Water Survey of Canada (2020) that date back to 1955, the lowest and highest measured flows on record for the Seal River are 58 and 1,850 cm, respectively. The average annual peak flow of the Seal River is 982 cm, with annual peak flows of 1,400 and 1,641 cm having 10-year and 25-year return periods.

Figure A5. Sequential flow hydrograph at Seal River below Great Island (06GD001)



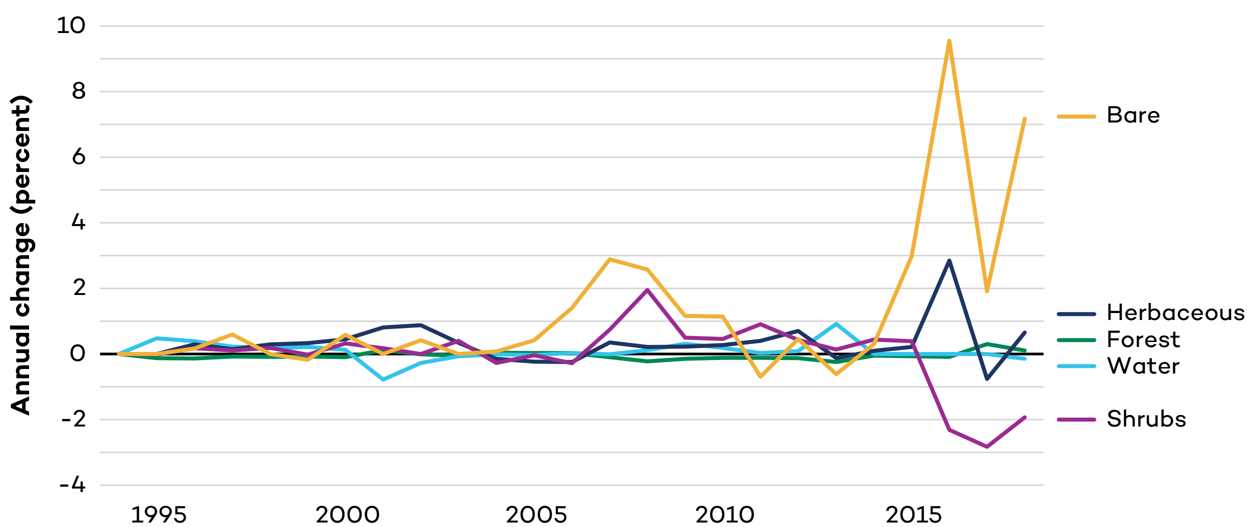
Source: Authors' diagram based on data from Water Survey of Canada, 2020.

Land Cover Change

An analysis of land cover from the ESA CCI (2019) demonstrates that a ~22 km^2 linear decrease in forested area per year has occurred since 1994. Conversely, a ~9 km^2 linear increase in herbaceous area per year has also been observed for the same period. Although no recognizable trend in shrub or surface water areas can be determined, an accelerating rate of bare land has been evident since 1994, peaking at a rate of ~6.5 km^2 per year from 2014 to the present. These changes are evident in Figure 15, where any data above 0% represents an annual percent increase of that land cover and below, a decrease. Figure 16 illustrates the absolute measured areas in km^2 from the same dataset, where the multiplicative factors in the legend provide normalization to the data for use in a single plot (i.e., the data for bare land cover with a y-axis value of 1.4 km^2 should be multiplied by [1E2 = 100] and results in a value of 140 km^2).

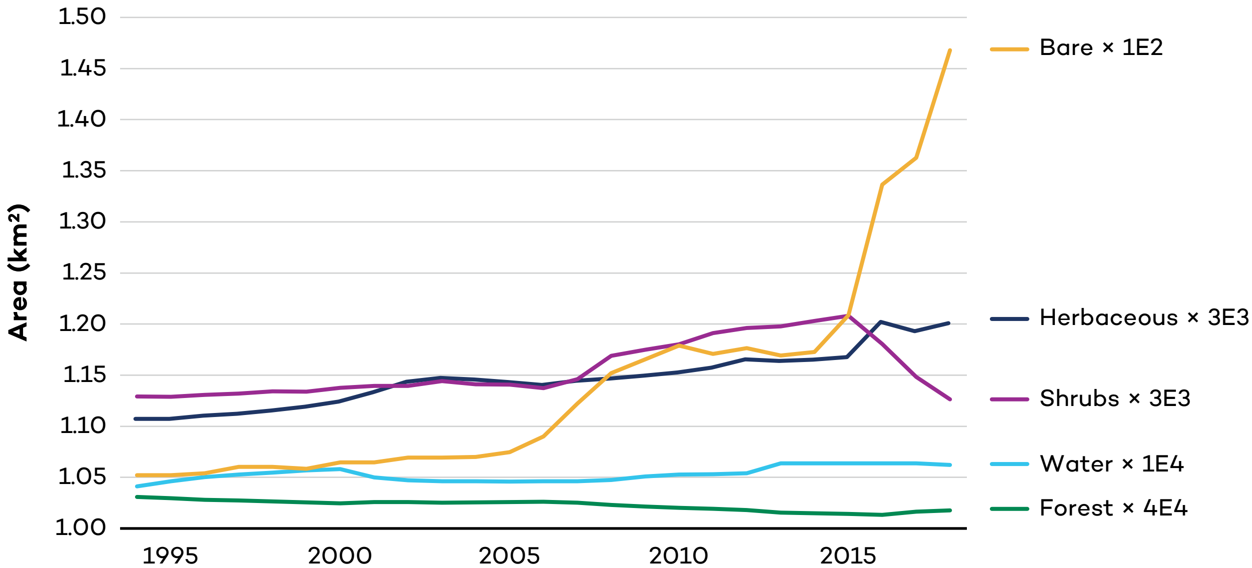
Some of this loss of forested area may be attributed to naturally occurring forest fires that occurred in the years of 2007 and 2013 (Manitoba Conservation and Water Stewardship, Parks and Protected Spaces Branch, 2014); thus, it is possible that forested area may be in the midst of a rebound.

Figure A6. Annual percent landcover change from 1994–2018



Source: Authors' figure based on data from ESA CCI, 2019.

Figure A7. Annual land cover area change from 1994—2018 (ESA CCI., 2019)

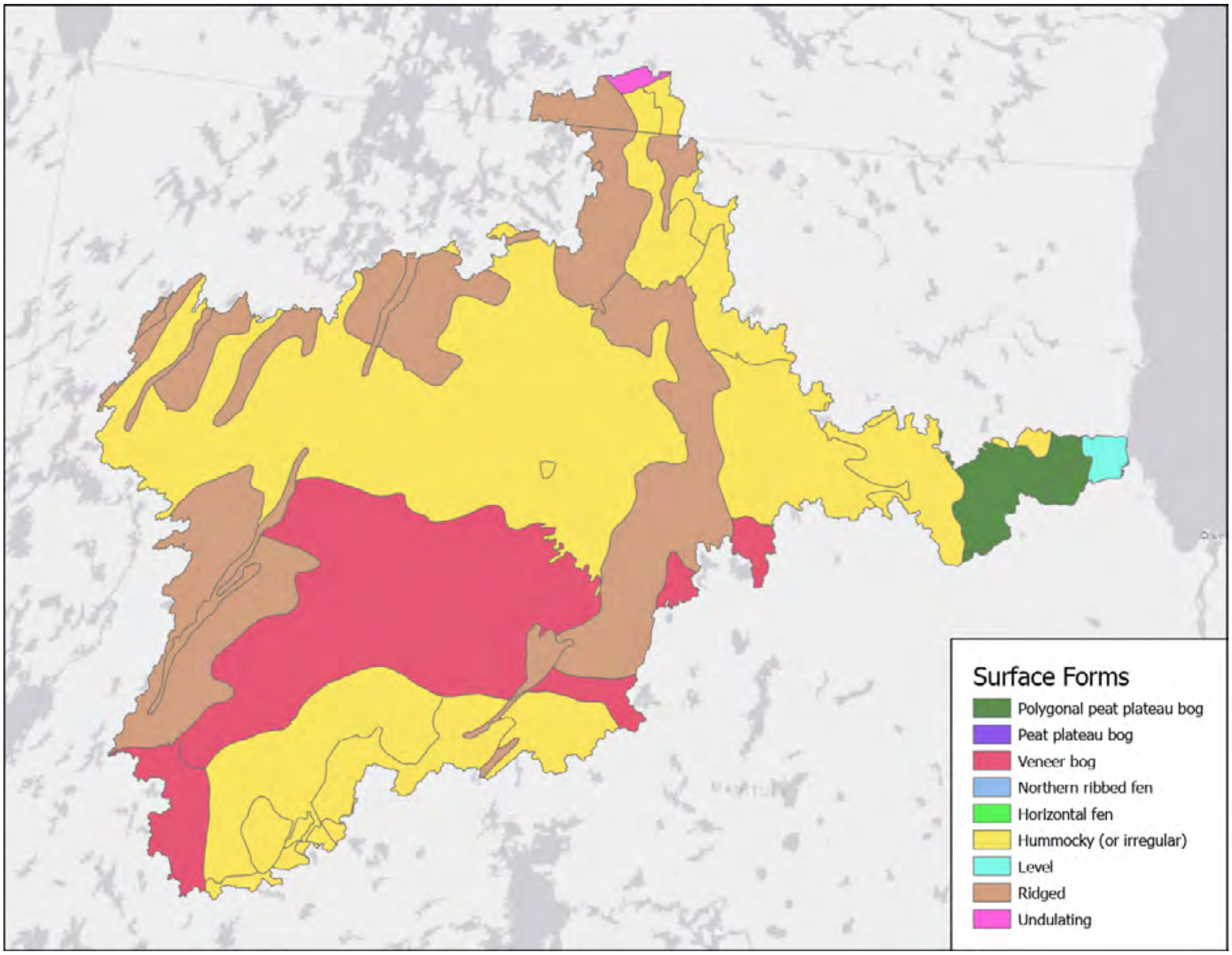


Source: Authors' figure based on data from ESA CCI, 2019.

