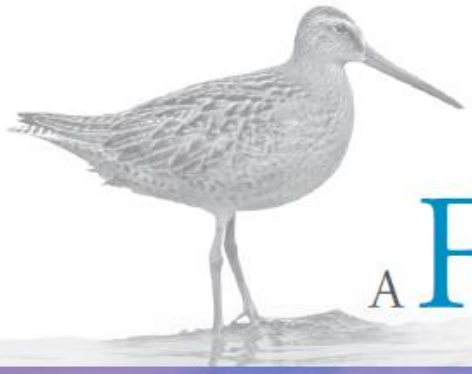

A Forest of Blue

Canada's Boreal

THE PEW ENVIRONMENT GROUP

Foreword

Water is the essence of life on our blue planet. Renewable fresh water is the most undervalued and overexploited of scarce, critical natural resources. Globally, readily available renewable fresh water comprises a small fraction of the global water pool.

The U.N. General Assembly recognized the importance of freshwater to humanity in its designation of 2005-2015 as the "International Decade for Action—Water for Life." Despite increasing global awareness of the importance of freshwater resources, human populations continue to alter hydrological cycles and hydrological connectivity, and degrade aquatic biological communities, threatening the integrity of freshwater systems. By 2025, it is predicted that humans will appropriate 70 percent of the renewable annual freshwater supply. Freshwater withdrawal and disruption of freshwater flow, primarily for agricultural, oil and mineral extraction, and hydroelectricity production, threaten the ability of the water cycle in the Canadian boreal forest to maintain freshwater biodiversity and may have unpredictable effects on ecosystem functioning. Climate change coupled with human impacts on watersheds is expected to further strain global water resources, causing greater discharge and water stress within altered watersheds.

Canada's boreal forest region provides one of the last opportunities for freshwater and intact forest protection that has globally significant implications. This region contains a significant proportion of the world's surface freshwater, including a relatively large proportion of the planet's wetlands intermingled with the most intact forest ecosystems on Earth. The boreal forest is defined by water as much as by forest, a fact that is too often underappreciated. The sheer abundance of water can make it seem limitless, but this is far from the case. Continued overexploitation and degradation of freshwater resources and ecosystems, particularly peatlands, across the boreal forest has consequences for climate cycles, nutrient cycles and livelihoods of the peoples that depend on this water for life.

Protecting large-scale intact aquatic and forest ecosystems will maintain abundant migratory and inland-water fish populations and aquatic biodiversity, intact headwaters, intact hydrologic and nutrient cycles, and carbon storage and sequestration in forested and non-forested peatland ecosystems.

The global freshwater accounting sheet between input and demand is becoming increasingly difficult to balance. Ever-increasing pressure on water resources globally can only be decreased by implementing new conservation and sustainable development policy and management strategies at big scales in places where political, social and water resource capital exists to do so. Canada, with its abundant water resources and informed citizenry, is one such place.

This report provides the facts and vision necessary to catalyze and to elevate the status of water to levels on par with conservation efforts historically focused on terrestrial habitats. Water is Canada's lifeblood; efforts to protect Canada's intact ecosystems must include an understanding of the interconnectedness between land and water in Canada's northern regions. To fail to protect the last free-flowing rivers, pristine lakes, and carbon-rich wetlands of Canada will impact the livability of our planet. Canada is at a crossroads and time to implement broad policy initiatives that protect vital water resources is running out. We applaud the efforts of this report and urge implementation of the recommendations therein.

International Boreal Conservation Science Panel

Pascal Badiou, John Jacobs, Jeremy Kerr, Micheline Manseau, Gordon Orions, Stuart Pimm, Peter Raven, Terry Root, Nigel Roulet, James Schaefer, David Schindler, Jim Strittholt, Nancy Turner, Andrew Weaver

Freshwater ecosystems are considered the most endangered of all major global ecosystems.
CREDIT: GARTH LENZ

Introduction

Canada's boreal forest region is the most water-rich area in the world. Water reaches into the history of all Canadians and runs a long and fluid path connecting aboriginal lands and historical trade and migration routes to southern Canada's cities and industry. This "forest of blue"—Canada's boreal forest—is the source for many Canadian iconic animals, including loons, moose, beavers and fish. These symbols of Canadian history and cultural values reflect the deep connection of people to their land and water that resonates from Newfoundland and Labrador to the Yukon and the Northwest Territories.

