WHAT WE FOUND: ALGONQUIN PARK OLD-GROWTH FOREST PROJECT 2022 SUMMARY

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Research in 2022 made clear that Algonquin Park has very old and intact, unprotected old-growth forest that has international significance. We used rapid survey methods (Henry, 2023a) and volunteer data collection to confirm two unprotected old-growth forests in the park. A third was identified in 2018 and will be included in our 2023-24 field seasons for additional surveys, and more than 30 other potential old-growth sites are found in the park.

Cayuga Lake West old-growth forest is among the oldest forest stands in Eastern North America, with a maximum age of 427 years and a conservative stand age of 263 years (Table 1). The forest is almost entirely pristine and has all the features of high quality old-growth forest including high ages, tree basal area, and coarse woody debris (logs and snags). At 176 hectares (1.7 square km), Cayuga Lake West is roughly equivalent in size to Toronto's Sunnybrook, Wilket Creek, Glendon, and Serena Gundy Parks combined. One quarter of the trees cored at Cayuga Lake West in 2022 were over 400 years old, while another tree cored in 2018 was also over 400, for a total of six trees more than 400-years-old found in Cayuga Lake West to date (Henry & Torenvliet, 2023).

FIGURE 1 NATE TORENVLIET AGEING A HEMLOCK AT CAYUGA LAKE WEST

Hemlock forest north of Longboot Lake was identified as potential old-growth forest in 2021 by recreational users of the park. We inventoried several hemlock stands as part of the Algonquin Park Old-growth Forest Project, and the results show that the forest north of Longboot Lake has ages, tree basal area, and coarse woody debris volume that are all indicative of high quality old-growth forest. Stumps show that there was limited selective logging roughly 80-100 years ago. The mean age of the forest is 211 years, and the maximum age is 338 years. These ages are higher than most old-growth forests in eastern North America, but comparable to old-growth hemlock forests in Adirondack State Park and Algonquin Park (Henry, 2023; Table 1).

TABLE 1 TREE AGES FROM OLD-GROWTH FORESTS IN EASTERN CANADA AND ADJACENT USA

Source	Max age	Mean age	Location
Henry & Torenvliet 2023	427	263	Cayuga Lake, NW Algonquin Park, ON
Henry 2023b	338	211	Longboot Lake, south Algonquin Park, ON
Henry & Quinby 2018	295	232	Hurdman Creek, N Algonquin Park, ON (preliminary results)
Keeton et al. 2007		205-410	10 old-growth forests in western Adirondack Park, NY
Hale et al. 1999		124-172	11 maple-basswood forests > 120 years old in Minnesota
Hale et al. 1999		128-164	7 oak forests >120 years old in Minnesota
Vasiliauskas 1995	454	154	1,576 hemlock tree cores in Algonquin Park, ON
Ziegler 2011	253-390		12 OG hemlock forests in Adirondack Park, NY

FIGURE 2 THE STUDY AREAS IN RELATION TO ROADLESS AREAS, OLD-GROWTH FOREST, AND KNOWN LOGGING IN ALGONQUIN PARK. ROADLESS AREAS MAPPING BY TED ELLIOTT.