Soil Landscapes

Surface forms throughout the region are primarily hummocky (51%) complemented by ridges (26%) and southern veneer bogs (20%) which transition to polygonal peat plateau bogs (2.5%) and level terrain (0.5%) between Great Island and Hudson Bay (Centre for Land and Biological Resources Research, 1996).

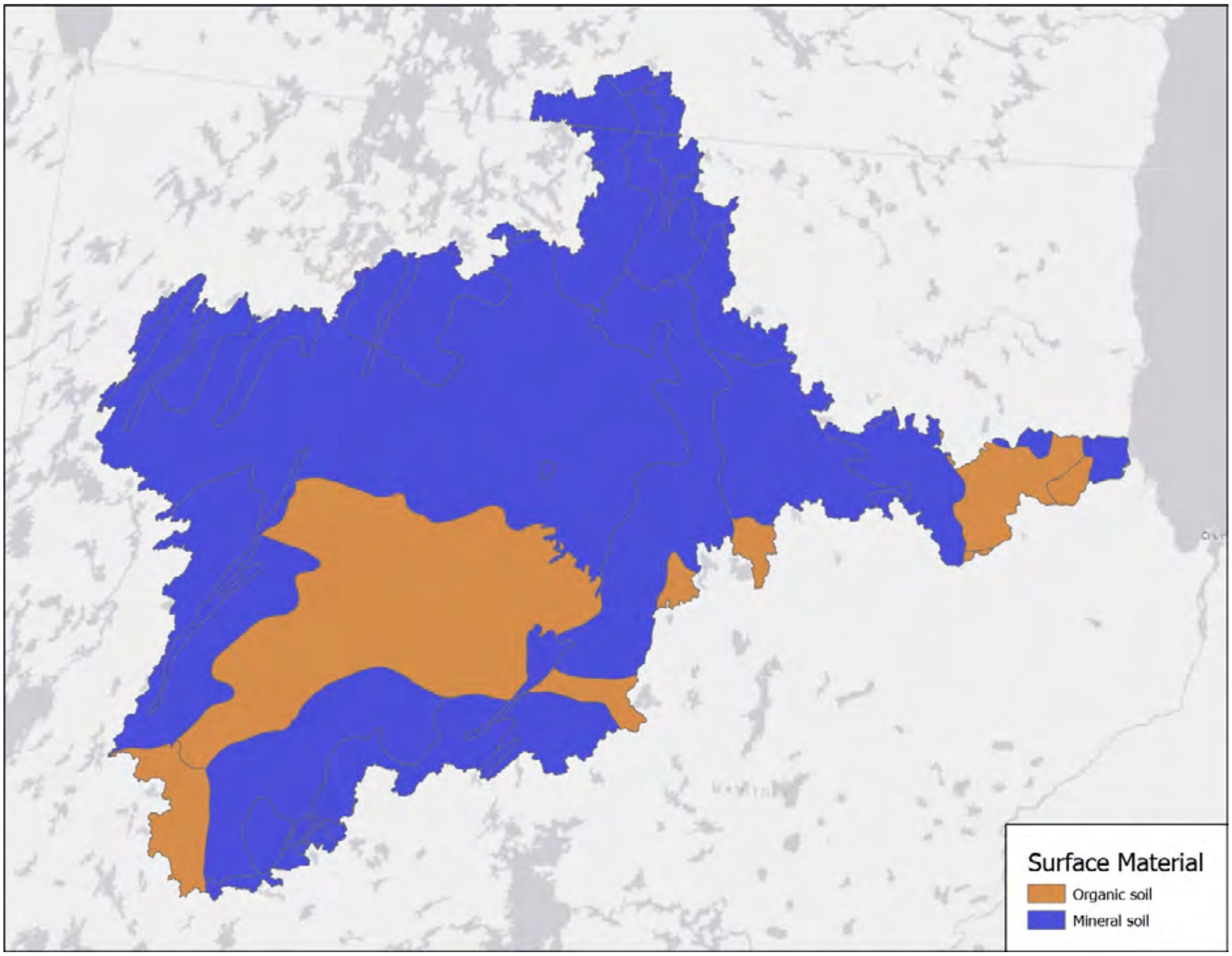
Figure A8. Seal River Watershed surface forms



Source: Authors' diagram, based on data from Centre for Land and Biological Resources Research, 1996.

The majority of soils are mineral (77%) and consist primarily of those from the dystric brunisolic (60%), tubic cryosolic (16%) and regolic (0.5%) soil development groups. The remaining soil is organic (23%) and is made up entirely of the organic cryosolic soil development group.

Figure A9. Seal River Watershed surface material

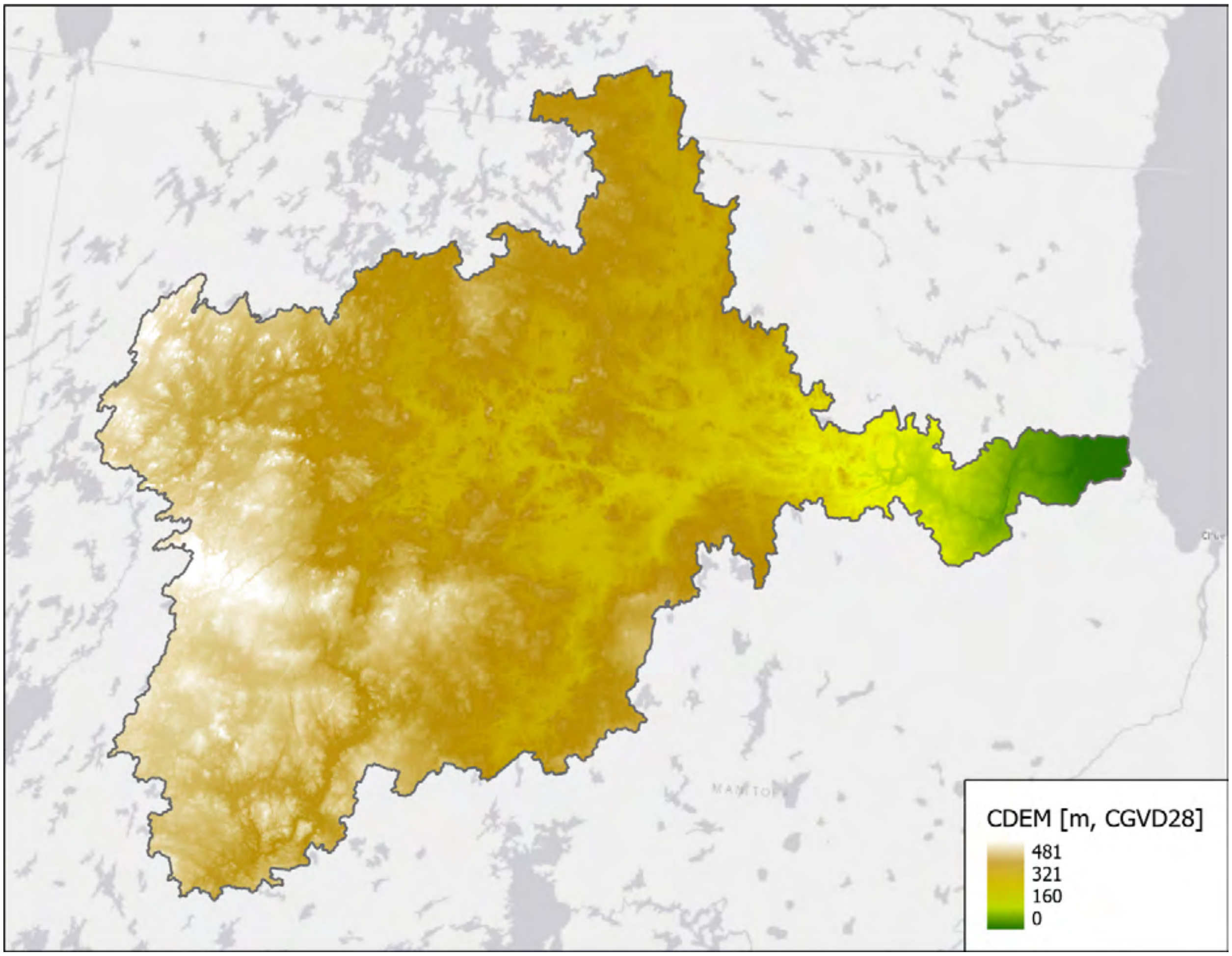


Source: Authors' diagram, based on data from Centre for Land and Biological Resources Research, 1996.