Canada's water resources are not only vital to national identity, but also provide irreplaceable ecosystem services at local, provincial, national and international levels. Many of the waterways and wetlands of the boreal forest are among the most pristine in Canada, as well as globally, with low or undetectable levels of human-caused pollutants, little human-made nitrogen and phosphorus inputs, and few invasive plant and animal species.

Canada's boreal forest contains the world's highest concentrations of large wetlands, lakes and undammed rivers (Fig. 1). Its waterways and wetlands make vast and critical contributions to the global environment—stabilizing climate and feeding the productivity of the world's oceans, ultimately supporting the health and welfare of people across the Earth. Its ice-locked, saturated forests and peatlands and the sediments within its lakes and deltas store the largest amount of soil carbon on the planet.

Against a backdrop of abundance of water in Canada's boreal forest, a harsher reality of destruction, degradation and pollution of freshwater resources exists globally and in other regions of North America. Freshwater ecosystems are now considered the most endangered in the world (Dudgeon *et al*. 2005, Millennium Ecosystem Assessment 2005). The same is true for much of the continental United States and southern Canada.

A report estimated that 2.5 million dams impact river ecosystems across the United States (National Research Council 1992), while a 2010 analysis found more than 800 large dams in existence across Canada (Global Forest Watch Canada, unpublished analysis). In the United States alone, an estimated $14 billion to $15 billion has been spent on efforts to restore degraded river systems since 1990 (Bernhardt *et al*. 2005).

Wetlands have fared no better than rivers across much of North America. Wetland losses have been estimated at greater than 50 percent in the United States since pre-European settlement. In Canada, up to 68 percent of wetlands in southern Ontario and 70 percent of prairie wetlands have been lost during the past two centuries. In many areas these losses continue to this day (Environment Canada 2009a). Only a single large river system in the lower 48 U.S. states (the 130-km [81-mile]) Pascagoula River in Mississippi) is not significantly impaired by dams (Dynesius and Nilsson 1994).

Nearly 70 percent of freshwater mussel species (Williams *et al*. 1993) and 51 percent of freshwater crayfish species are endangered or threatened in North America (Taylor *et al*. 1996). More than half of Canada's endangered vertebrates are freshwater species, and a higher proportion of Canada's freshwater mussels are of global conservation concern than any other animal or plant group (Cannings *et al*. 2005). The number of imperiled freshwater fish species in Canada increased from 4 percent in 1979

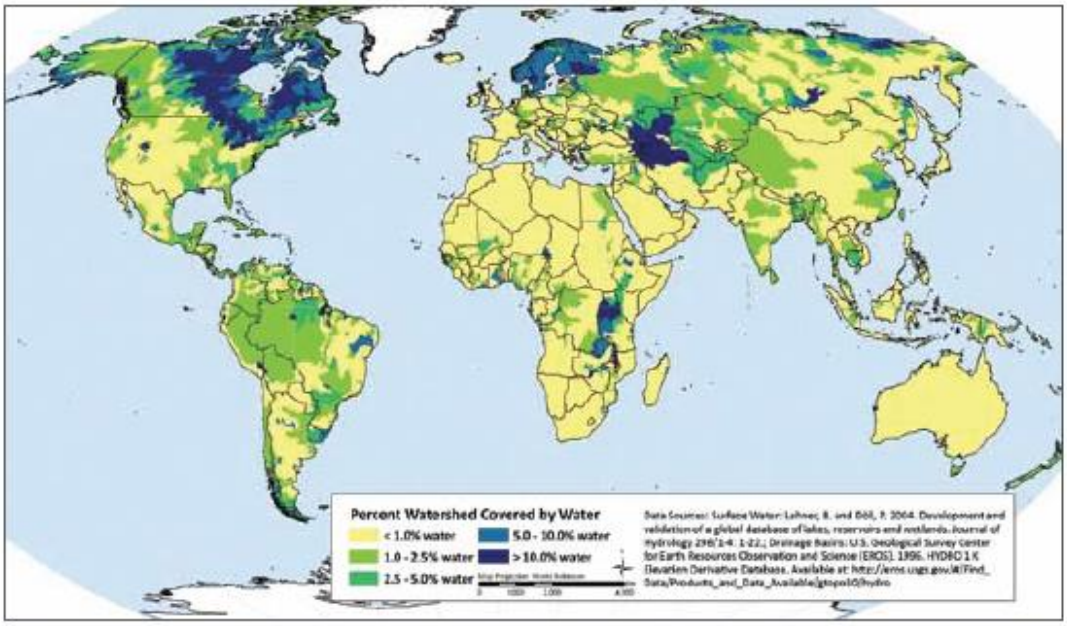

Figure 1. Global surface water represented by percentage of a watershed covered with water. Canada is the "World's Waterkeeper," housing more surface water than any other country.

to 10 percent in 2008, while the number of imperiled populations and subspecies increased from 10 percent to 26 percent (Environment Canada 2009a). The number of established invasive alien species in the Great Lakes increased from approximately 10 in the early 1800s to 180 by 2007 (Environment Canada 2009a).