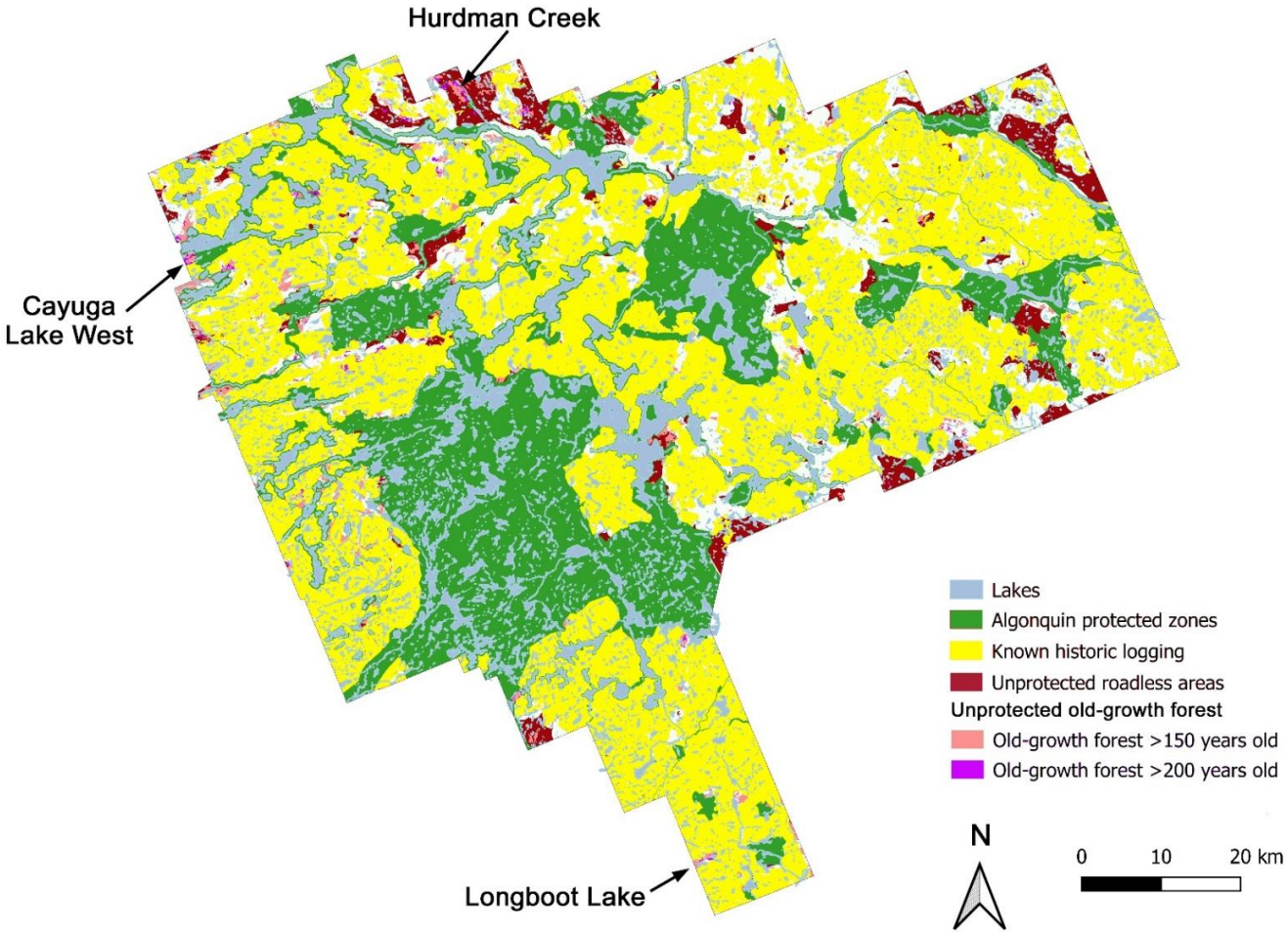


FIGURE 3 UNPROTECTED OLD-GROWTH HEMLOCK FOREST NORTH OF LONGBOOT LAKE

While Cayuga Lake West was somewhat older and more pristine than Longboot Lake, the latter had more large trees suggesting better growing conditions. In Longboot Lake 8.6 percent of trees (by basal area) were over 70 cm diameter, at Cayuga only 1.6 percent were over 70 cm diameter. The volume of logs is also 2.4 times higher at Longboot Lake. These differences tend to make Longboot Lake "feel" more like the old-growth forest that people typically expect (Figure 3).

Algonquin's old-growth hemlock forests have international significance as some of the oldest, most intact hemlock forest that occur beyond the cold tolerance limit of the invasive hemlock woolly adelgid (HWA), even under climate predictions for the remainder of this century (McAvoy et al., 2017). HWA kills hemlock trees and has spread through much of the range of hemlock including parts of Southern Ontario, but Algonquin Park is a rare climatic refuge for hemlock.

In 2018 a reconnaissance survey found that 377 ha of contiguous old-growth forest adjacent to Hurdman Creek appears to relatively pristine, with an average age from tree cores of 232 years, a maximum age of 295 years, and few signs of historical logging in most of the surveyed areas (Henry & Quinby, 2018). The oldest documented black ash in Ontario was found in this unprotected forest, at 218 years old. A more rigorous survey will be undertaken in 2023-24.

The Hurdman Creek forest is particularly significant because it is part of a very large roadless area mapped by Ted Elliott and Peter Quinby (Quinby, 2021; Figure 2). This is the largest unprotected roadless area remaining in Algonquin Park; at over 6600 hectares (66 square km) it is about 2/3 the size of old Toronto, or the same size as Peterborough Ontario.

The scientific consensus indicates that the best way to mitigate climate change and meet Canada's international commitment to reduce greenhouse gas emissions is to leave old-growth forests undisturbed. Because Algonquin Park has a disproportionate share of old-growth forests in south and central Ontario, it bears an equally large responsibility to conserve these large carbon banks.