Elevation

The Seal River basin drops ~480 m from its highest elevation headwaters to Hudson Bay.

Figure A10. Seal River Watershed topography

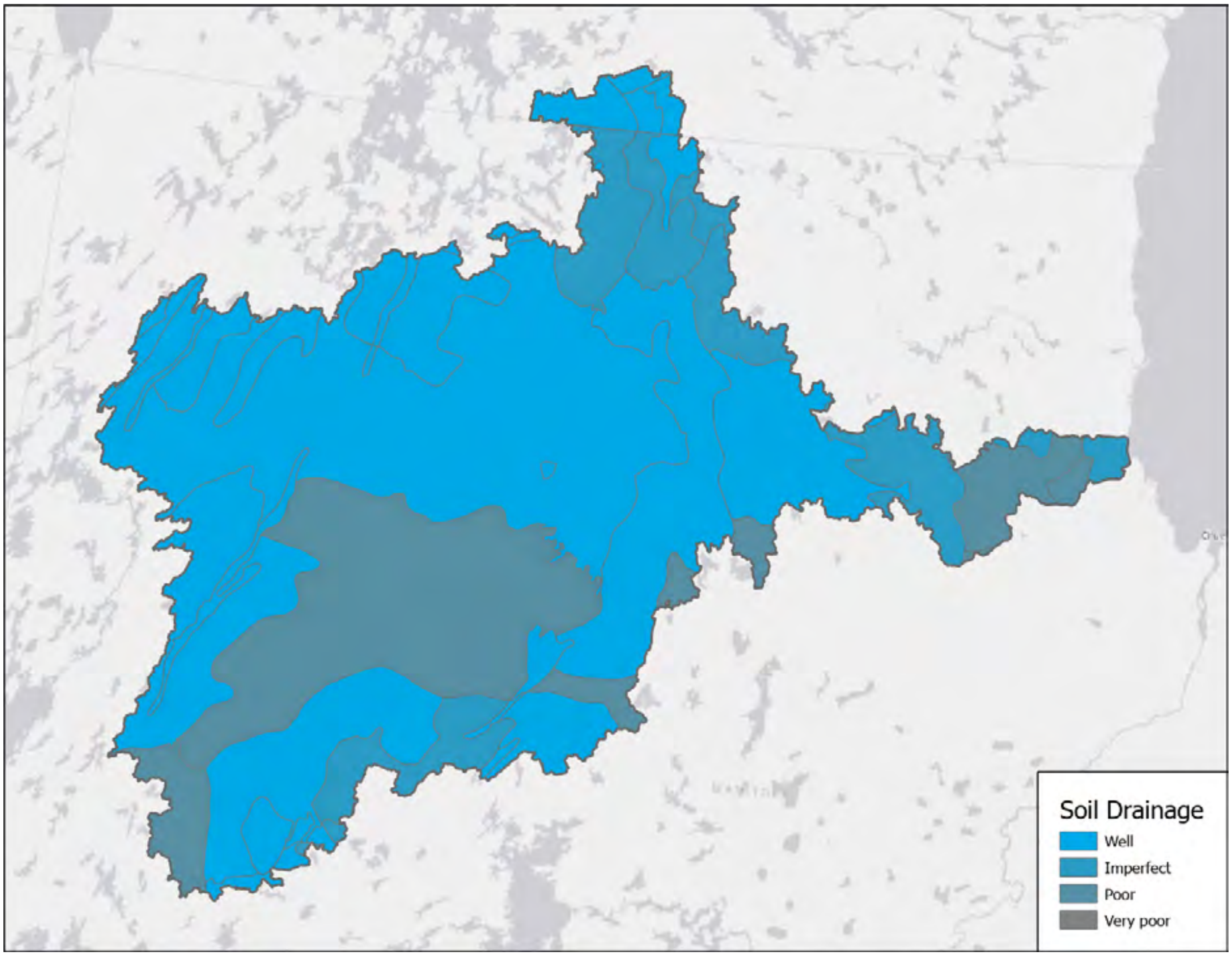


Source: Authors' diagram based on data from Natural Resources Canada, 2015.

Drainage

Drainage in the basin is considered good in most of the basin (64.8% well drained"), though also imperfect (12.6%), particularly in regions with turbic cryosolic soil development and is poor (22.6%) in the veneer bogs (Centre for Land and Biological Resources Research, 1996).

Figure A11. Seal River Watershed soil drainage



Source: Authors' diagram based on data from Centre for Land and Biological Resources Research, 1996.

Appendix B. Animal and Plant Species

Table A1. List of animal and plant species in the Seal River Watershed designated as "at risk" according to the Canada Species at Risk Act (SARA), Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Endangered Species and Ecosystems Act Manitoba (MB ESEA) and/ or the International Union for Conservation of Nature (ICUN).

Common Name	Scientific Name	Designation
Black Scoter	*Melanitta americana*	Near Threatened (IUCN)
Blackpoll Warbler	*Dendroica striata*	Near Threatened (IUCN)
Buff-breasted Sandpiper	*Calidris subruficollis*	Near Threatened (IUCN); Special Concern (SARA); Special Concern (COSEWIC)
Common Eider	*Somateria mollissima*	Near Threatened (IUCN)
Common Nighthawk	*Chordeiles minor*	Threatened (MB ESEA); Threatened (SARA); Threatened (COSEWIC);
Harris' Sparrow	*Zonotrichia querula*	Near Threatened (IUCN); Special Concern (COSEWIC)
Horned Grebe	*Podiceps auratus*	Vulnerable (IUCN); Special Concern (SARA); Special Concern (COSEWIC)
Long-Tailed Duck	*Clangula hyemalis*	Vulnerable (IUCN)
Olive-sided Flycatcher	*Contopus cooperi*	Near Threatened (IUCN); Threatened (MB ESEA); Threatened (SARA); Threatened (COSEWIC)
Peregrine Falcon	*Falco peregrinus*	Endangered (MB ESEA)
Rusty Blackbird	*Euphagus carolinus*	Vulnerable (IUCN); Special Concern (SARA); Concern (COSEWIC)
Semipalmated Sandpiper	*Calidris pusilla*	Near Threatened (IUCN)
Short-eared Owl	*Asio flammeus*	Special Concern (SARA); Special Concern (COSEWIC)
Lake Sturgeon	*Acipenser fulvescens*	Special Concern (COSEWIC)
Barren-Ground Caribou	*Rangifer tarandus*	Vulnerable (IUCN); Threatened (COSEWIC)
Barren-Ground Grizzly	*Ursus arctos*	Special Concern (SARA); Special Concern (COSEWIC)

Common Name	Scientific Name	Designation
Beluga Whale	*Delphinapterus leucas*	Special Concern (COSEWIC)
Bowhead Whale	*Balaena mysticetus*	Special Concern (SARA); Special Concern (COSEWIC)
Polar Bear	*Ursus maritimus*	Vulnerable (IUCN); Threatened (MB ESEA); Special Concern (SARA); Special Concern (COSEWIC)
Wolverine	*Gulo gulo*	Special Concern (SARA); Special Concern (COSEWIC)

Source: Swan (2022).

Table A2. List of 261 species documented to occur within the Seal River Watershed.