Despite the dire statistics and trends that present a worrisome picture of global freshwater resources, Canada's boreal forest offers a story of hope and abundance in a world of overuse, abuse and scarcity. While much of the globe spends billions of dollars annually to restore wetlands and river systems and provide clean water supplies, the boreal forest and its healthy wetlands and waterways provide more than $700 billion in ecosystem services every year (Anielski and Wilson 2009).

Canada's boreal forest region provides one of the last global opportunities to conserve large-scale, pristine aquatic ecosystems, the biodiversity they sustain, and the ecosystem services they provide. While the abundance and integrity of Canada's water resources are unmatched globally, the water richness of the boreal forest is delicately balanced. In much of the region, annual inputs of water from precipitation are offset by water loss from evaporation and evapotranspiration, and this is often equal to the amount of water that leaves the region in the form of runoff to the oceans. Only with careful planning and protections can this delicate balance be maintained.

This report highlights the unique status of the Canadian boreal forest in housing globally significant water resources. Maintaining the integrity and abundance of this "forest of blue" is still possible, and increasingly urgent. The report explores the ever-expanding list of threats to remote and abundant water resources across the Canadian boreal, and identifies opportunities to protect water resources at geographic scales that will maintain freshwater integrity and abundance into the future.

Because it is largely intact, Canada's boreal forest presents a unique opportunity to set a model for large-scale aquatic conservation.

CREDIT: IRENE OWSLEY

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Climate change is expected to affect boreal forests at higher rates than lower-latitude forests such as tropical forests.
CREDIT: GARTH LENZ

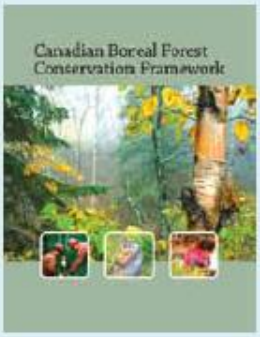
peatlands on the east side. Although the west-side route will be longer, the potential costs to east-side ecosystems would be greater, as they would impact the largest contiguous block of intact forests left in the world, which runs from the east side of Lake Winnipeg across to northeastern Ontario.

In addition, the government feared that east-side transmission lines would threaten approval of the proposed Pimachiowin Aki UNESCO World Heritage site, an initiative led by First Nations who want to protect their traditional lands and cultures.

Climate Change and Threats to Boreal Freshwater

Canada's boreal forest is water-rich as a result of accumulation in peatlands, snowpacks, glaciers, permafrost and groundwater. In much of the forest, water from annual rain and snowfall (minus water lost to evaporation and evapotranspiration) has historically been only slightly higher than the volume of runoff that eventually flows into the oceans (Schindler and Lee 2010, Schindler 2009). Thus in drier and warmer years, more water is lost than is replenished. The water "bank" of the forest is therefore highly sensitive to changes from industrial disturbance and global warming (Schindler and Smol 2006, Schindler and Lee 2010).

The rise in global temperatures from climate change, predicted to increase by 2.5° C (global average) by 2100, is most pronounced at higher latitudes, including the northern regions of the Earth (IPCC 1995). Continental areas in the northern range of the Canadian boreal may rise to twice the global average at 50° N, and to 3.5 times the global average at 80° N by 2100 (Etkin *et al.* 1998). Major effects in Canada's boreal and Arctic ecosystems as a result of the warming that has occurred in the last 100 years have already been well documented (Serreze *et al.* 2000, Hinzman *et al.* 2005).



BOREAL FOREST CONSERVATION FRAMEWORK

The Boreal Forest Conservation Framework calls for conservation of at least 50 percent of Canada's boreal forest in a network of interconnected, protected areas; and application of state-of-the-art ecosystem-based resource management practices across the remaining landscape.