Logging of old-growth forest and roadless areas in Algonquin Park clearly undermines the ecological integrity of the park. A strategy for protecting remaining old-growth forest and roadless areas in the park should be included in the next review of the Algonquin Park Management Plan. Adding the remaining unprotected roadless areas and intact old-growth forest to the protected zones of Algonquin Park would likely increase the protected area of the park by only five to six percent, roughly from 35% to 40%.

The discovery of unprotected 300 to 400-year-old forest in Algonquin Park is a clear indication that the status quo is no longer viable. Protecting the remaining intact old growth and roadless areas in the park while leaving the majority of the park available for logging would be a considerable compromise from the complete phase-out of commercial logging in the park urged by the Environmental Commissioner of Ontario in 2014 (ECO, 2014) and many environmental groups, and could hopefully find support among resource managers and local communities.

FIGURE 4 A TREE CORE EXTRACTED FROM A 425-YEAR-OLD TREE IN ALGOQNUIN PARK. THIS TREE IS AVAILABLE FOR LOGGING

HISTORY OF FOREST CONSERVATION POLICY IN ALGONQUIN PARK

Algonquin Park was created in 1893 with the primary purpose of protecting the headwaters of rivers draining into the Ottawa River and Georgian Bay. The Royal Commission that recommended the creation of the park intended that white and red pine continue to be logged, and allowed that mature hardwood forest might be harvested. However the report also enumerated one of the goals of the park as "the maintenance of the Park in a state of nature as far as

possible, having regard to existing interests; and the preservation of native forests therein and of their indigenous woods as nearly as practicable" (Ontario Royal Commission on Forest Reservation and National park, 1893).

For the first twenty years of the park's existence only logging of white and red pine was permitted. Logging of all species in the park was allowed after 1913. Over time this caused increasing tension between logging, recreational use of the park, and conservation. In 1968 the Algonquin Wildlands League was formed, a citizen's group that sought the end of logging in the western half of the park initially, and later for the entire park.

On October 22 1974 the Algonquin Provincial Park Master Plan was released, which created new park zoning that would protect approximately 22% of the park, while leaving 78% available for logging in the Recreation / Utilization zone. This compromise was immediately rejected by the Algonquin Wildlands League, which felt it gave inadequate weight to the protection of natural values (Killan, 1993), nevertheless this zoning would endure for almost 40 years.

In 2005, when the Provincial Parks Act was under review the Minister of Natural Resources asked the Ontario Parks Board to provide advice on how to lighten the ecological footprint of logging in Algonquin Park. In December 2006 the Ontario Parks Board submitted a proposal to the Minister that included an increase of protection from 22% to 54% of the park. This proposal was rejected by the Minister and a joint proposal of the Ontario Parks Board and the Algonquin Forestry Authority that increased protection to 35% of the park was accepted, and incorporated into the Algonquin Park Management Plan Amendment of 2013 (Ontario Ministry of Natural Resources, 2013).

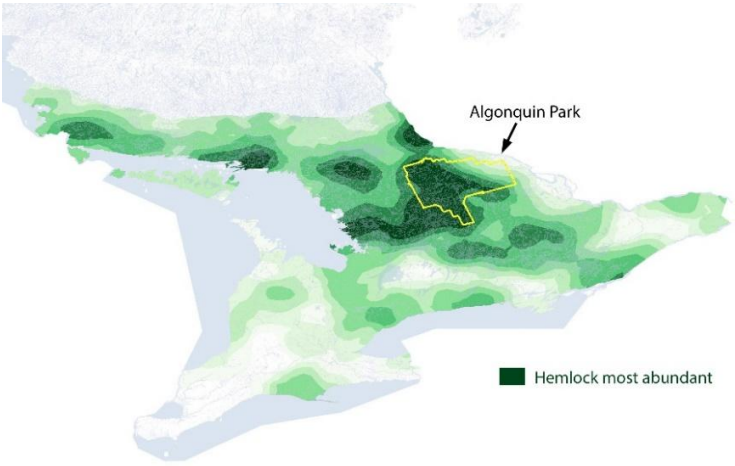
This joint proposal emphasized protection of recreational canoe routes, primarily creating a network of waterway parks within Algonquin Park, but added very little to the Nature Reserve and Wilderness zones of the park. Even the 200 meter buffer around high use canoe routes was narrowed to 120 meters in many areas as a concession to the forest industry. The joint proposal also failed to identify and protect large tracts of pristine old-growth forest, or remaining roadless areas within the park. While the joint proposal reduced the impact of logging on recreation in Algonquin Park, it failed to adequately reduce the ecological footprint of logging in the park.