Species Type	Common Name	Scientific Name
Bird	Alder Flycatcher	*Empidonax alnorum*
Bird	American Black Duck	*Anas rubripes*
Bird	American Golden-Plover	*Pluvialis dominica*
Bird	American Herring Gull	*Larus argentatus smithsonianus*
Bird	American Pipit	*Anthus rubescens*
Bird	American Robin	*Turdus migratorius*
Bird	American Three-toed Woodpecker	*Picoides dorsalis*
Bird	American Three-toed Woodpecker	*Picoides tridactylus bacatus*
Bird	American Tree Sparrow	*Spizella arborea*
Bird	American Wigeon	*Anas americana*
Bird	Arctic Tern	*Sterna paradisaea*
Bird	Baird's Sandpiper	*Calidris bairdii*
Bird	Bald Eagle	*Haliaeetus leucocephalus*
Bird	Belted Kingfisher	*Megaceryle alcyon*
Bird	Black Guillemot	*Cepphus grylle*
Bird	Black Scoter	*Melanitta americana*

Species Type	Common Name	Scientific Name
Bird	Black-bellied Plover	*Pluvialis squatarola*
Bird	Black-legged Kittiwake	*Rissa tridactyla*
Bird	Blackpoll Warbler	*Dendroica (Setophaga) striata*
Bird	Bohemian Waxwing	*Bombycilla garrulus*
Bird	Bonaparte's Gull	*Chroicocephalus philadelphia*
Bird	Boreal Chickadee	*Poecile hudsonicus*
Bird	Brant	*Branta bernicla*
Bird	Buff-bellied Pipit	*Anthus spinoletta rubescens*
Bird	Buff-breasted Sandpiper	*Tryngites subruficollis*
Bird	Cackling Goose	*Branta hutchinsii*
Bird	Canada Goose	*Branta canadensis*
Bird	Cliff Swallow	*Petrochelidon pyrrhonota*
Bird	Common Eider	*Somateria mollissima*
Bird	Common Goldeneye	*Bucephala clangula*
Bird	Common Loon	*Gavia immer*
Bird	Common Merganser	*Mergus merganser*
Bird	Common Nighthawk	*Chordeiles minor*
Bird	Common Raven	*Corvus corax*
Bird	Common Redpoll	*Acanthis flammea*
Bird	Dark-eyed Junco	*Junco hyemalis hyemalis*
Bird	Dovekie	*Alle alle*
Bird	Dunlin	*Calidris alpina*
Bird	Fox Sparrow	*Passerella iliaca*
Bird	Glaucous Gull	*Larus hyperboreus*
Bird	Golden Eagle	*Aquila chrysaetos*
Bird	Gray Jay	*Perisoreus canadensis*
Bird	Gray-cheeked Thrush	*Catharus minimus*

Species Type	Common Name	Scientific Name
Bird	Greater Scaup	*Aythya marila*
Bird	Greater Yellowlegs	*Tringa melanoleuca*
Bird	Green-winged Teal	*Anas carolinensis*
Bird	Grey-cheeked Thrush	*Catharus minimus minimus*
Bird	Gyrfalcon	*Falco rusticolus*
Bird	Harris' Sparrow	*Zonotrichia querula*
Bird	Herring Gull	*Larus argentatus*
Bird	Hoary Redpoll	*Acanthis hornemanni*
Bird	Hooded Merganser	*Lophodytes cucullatus*
Bird	Horned Grebe	*Podiceps auritus*
Bird	Horned Lark	*Eremophila alpestris*
Bird	Hudsonian Godwit	*Limosa haemastica*
Bird	Iceland Gull	*Larus glaucoides*
Bird	Killdeer	*Charadrius vociferus*
Bird	Lapland Longspur	*Calcarius lapponicus*
Bird	Least Sandpiper	*Calidris minutilla*
Bird	Lesser Yellowlegs	*Tringa flavipes*
Bird	Lincoln's Sparrow	*Melospiza lincolnii*
Bird	Little Gull	*Hydrocoloeus minutus*
Bird	Long-tailed Duck	*Clangula hyemalis*
Bird	Long-tailed Jaeger	*Stercorarius longicaudus*
Bird	Mallard	*Anas platyrhynchos*
Bird	Merlin	*Falco columbarius*
Bird	Nelson's Sparrow	*Ammodramus nelsoni*
Bird	Northern Flicker	*Colaptes auratus*
Bird	Northern Harrier	*Circus cyaneus*
Bird	Northern Pintail	*Anas acuta*

Species Type	Common Name	Scientific Name
Bird	Northern Shoveler	*Anas clypeata*
Bird	Northern Shrike	*Lanius excubitor*
Bird	Northern Waterthrush	*Parkesia noveboracensis*
Bird	Olive-sided Flycatcher	*Contopus cooperi*
Bird	Orange-crowned Warbler	*Vermivora celata*
Bird	Osprey	*Pandion haliaetus*
Bird	Pacific Loon	*Gavia pacifica*
Bird	Parasitic Jaeger	*Stercorarius parasiticus*
Bird	Pectoral Sandpiper	*Calidris melanotos*
Bird	Peregrine Falcon	*Falco peregrinus*
Bird	Pine Grosbeak	*Pinicola enucleator*
Bird	Pomarine Jaeger	*Stercorarius pomarinus*
Bird	Purple Finch	*Haemorhous purpureus*
Bird	Red-breasted Merganser	*Mergus serrator*
Bird	Red-necked Phalarope	*Phalaropus lobatus*
Bird	Red-throated Loon	*Gavia stellata*
Bird	Ring-billed Gull	*Larus delawarensis*
Bird	Ross's Goose	*Chen rossii*
Bird	Ruddy Turnstone	*Arenaria interpres*
Bird	Rusty Blackbird	*Euphagus carolinus*
Bird	Sanderling	*Calidris alba*
Bird	Sandhill Crane	*Grus canadensis*
Bird	Savannah Sparrow	*Passerculus sandwichensis*
Bird	Semipalmated Plover	*Charadrius semipalmatus*
Bird	Semipalmated Sandpiper	*Calidris pusilla*
Bird	Short-billed Dowitcher	*Limnodromus griseus*
Bird	Short-eared Owl	*Asio flammeus*

Species Type	Common Name	Scientific Name
Bird	Smith's Longspur	*Calcarius pictus*
Bird	Snow Goose	*Chen caerulescens*
Bird	Spotted Sandpiper	*Actitis macularia*
Bird	Spruce Grouse	*Dendragapus canadensis canadensis*
Bird	Stilt Sandpiper	*Calidris himantopus*
Bird	Surf Scoter	*Melanitta perspicillata*
Bird	Swainson's Thrush	*Catharus ustulatus*
Bird	Swamp Sparrow	*Melospiza georgiana*
Bird	Tennessee Warbler	*Leiothlypis peregrina*
Bird	Tree Swallow	*Tachycineta bicolor*
Bird	Tundra Swan	*Cygnus columbianus*
Bird	Whimbrel	*Numenius phaeopus*
Bird	White-crowned Sparrow	*Zonotrichia leucophrys*
Bird	White-rumped Sandpiper	*Calidris fuscicollis*
Bird	White-winged Crossbill	*Loxia leucoptera*
Bird	White-winged Scoter	*Melanitta deglandi*
Bird	Willow Ptarmigan	*Lagopus lagopus*
Bird	Wilson's Snipe	*Gallinago delicata*
Bird	Yellow Warbler	*Dendroica petechia amnicola*
Bird	Yellow-rumped Warbler	*Setophaga coronata*
Fish	Arctic Char	*Salvelinus alpinus*
Fish	Arctic Grayling	*Thymallus arcticus*
Fish	Arctic Sculpin	*Myoxocephalus scorpoides*
Fish	Brook Trout	*Salvelinus fontinalis*
Fish	Burbot	*Lota lota*
Fish	Capelin	*Mallotus villosus*

Species Type	Common Name	Scientific Name
Fish	Cisco	*Coregonus artedi*
Fish	Fourhorn Sculpin	*Myoxocephalus quadricornis*
Fish	Lake Chub	*Couesius plumbeus*
Fish	Lake Sturgeon	*Acipenser fulvescens*
Fish	Lake Trout	*Salvelinus namaycush*
Fish	Lake Whitefish	*Coregonus clupeaformis*
Fish	Longnose Sucker	*Catostomus catostomus*
Fish	Ninespine Stickleback	*Pungitius pungitius*
Fish	Northern Pike	*Esox lucius*
Fish	Shorthorn Sculpin	*Myoxocephalus scorpius*
Fish	Troutperch	*Percopsis omiscomaycus*
Frog	Boreal Chorus Frog	*Pseudacris maculata*
Frog	Wood Frog	*Lithobates sylvaticus*
Insect	A Ground Beetle	*Bembidion compressum*
Insect	A Ground Beetle	*Bembidion hyperboraeorum*
Insect	A Ground Beetle	*Dicheirotrichus mannerheimii*
Insect	A Ground Beetle	*Dyschirius hiemalis*
Insect	A Ground Beetle	*Pterostichus brevicornis*
Mammal	Arctic Ground Squirrel	*Spermophilus parryii*
Mammal	Barren-Ground Caribou	*Rangifer tarandus*
Mammal	Barren-Ground Grizzly	*Ursus arctos*
Mammal	Beaver	*Castor canadensis*
Mammal	Beluga Whale	*Delphinapterus leucas*
Mammal	Black Bear	*Ursus americanus*
Mammal	Bowhead Whales	*Balaena mysticetus*
Mammal	Cinereous shrew	*Sorex cinereus cinereus*
Mammal	Fox	