It was developed by the Boreal Leadership Council (BLC), an unusual partnership of leading conservation organizations, resource companies, and First Nations, who joined together to promote the conservation and sustainable use of Canada's boreal forest region. Members of the BLC, convened by the Canadian Boreal Initiative, recognize that all who depend on the forest must come together to plan for its ecological, cultural, and economic future. The Framework is based on the best available principles of conservation biology and land use planning, and has been endorsed by 1,500 international scientists, 25 Canadian First Nations, international conservation groups, and major businesses with annual sales totaling over $30 billion.
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Significant progress has been made toward the goals set out in the Framework. Recent key land protection actions include the following:

- In September 2010, the Ontario Legislature passed a bill protecting 110 million acres of pristine boreal forest and wetlands in the northern half of the province. The Far North Act is one of the largest wildlands protection efforts in history. It mandates that the entire 110 million acres undergo conservation planning, and puts a minimum of 55 million acres permanently off limits to development.

- Quebec: Premier Charest pledged in March 2009 to protect at least 50% of northern Quebec's boreal forest; this commitment totals more than 645,000 km²—160 million acres.

- Northwest Territories (NWT): Over 120,000 km²—30 million acres has been slated for protection in the NWT since 2007; most recently in April, 2010, 33,000 km²—8 million acres was set aside for creation of a new national park around the East Arm of Great Slave Lake, the tenth largest lake in the world.

These and other land protection actions represent a significant commitment to the future of Canada's boreal forest, although much remains to be done to ensure equal treatment of conservation, sustainable development and Aboriginal rights across the region.

For example, studies in the boreal forest and Arctic ecozones of Alaska show that the region has experienced a warming climate with longer growing seasons and permafrost warming (Serreze *et al.* 2000, Hinzman *et al.* 2005, McGuire *et al.* 2009). Closed-basin ponds decreased by as much as 31 percent in the study region and up to half of closed-basin ponds are disappearing (Riordan 2006). Similar trends are also being observed in Russia, where widespread disappearance of lakes is likely due to thawing permafrost (Smith *et al.* 2005).

Wetlands and waterways are among the ecosystems that will be most affected by continued global warming (Schindler *et al.* 1996, Poff *et al.* 2002). Already, records show that Canada's boreal forest lakes and rivers are responding to changes in climate with a shift toward shorter ice-cover periods and greater year-to-year variability (Schindler *et al.* 1990, 1996, Wrona *et al.* 2005, Schindler and Smol 2006, White *et al.* 2007). These changes can result in complicated and sometimes unpredictable ecosystem effects (Schindler *et al.* 1996, Schindler and Smol 2006, Schindler 2009).

In areas with decreased precipitation, drying lakes and ponds can become so low that they no longer have outflow and they begin to accumulate salts and show increased eutrophication (Schindler 2009) that can eventually cause widespread losses of aquatic organisms. Decreased flow in rivers and streams lowers movement of nutrients to lakes and marine estuaries affecting food webs and decreasing the ability of migratory and dispersal movements of fish and other aquatic species (Schindler and Smol 2006). Such decreased flows can also reduce input of organic matter in lakes, which serves as a natural "sunscreen" to lessen the penetration of solar radiation affecting both the depth of the photosynthetically active zone and the level of harmful UV radiation (Reist *et al.* 2006, Schindler 2009). Climate change can impact the acidity of lakes and streams in complex ways (Schindler 2009).

Climate change is expected to result in higher winter flows and lower spring and summer flows in river systems of Canada's boreal forest (Woo *et al.* 2008). Such changes in timing of peak flows are expected to cause major problems for species adapted to spawning under high water conditions in certain seasons (Reist *et al.* 2006, Schindler and Smol 2006). Thousands of closed basin lakes and ponds in globally important delta systems in the boreal forest, including the Peace-Athabasca Delta and the Mackenzie Delta, have historically been recharged with water and nutrients as a result of spring flooding that is already reduced and is projected to decline further (Schindler and Smol 2006, Schindler 2009).

Canada's boreal waterways and the fish and other organisms that inhabit them are expected to see increases in levels of various contaminants as a result of climate change. Various airborne industrial pollutants originally released in warmer, southern regions can condense in cold, northern regions in snow, ice and water. As global warming results in increased melting of glaciers and snowpacks, these compounds flush into lakes, ponds and rivers where they can be biomagnified to levels that harm or kill some organisms (Schindler and Smol 2006, Tarnocai 2009). Mercury levels are likely to rise from release of methylmercury in thawing peatlands and from atmospheric deposition of mercury from forest fires, which are expected to increase in frequency from global warming (Reist *et al.* 2006, Schindler 2009, Tarnocai 2009).