Species Type	Common Name	Scientific Name
Mammal	Gray Wolf	*Canis lupus*
Mammal	Harbour Seal	*Phoca vitulina*
Mammal	Moose	*Alces alces*
Mammal	Northern Short-tailed Shrew	*Blarina brevicauda*
Mammal	Otter	*Lontra canadensis*
Mammal	Polar Bear	*Ursus maritimus*
Mammal	Snowshoe Hare	*Lepus americanus*
Mammal	Southern red-backed Vole	*Myodes gapperi*
Mammal	Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*
Mammal	Wolverine	*Gulo gulo*
Plant	Alaska Bog Willow	*Salix fuscescens*
Plant	Alpine Azalea	*Loiseleuria procumbens*
Plant	Alpine Bearberry	*Arctostaphylos alpina*
Plant	Alpine Sweet Grass	*Anthoxanthum monticola*
Plant	Arctic Bellflower	*Campanula uniflora Linnaeus*
Plant	Arctic Bellflower	*Campanula uniflora Vill.*
Plant	Arctic Rush	*Juncus arcticus Willdenow*
Plant	Assiniboia Sedge	*Carex assiniboinensis*
Plant	Beautiful Cottongrass	*Eriophorum callitrix*
Plant	Bent Northern Sedge	*Carex deflexa*
Plant	Big-spore Quillwort	*Isoetes macrospora Durieu*
Plant	Bigelow's Sedge	*Carex bigelowii*
Plant	Bigelow's Sedge	*Carex bigelowii*
Plant	Black Spruce	*Picea mariana*
Plant	Bluejoint	*Calamagrostis canadensis*
Plant	Boreal Bog Sedge	*Carex magellanica*
Plant	Boreal Starwort	*Stellaria borealis*

Species Type	Common Name	Scientific Name
Plant	Brownish Sedge	*Carex brunnescens*
Plant	Capitate Sedge	*Carex arctogena*
Plant	Chamisso's Cottongrass	*Eriophorum chamissonis*
Plant	Common Cottongrass	*Eriophorum angustifolium*
Plant	Common False Asphodel	*Tofieldia pusilla*
Plant	Common Juniper	*Juniperus communis*
Plant	Common Moonwort	*Botrychium lunaria*
Plant	Common Woodrush	*Luzula multiflora*
Plant	Creeping Sedge	*Carex chordorrhiza*
Plant	Creeping Thistle	*Cirsium arvense*
Plant	Crowberry	*Empetrum nigrum*
Plant	Deergrass	*Trichophorum cespitosum*
Plant	Dwarf Birch	*Betula glandulosa*
Plant	Dwarf Scouring Rush	*Equisetum scirpoides Michaux*
Plant	Fasle Toadflax	*Geocaulon lividum*
Plant	Fir Clubmoss	*Lycopodium selago Linnaeus*
Plant	Fireweed	*Chamaenerion angustifolium*
Plant	Flixweed	*Descurainia sophioides*
Plant	Fox-tail Sedge	*Carex alopecoidea*
Plant	Foxtail Barley	*Hordeum jubatum*
Plant	Fragrant Woodfern	*Dryopteris fragrans*
Plant	Glacier Sedge	*Carex glacialis*
Plant	Glaucous Bluegrass	*Poa glauca*
Plant	Green Alder	*Alnus viridis*
Plant	Hair-like Sedge	*Carex capillaris*
Plant	Hairy Butterwort	*Pinguicula villosa Linnaeus*
Plant	Intermediate Sedge	*Carex media*

Species Type	Common Name	Scientific Name
Plant	Jack Pine	*Pinus banksiana*
Plant	Lake Quillwort	*Isoetes lacustris*
Plant	Lapland Sedge	*Carex lapponica*
Plant	Lesser Saltmarsh Sedge	*Carex glareosa*
Plant	Long-beaked Willow	*Salix bebbiana*
Plant	Long-stalked Starwort	*Stellaria longipes*
Plant	Meadow Sedge	*Carex praticola Rydberg*
Plant	Mountain Firmoss	*Huperzia appressa*
Plant	Northern Cluster Sedge	*Carex arcta Boott*
Plant	Northern Firmoss	*Huperzia selago*
Plant	Northern Ground-cedar	*Diphasiastrum complanatum*
Plant	Northern interrupted-clubmoss	*Spinulum canadense*
Plant	Northern Seabeach Sandwort	*Honckenya peploides*
Plant	Northern White Rush	*Juncus albescens*
Plant	Northern Willow	*Salix arctophila*
Plant	Northern Woodrush	*Luzula confusa*
Plant	Nuttall's alkaligrass	*Puccinellia nuttalliana*
Plant	One-cone Clubmoss	*Lycopodium lagopus*
Plant	Ostrich Fern	*Matteuccia struthiopteris*
Plant	Peck's Sedge	*Carex peckii Howe*
Plant	Pendant Grass	*Arctophila fulva*
Plant	Pincushion Plant	*Diapensia lapponica L.*
Plant	Polar Daisy	*Arctanthemum*
Plant	Purple Reed Grass	*Calamagrostis purpurascens*
Plant	Red Elderberry	*Sambucus racemosa*
Plant	Richardson's Willow	*Salix richardsonii*
Plant	Rock Sedge	*Carex saxatilis*

Species Type	Common Name	Scientific Name
Plant	Rough Bentgrass	*Agrostis scabra*
Plant	Round-branch Ground-Pine	*Lycopodium dendroideum*
Plant	Round-fruited Sedge	*Carex rotundata Wahlenberg*
Plant	Savin-leaved Clubmoss	*Diphasiastrum sabinifolium*
Plant	Scant Sedge	*Carex rariflora*
Plant	Scant Sedge	*Carex rariflora*
Plant	Seabeach Sandwort	*Honckenya peploides*
Plant	Seaside Arrowgrass	*Triglochin maritima*
Plant	Silvery Sedge	*Carex canescens*
Plant	Sitka Clubmoss	*Diphasiastrum sitchense*
Plant	Small-flowered Woodrush	*Luzula parviflora*
Plant	Softleaf Sedge	*Carex disperma Dewey*
Plant	Sparse-flowered Sedge	*Carex tenuiflora*
Plant	Spiny-spore Quillwort	*Isoetes muricata*
Plant	Stiff Clubmoss	*Lycopodium annotinum*
Plant	Tamarack	*Larix laricina*
Plant	Thread rush	*Juncus filiformis*
Plant	Three-hulled Rush	*Juncus triglumis*
Plant	Three-leaved False Solomon's Seal	*Smilacina trifolia*
Plant	Three-toothed Saxifrage	*Saxifraga tricuspidata*
Plant	Tufted Pearlwort	*Sagina caespitosa*
Plant	Tussock Cottongrass	*Eriophorum spissum.*
Plant	Twinflower	*Linnaea borealis subsp. longiflora*
Plant	Wahlenberg's Woodrush	*Luzula wahlenbergii*
Plant	Water Sedge	*Carex aquatilis*
Plant	Weak Sedge	*Carex supina ssp. spaniocarpa*
Plant	White Cottongrass	*Eriophorum scheuchzeri*

Species Type	Common Name	Scientific Name
Plant	White Spruce	*Picea glauca*
Plant	Williams' Sedge	*Carex williamsii*
Plant	Wood Horsetail	*Equisetum sylvaticum*

Source: Swan (2022)

Appendix C. Economic Valuation of the EGS in the Seal River Watershed

Stocks

Measuring the stocks of natural capital helps us understand the ecosystem extent and condition at a given point in time. Stocks also enable the provision of ecosystem services, which is why it is important to measure the stocks and track changes over time. For example, carbon stored in the Seal River Watershed contributes to the service of climate regulation. The stock of carbon can be reassessed in the future to determine the change in the state of an ecosystem. This could be complemented by the analysis of environmental and social pressures that have affected the ecosystem condition. The stocks can also be assigned a monetary value.

Carbon Storage

Carbon storage refers to the total amount of carbon contained in an ecosystem at a given time. Ducks Unlimited Canada estimated that the Seal River Watershed contains approximately 1.7 billion tonnes of carbon or 6.2 billion tonnes CO_2 in its soil and sediment (Ducks Unlimited, 2021; Seal River Watershed Initiative, n.d.).

One way to estimate the value of CO_2 stored or sequestered is by applying the **social cost of carbon (SCC)** per tonne of CO_2 to the amount of CO_2. The SCC is commonly used in cost–benefit analyses to justify certain climate change mitigation policies. It reflects the present value of economic damages to global society (or, in other words, reductions in future consumption) from releasing an additional tonne of CO_2 under certain economic and climatic scenarios. Avoiding these economic damages by keeping the carbon stored in the ground is the benefit associated with protecting the Seal River Watershed. Its value can be calculated by multiplying the watershed's carbon storage capacity by the SCC. Unlike the SCC that is used specifically to inform cost–benefit analysis of environmental regulations, a carbon price is a policy that incents people and businesses to reduce GHG emissions. Therefore, to estimate the carbon storage benefits, it is appropriate to use the SCC as opposed to the carbon price.

The SCC values that the Government of Canada is using in decision making are listed in the Environment and Climate Change Canada (2016) according to the response of the Minister of Environment and Climate Change to the Environmental Petition No. 435 from February 26, 2020 (Office of the Auditor General of Canada, 2019). The 2020 updated central value is CAD 45.1 in 2012 dollars or CAD 50.75 in 2020 dollars per tonne of CO_2. Using this SCC, we can estimate that the value of CO_2 stored in the Seal River Watershed is **at least CAD 314.5 billion**, which is more than four times the GDP of Manitoba.[16]

[16] Manitoba's nominal GDP in 2019 was equal to CAD 74.8 billion (Government of Manitoba, 2020).

However, some experts argue that the current SCC values used by governments in policy-making, including the Government of Canada, underestimate the potential damages of climate change to society and the benefits of reducing carbon emissions (Samson & River, 2020; Stern & Stiglitz, 2021; Wright, 2017). Estimating SCC is an evolving field of study: considering uncertainties regarding the climate system's response to CO_2 and uncertainties regarding the economic harm expected from climate change, there is an ongoing discussion on how to measure the SCC. Ricke et al. (2018) examined the country-level differences in economic damages in calculating the SCC and estimated the median global social cost of carbon of USD 417 per tonne of CO_2. The study looked at GDP per capita growth rates and temperature increases for the period 2020–2100. Using this SCC, the value of carbon stored in the Seal River Watershed **could be as high as CAD 3.49 trillion**, which is roughly equivalent to 1.5 times the GDP of Canada (Statistics Canada, n.d.).

Flows

In ecosystem accounting, the flows are expressed as a quantity of ecosystem service per unit area per unit time. In our case, the flows are the stream of benefits from the Seal River Watershed per year. This is only a partial assessment based on the available data and methodologies. We have calculated direct use values, both consumptive and non-consumptive (of caribou harvest, mental health services and ecotourism), and non-use values, i.e., willingness to pay for conservation of three species: beluga whales, barren-ground caribou and northern pintails for which we could find existing studies estimating willingness to pay for these species in similar locations. In contrast to the carbon storage values, which represent a stock of benefits at a given point in time (valued at 2020 CAD), the flows are the *annual* benefits provided by the Seal River Watershed expressed in 2020 CAD. Most of the annual EGS value that we have estimated (94%) is associated with the non-use aspect of biodiversity.

Hunting and Gathering

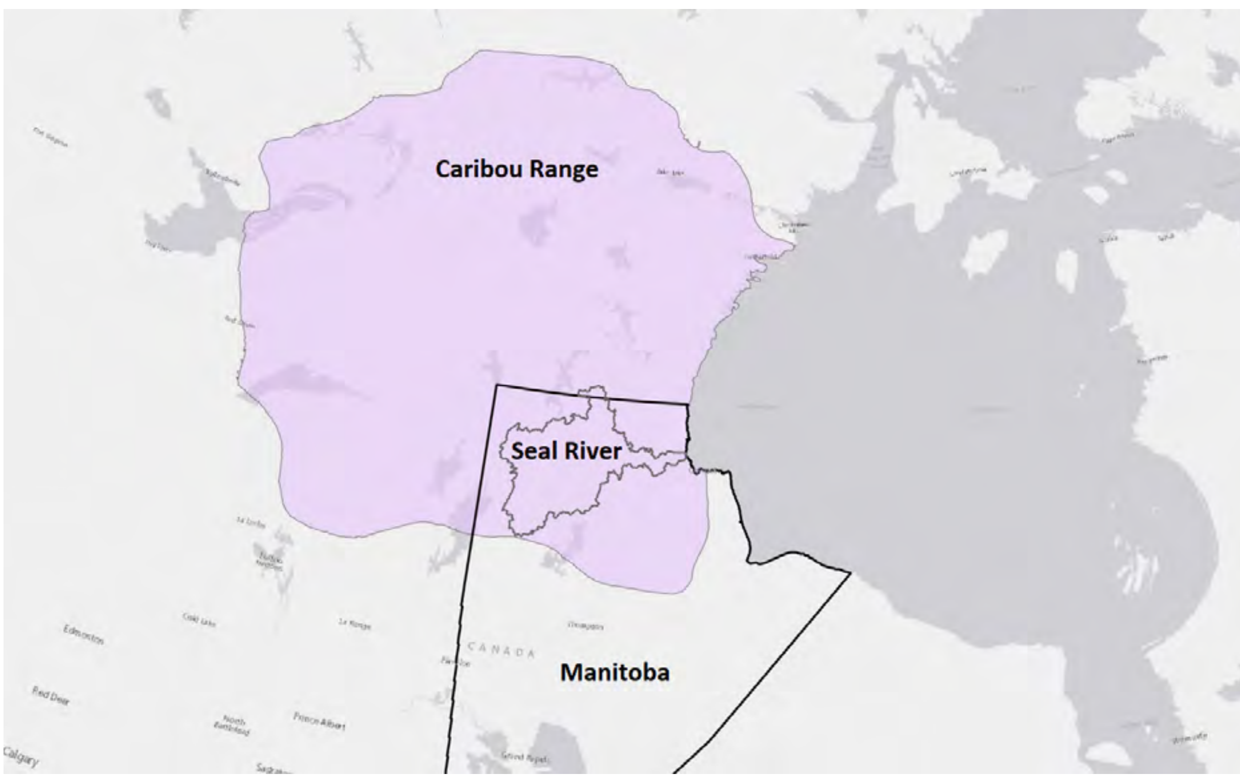
Direct Use Value (Consumptive)

The basis for our economic evaluation of hunting in the Seal River Watershed was InterGroup Consultants Ltd. (2013), whose study calculated the value of goods produced from the harvest of caribou of the Beverly and Qamanirjuaq herds. The study estimated the net annual value of the caribou harvest in Manitoba at CAD 3.8 million (CAD 2006). The direct quantifiable economic value of caribou harvest is the sum of values of all meat, hides, and antlers harvested. In this study, the economic valuation was conducted for three types of harvest activities: **domestic harvest**, **commercial harvest**, and **outfitting harvest**. For the meat, the values were calculated using the replacement cost method—an equivalent amount of food harvesters would need to purchase to obtain the same nutrition value. When the price of commercially harvested caribou was unavailable, the price of imported beef was used to estimate the value of the commercial harvest. The value of hides sold was also incorporated into the calculations. The result is the **net**

annual value of the caribou harvest, which is the market value or replacement value of the harvest minus production costs.

Approximately 2,070 caribou inclusive of domestic, licensed, and outfitted harvests were harvested in Manitoba in 2005/2006. That study's harvest estimates were derived from the Beverly and Qamanirjuaq Caribou Management Board (BQCMB) (2006, Appendix 4). More recent harvest numbers from BQCMB are not available (L. Wakelyn, personal communication, August 21, 2020). The 2017/18 annual report of the BQCMB (BQCMB, 2018, p. 8) states that "up to 12 Manitoba communities harvest Qamanirjuaq caribou each year; however, currently there is no system in place for collecting harvest data from those communities." For the present valuation, we are assuming the same harvest volumes in 2020 as stated in 2005/2006. However, this assumption should be treated with caution: for example, there was a significant increase in harvest prior to 2006—from 1990 to 2006, there was an increase of approximately 40% in the number of animals harvested.

Figure A12. Barren-ground caribou range in Northern Canada and the Seal River Watershed boundaries



Source: Authors' diagram based on BQCMB, 2015.

We have adjusted the net annual value of the caribou harvest in Manitoba (CAD 3,805,448 [2006 dollars]) by inflation and multiplied by the share of the barren-ground caribou range in the Seal

River Watershed to the caribou range in Manitoba (31.2%) as depicted in the Figure A12 to arrive at the value of **CAD 1.5 million** (2020 CAD) for the net annual value of caribou harvest in the Seal River Watershed.

Ecotourism

Direct Use Value (Non-Consumptive)

We were able to obtain visitor numbers and revenue estimates from three lodging operations in the Seal River Watershed: Gangler's North Seal River Lodge, Big Sand Lake Lodge, and Seal River Heritage Lodge, operated by Churchill Wild.

Gangler's North Seal River Lodge has seven locations throughout the watershed and more than 100 boats for fishing trips (K. Gangler, personal communication, December 18, 2020). It offers ecotours that focus on archaeology, sand eskers, wildlife photography, traditional medicines, and knowledge exchange (B. Kotak, personal communication, December 18, 2020). Visitors primarily come from the United States; however, there is a growing interest from European clientele (K. Gangler, personal communication, December 18, 2020). Typically, Gangler's North Seal River Lodge hosts 900 visitors annually for all its activities; there is potential for his number to grow to 1,100 visitors in the future (ibid.). The operation also provides guide jobs for band members from Barren Lands First Nation and Northlands Denesuline First Nation. It contributes around CAD 705,000 in wages to locals annually (K. Gangler, personal communication, December 18, 2020; B. Kotak, personal communication, December 18, 2020). The visitors to the Gangler's North Seal River Lodge bring more than CAD 5 million in ecotourism revenue annually (K. Gangler, personal communication, December 18, 2020).