Rising temperatures from global warming could cause large releases of greenhouse gases from wetlands.
CREDIT: JEFF WELLS

One of the most obvious effects from global warming will be the loss of habitat for species reliant on lakes, rivers and wetlands. Many fish and other aquatic organisms are highly sensitive to water temperature. The higher air temperatures from global warming will increase water temperatures so that water bodies could either become too warm for some species to survive or the depth at which the cooler waters they require will increase. The species composition of waterways and wetlands will then change as some species disappear or are reduced in abundance, and those adapted to warmer, more southerly conditions increase in abundance and colonize new northerly locations (Reist *et al.* 2006, Schindler and Smol 2006, Rahel *et al.* 2008, Prowse *et al.* 2009a, b). Northern pike and Arctic char are two species predicted to undergo major declines in range and abundance with unchecked global warming (Reist *et al.* 2006a, b) and the salmonids (trout, salmon, whitefish) that inhabit the waters of Canada's boreal forest are among the fish species that are least able to tolerate rising water temperatures (Eaton and Scheller 1996).

Peatland systems of the boreal forest are also expected to show major impacts from current predicted increases in global warming (McGuire *et al.* 2009). Approximately 667,000 km² (165 million acres) of Canadian peatlands are predicted to experience extremely severe or severe impacts under current climate change scenarios, and virtually all of the most vulnerable peatlands are within the boreal forest region (Tarnocai 2009). This includes the Hudson Bay-James Bay lowlands and most of the Mackenzie River Basin (Tarnocai 2009). For the many species of plants and animals reliant on peatland habitats, this will certainly entail a reduction in the

amount and quality of available habitat and a likely decrease in their range and abundance. Without strong measures to reduce the rate of climate change and maintain these now-intact systems, some models suggest that peatlands could release massive amounts of carbon and methane, which would exacerbate global warming (McGuire *et al.* 2009, Tarnocai 2009, Schindler and Lee 2010) though major uncertainties exist in various model parametres (Zhuang *et al.* 2006, McGuire *et al.* 2009).

As species ranges shift northward across North America in response to global warming, it has become increasingly clear that large intact and healthy ecosystems are the most likely to be able to absorb climate impacts and to allow species to move across the landscape as they adapt to a warming world. Lakes, rivers, and wetlands are intrinsically isolated from each other because of the geographic features that allow their creation (i.e., mountains, ridges, valleys). Global warming impacts expected in rivers and lakes of the boreal forest include changes in discharge of freshwater and greater water stresses on wetlands, rivers and lakes (Palmer *et al.* 2008). Climate impacts coupled with human impacts, such as roads, dams, and habitat loss and degradation, will affect the ability of aquatic organisms to naturally disperse from one waterway or wetland to another—a process that will be required for species to shift the ranges in response to changing climate conditions. Large pristine, intact and unfragmented waterways and wetlands, such as those found in Canada's boreal forest, provide the best conditions for species to adapt to change and ensure large-scale terrestrial and freshwater ecosystem resilience in the face of global warming (Palmer *et al.* 2008).

Protecting the World's Last Great Blue Water Forest

Within Canada's boreal forest region relatively few protected areas exist that specifically strive to maintain the full complement of ecosystem services, biodiversity features and traditional use needs of aquatic systems. Maintaining very large intact forests and peatlands is one of the best solutions for protecting aquatic systems as it prevents or slows human-caused alteration of hydrology from industrial land-use activities, and prevents or slows the spread of invasive species and pollutants. Ideally in landscapes where possible, the protection of entire watersheds from headwaters to the outlet should be the goal. Whole-basin protections are still rare, but not without precedent. For example in 2006 Russia designated the entire 2,000-km² (500,000-acre) watershed of the Kol River as a protected area specifically because of its importance for migratory salmon and other fish (Augerot and Foley 2005).

The Canadian Boreal Forest Conservation Framework envisions the implementation of these types of large-scale protections (Boreal Leadership Council 2003). The Canadian Boreal Conservation Framework spells out the need to maintain at least 50 percent of the boreal forest in a system of protected areas while implementing leading-edge sustainable development practices on areas outside of the protected area system (Boreal Leadership Council 2003). This vision will require linking terrestrial and freshwater conservation planning efforts at vast scales that encompass entire watersheds and riverine corridors that may stretch for thousands of kilometres.