Big Sand Lake Lodge is a fully Indigenous-owned business that offers fishing and hunting trips. It is owned and operated by the Community Association of South Indian Lake and employs 90% of staff from the local community of South Indian Lake/O-Pipon-Na-Piwin Cree Nation. This operation in the Seal River Watershed brings direct benefits to the community of South Indian Lake/O-Pipon-Na-Piwin Cree Nation. Some of the benefits are the income for the community members,[17] Employment Insurance benefits during the off season when there are limited employment opportunities, moose hunting as a source of traditional meat to community members, training opportunities that enable many community members to advance their careers and move to higher levels of employment (L. Dysart, personal communication, October 19, 2021). The average number of visitors to the Big Sand Lake Lodge per year is 237, and the average total revenue they bring is CAD 927,000 per year (L. Dysart, personal communication, October 19, 2021). Most customers are U.S. citizens.

Seal River Heritage Lodge, operated by Churchill Wild, is one of the three lodges it operates that are open 4 months of the year. Seal River Heritage Lodge hosted 312 visitors in 2019 (A. Pauls, personal communication, October 6, 2021). Visitors typically pay between CAD 12,000 and CAD

[17] Around CAD 300,000 per year paid to community residents in wages.

20,000 per person for a 1-week stay (M. Reimer, personal communication, August 22, 2021). If we assume that visitors pay on average CAD 16,000 per trip, this amounts to close to CAD 5,000,000 in value.

The combined estimated number of visitors to the Seal River Watershed that come as ecotourists, hunters, and fishers is thus at least 1,449 individuals per year, and the total estimated annual tourism value is **CAD 10,927,000**.

This does not include the economic contributions of the Lodge at Little Duck Lake and the five commercial operators that offer excursions into the Seal River Watershed: Monroe Lake Lodge (located north of the watershed); Churchill-based Lazy Bear Expeditions and Hudson Bay Helicopters; and paddling excursion operators Black Feather and Wilderness Spirit.

The Seal River Watershed also contributes to the significant ecotourism industry in Churchill, Manitoba, by providing habitat for key migratory attractions like polar bears and beluga whales. These values were not calculated; however, this industry also relies on the pristine Seal River Watershed that supports this habitat.

Mental Health Services

Direct Use Value (Non-Consumptive)

Buckley et al. (2019) have discussed and documented the previously unrecognized economic value of protected areas and conservation in terms of mental health services. We are following the approach of this study and assuming that ecotourism in the Seal River Watershed translates into economic benefits associated with improved mental health and well-being, including reduced treatments, reduced caregiver costs, improved workplace productivity, and improved overall well-being. Based on Australian data, Buckley et al. (2019) found that protected area visitation results in an increase in the Personal Wellbeing Index of around 2.5% annually, equivalent to 0.025 quality-adjusted life years (QALY) gained annually. QALY is an indicator commonly used in health policy and economics to capture a gain in life years in perfect health from a particular intervention. If price for 1 QALY is USD 200,000,[18] then it results in mental health savings of USD 5,000 per person annually in improved mental health of visitors to protected areas. We have adjusted this value for inflation and converted it to Canadian dollars, resulting in cost savings of CAD 6,600 (2020 CAD) per visitor annually. For 1,449 visitors to the Seal River Watershed, this translates into the CAD 9,563,400 in annual value of mental health services provided by the Seal River Watershed.

This estimation is based on the Australian data. Fully replicating the methods of the above study in the Northern Manitoba context to better understand how visitation to the region improves mental health and well-being would require a substantive collection of local data on protected-area visitation, mental health statistics, and distributing questionnaires to capture duration of

[18] Value of QALY in developed countries used in Buckley et al. (2020).

health effects from visitation, people's individual characteristics, and so on. More people visiting the Seal River Watershed in the future means that more people will benefit from the mental health services that the Seal River Watershed provides, increasing its value.

It is worth noting that five other commercial operators offer excursions in the watershed. Since that visitor data was not obtained, those values were not included. The mental health benefits of visitors to the community of Tadoule Lake were also not calculated due to a lack of data.

Species Conservation

Non-Use Value (WTP)

The Seal River Watershed is an area of pristine and undisturbed wilderness, a habitat for many remarkable species. As mentioned in Section 2.2, there are 261 known animal and plant species in the Seal River Watershed that are an integral part of this ecosystem and are valuable to local and distant communities. To be able to capture this value, a series of contingent valuation studies are required, so surveys need to be administered to determine people's willingness to pay for species conservation. We have found existing studies that estimated the willingness to pay by Canadian households and households abroad for conservation of three species—beluga whales, barren-ground caribou, and northern pintails—that are also present in the Seal River Watershed. This helped us estimate the non-use values of biodiversity. We have found that households in Canada, the United States, and Mexico are willing to pay **CAD 192 million annually** in total for the protection of these three species. A breakdown of our total and a description of our methods are presented below.

Beluga whales: CAD 154.1 million/year

Boxall et al. (2012) estimated Canadian households' WTP for conservation of the beluga whale population in the St. Lawrence estuary. WTP represents the maximum amount an individual would be willing to pay for a certain outcome or good. The results of this study can be adapted to the Western Hudson Bay beluga whale population.

Boxall et al. (2012) designed and executed a choice experiment and a contingent valuation that presented multiple recovery program options to a sample of respondents that are representative of the Canadian population. They estimated that Canadian households were willing to pay an average of CAD 111.46 per year over an unspecified time period for an improvement in beluga whale status in the St. Lawrence Estuary from a "Threatened to Special Concern" (Program B) and an average of CAD 119.68 per year per household for an improvement from "Threatened to Not at Risk" (Program D).

Before adapting these results to the Seal River context, it is important to knowledge the differences in the status of beluga whale populations in the St. Lawrence estuary and Seal River Estuary:

- The beluga whale population in St Lawrence River Estuary is geographically isolated from other populations, and its size is estimated at 900 individuals in 2012 (Fisheries and Oceans Canada, 2019). Species at Risk Act and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) report the status as "Endangered."
- In contrast, the beluga whale population in Western Hudson Bay (which includes the Seal River Estuary) is more abundant (57,300 individuals based on Richard [2005]) and not presently listed under the Species at Risk Act. COSEWIC status as of May 2004 is "Special Concern," which means that the population may become threatened or endangered because of a combination of biological characteristics and identified threats (Fisheries and Oceans Canada, 2017).

We assume that the WTP obtained for the St. Lawrence Estuary is applicable to Western Hudson Bay. We took the difference between Program D ("Threatened to Not at Risk") and Program B ("Threatened to Special Concern") to assess the WTP for beluga whale recovery from "Special Concern" (the status of beluga whales in Western Hudson Bay) to "Not at Risk" and estimated the total WTP for Canadian households in 2020. The details are presented in Table A2.

Table A2. WTP for beluga whale status improvement from "Special Concern" to "Not at Risk"

	WTP for beluga whale population recovery from "Special Concern" to "Not at Risk" (all votes pooled)
WTP per person (2006)	CAD 8.22
WTP per person (2020)	CAD 10.30
Number of households in Canada (2020)*	14,968,616
National Annual WTP (2020)	CAD 154,176,741

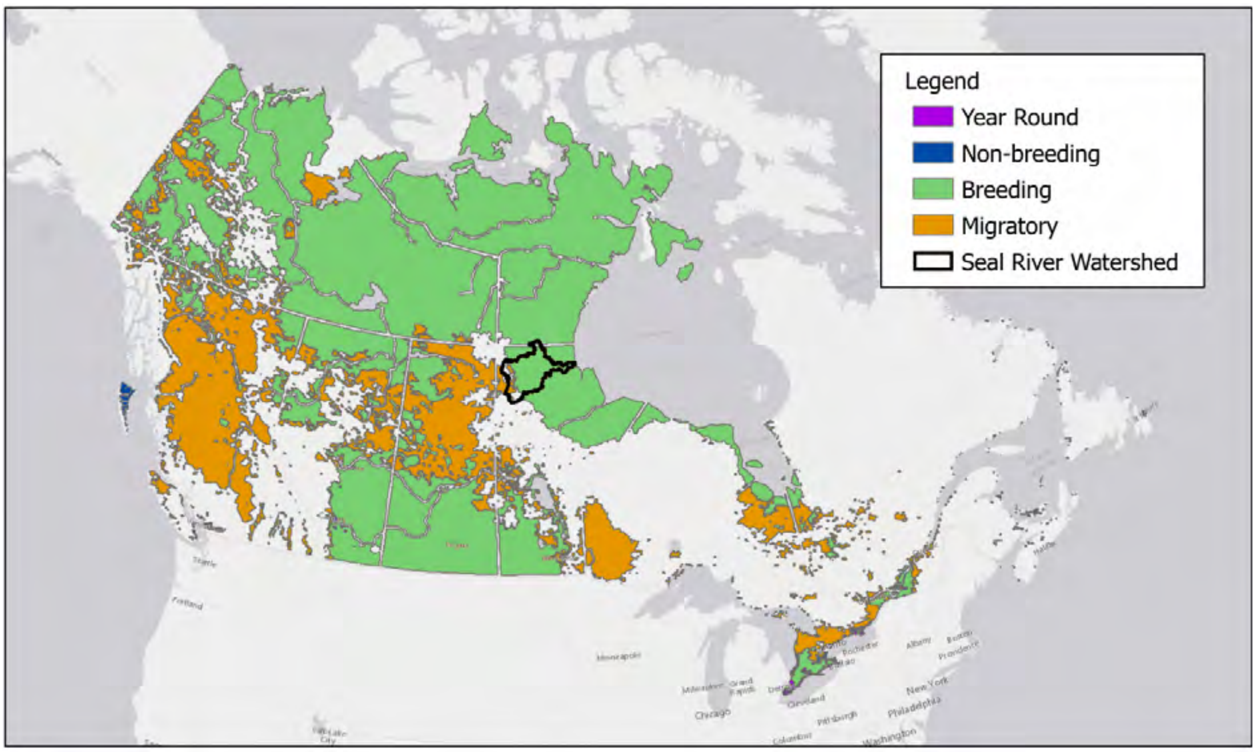
*Projected based on the average growth rates over 2005–2015

Northern pintails: CAD 37.9 million/year

Northern pintails are a waterfowl species abundant in the Sea River Watershed. Ball et al. (2020) report that the northern pintail was the second most abundant duck in the 2013–2015 Waterfowl Surveys in Seal River Estuary and Knife River Delta and was moderately high in the Seal River (SEA) region, compared to other areas of the continent. These ducks are popular for birdwatching, photography, and recreational hunting. Their breeding habitats are wetlands in Canada and Alaska, and their overwintering habitat is in Mexico and the southern United States (Haefele et al., 2019).

Haefele et al. (2019) applied a contingent evaluation method to calculate WTP for conservation of northern pintails in Canada, the United States and Mexico. The authors constructed and administered a questionnaire to citizens in each country, presenting two scenarios. The first, called Program A, would conserve habitat to stop the decline in pintails and stabilize the population at the current level (approximately 3 million birds). The second, Program B, would provide habitat allowing the population of pintails to grow to meet long-term abundance goals (Haefele et al., 2019). The final sample consisted of some 1,200 complete responses from the United States, 500 from Canada, and 500 from Mexico. Based on the Program A estimates for habitat in Canada (stabilizing the population of northern pintails in Canada), we have estimated the WTP for northern pintails conservation by the households of three countries, Mexico, the United States, and Canada.

Figure A13. Northern pintail range in Canada and Seal River Watershed boundaries



Source: Fink et al., 2020, reprinted with permission.

Table A3. WTP to stabilize the population of northern pintails in Canada

	Canada	U.S.	Mexico	Total
Habitat in Canada, 2016 USD/ household, mean*	11.64	18.07	5.11	
Habitat in Canada, 2016 CAD/ household, mean	16.05	24.92	7.047	
Habitat in Canada, 2020 CAD/ household, mean	17.06	26.48	7.49	
Number of households, 2020[19]	14,968,616	123,324,404	36,036,273	
Total WTP, 2020 CAD	**255,364,583**	**3,265,630,207**	**269,911,681**	**3,790,906,471**

Source: Based on data from Haefele et al. (2019).

We have adjusted the total WTP for northern pintail conservation in Canada (Table A3) by the proportion of their habitat in the Seal River region to total Canadian habitat (1%) (Figure A13) and arrived at a total WTP of **CAD 37,909,065/year**. The adjustment by the proportion of the range of northern pintails in the Seal River area to the total habitat in Canada does not account for the density of breeding pairs across their habitat in Canada. Since the Seal River Watershed has a high density of breeding pairs, we are likely underestimating the value of northern pintails in the Seal River area.

Barren-ground caribou: CAD 10,027/year

Two significant barren-ground caribou herds—Beverly herd and Qamanirjuaq herd—travel south from Nunavut to winter near the Seal River. The size of these herds is estimated at around 400,000 individuals (Government of Northwest Territories, n.d.). The barren-ground caribou population has been placed under "Threatened" status by COSEWIC (Government of Canada, 2019). These caribou are important not only as signature species of the North; they are also a source of food and other means of subsistence for the local Indigenous communities. The caribou carry a great cultural value. Local Indigenous people pass down Traditional Knowledge and bond as a community while hunting caribou.

The BQCMB is a co-management board established to safeguard the Beverly and Qamanirjuaq herds for present and future generations. The board provides advice and works together with federal, provincial, and territorial governments and communities to ensure the long-term conservation of the herds. BQCMB received CAD 182,311 in funding in 2019–2020 from provincial, territorial, and federal governments (BQCMB, 2020).

[19] Household numbers in 2020 were projected based on the average growth rates over 2005–2015 for Canada, 2010–2012 for the United States, and 2000–2015 for Mexico.

We are considering BQCMB revenue as the society's WTP for protection of barren-ground caribou since all the funding received is used for conservation activities. We have adjusted this amount for inflation and for the share of the caribou range in the Seal River Watershed to the total area served by the BQCMB (5.5%) (Figure A12). The resulting WTP for conservation barren-ground caribou in the Seal River Watershed is **CAD 10,027/year** (2020 CAD). However, one should recognize that it is a politically based decision, and not based on people's preferences. As can be seen, this produced the lowest value compared to WTP for the protection of beluga whales and northern pintails based on contingent valuation studies measuring household preferences.

Limitations of the WTP Approach

We have made certain assumptions in our methodology that those interpreting the numbers should be aware of. First, adjustment of the WTP values by the proportion of species habitat in the Seal River Watershed to the total habitat (where WTP value is known) assumes a uniform contribution of all areas within the range to the sustainability and health of the wildlife population, which may not be the case. However, it is the best estimate given the limitations, for example, higher densities of the waterfowl in Seal River Watershed compared to other breeding areas across the country are not accounted for.

Second, it is important to acknowledge the limitations of the "benefit transfer" approach, where values pertaining to one specific scenario or region are applied to a different context. Evaluation results obtained in one area may not be applicable to another similar area; however, we highlighted any differences in the regions and considered the numbers obtained to be the best estimates derived with the most recent data available.

Third, the value of biodiversity in choice experiment methods depends heavily on the level of awareness about the issue that people responding to the survey have (Hanley & Perrings, 2018). Since biodiversity involves complex interactions and is a core determinant of human well-being in so many ways, if the respondents are not well informed, the value of biodiversity might not be fully captured by people's answers.

And finally, the questionnaire design in the contingent valuation studies that provided the basis for our estimation can contain potential biases, leading, for example, to people overstating their preferences (known as hypothetical bias) (Loomis, 2011). Additionally, people tend to care or to conserve certain species over others for their charisma or cuteness, rather than other considerations, which gets captured by WTP estimates (Hanley & Perrings, 2019).

EGS That Were Not Monetized

Many benefits were not included in our calculation of the EGS in the Seal River Watershed due to the lack of data on measurement of the good or service (**How much of something does the ecosystem produce?**), data on local markets for goods and services (**How much local demand is there for it?**), and academic literature or surveys on public values (**How much distant**

demand is there for it?). For example, the following EGS provided by the Seal River Watershed were not monetized:

- Heritage value of a fully functioning, ecologically intact watershed
- Willingness to pay to conserve 258 of the 261 known species in the watershed
- Beluga whales harvesting in Western Hudson Bay by Nunavut and Nunavik Inuit, which is a key food source for the Indigenous communities, especially when the store options are deficient
- Harvesting of fish, birds, moose, berries, and other food sources by area residents and visitors
- Harvesting of timber and firewood by area residents and visitors
- Commercial and cultural value of traplines
- Mental health value of living in a pristine environment for area residents
- Nutrient cycling from the Seal River Watershed to Hudson Bay
- Jobs/employment created as part of the Seal River Watershed Indigenous Protected Area Initiative[20]
- Willingness to pay for large-scale wilderness conservation
- Socio-economic benefits of establishing an Indigenous Protected Area
- Potential benefits of expanding tourism opportunities following the establishment of an Indigenous Protected Area
- Cultural and spiritual values associated with biodiversity integral to the Indigenous communities that are hard to capture in economic terms, e.g., Sayisi Dene people's long-term relationship and cultural bond formed around caribou hunting.

[20] Environment and Climate Change Canada (2020) reports that the Seal River Watershed Alliance, the not-for-profit established by Sayisi Dene First Nation, with the support of their Cree, Dene, and Inuit neighbours to manage the Seal River Watershed conservation project, has already created 17 jobs within the communities.

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Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org
Twitter: @IISD_news

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