The amendment will be formally incorporated into the park management plan after a review of the current management plan, which was due to occur in 2018 but has not yet taken place. As the first initiative to review and expand protection in the park in over 40 years, a detailed study of the ecological features in the recreation / utilization zone is needed, including identification and protection of the remaining tracts of old-growth forest and roadless areas. The Algonquin Old-Growth Forest Project aims to identify some of the highest priority forests for conservation, however a more comprehensive analysis should be undertaken by the province.

HEMLOCK: A FOUNDATION SPECIES IN DECLINE

Hemlock was a dominant tree at both Cayuga Lake West (47% of basal area) and Longboot Lake (63% of basal area). Algonquin Park bears a disproportionate responsibility for the conservation of hemlock forests in Ontario and globally. Although Algonquin Park makes up only 1.8% of the productive forest area of Ontario, it contains 60% of the hemlock working group over the age of 140 in the province (Henry & Quinby 2006; Figure 5).

FIGURE 5 HEMLOCK ABUNDANCE IN ONTARIO RELATIVE TO ALGONQUIN PARK



Hemlock has declined by almost 75% in the landscape adjacent to and west of the Park (Leadbitter et al., 2002) and has been virtually eliminated in many parts of southern Ontario where it was once a common forest type (Suffling et al., 2003). These changes in forest composition likely affect many other species that use hemlock forests as habitat. For example, in the northeastern United States, 96 bird species and 47 mammal species are associated with hemlock forests (Yamasaki et al., 1999).

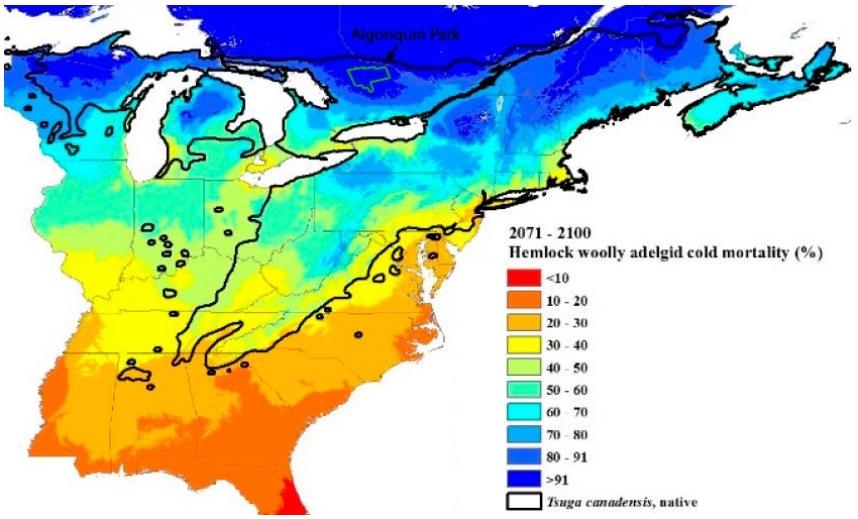
Eastern hemlock is considered a "foundation species" because of its strong influence on the environment and on other species (Martin & Goebel 2013). Although eastern hemlock can decrease productivity of terrestrial ecosystems, the unique vegetation communities found in hemlock forest understories can increase landscape-level terrestrial diversity (K. L. Martin & Goebel, 2013; Quimby, 1996).

Streams that run through hemlock forests have greater diversity of fish species, and markedly different fish and aquatic invertebrate communities compared with streams in hardwood forests. Eastern hemlock is also important in regulating stream temperature and volume of flow, and in supporting cold-water fish species such as brook trout (D. M. Evans et al., 2012; R. A. Evans, 2002; Ross et al., 2003; Snyder et al., 2002).

Numerous impacts resulting from the loss of eastern hemlock have been documented, including colonization by invasive species (Eschtruth et al., 2006), changes in invertebrate communities (Adkins & Rieske, 2013), changes in carbon cycling (Nuckolls et al., 2009), and decline or loss of habitat specialist bird species such as blackburnian warbler, black-throated green warbler, Acadian flycatcher, hermit thrush, solitary vireo, and northern goshawk(Foster et al., 2014; Quimby, 1996).

Hemlock Woolly Adelgid (HWA) is an invasive pest that kills hemlock trees in the stands that it infests. Although cold winters have hindered the spread of HWA, much of the northern range of eastern hemlock may become at risk to HWA infestation during this century due to global warming (McAvoy et al., 2017; Paradis et al., 2008; Trotter, 2010) and/or by continued evolution of cold tolerance by HWA (Butin et al., 2005; Whitmore, 2014).

FIGURE 6 PREDICTED WINTER MORTALITY OF HEMLOCK WOOLLY ADELGID 2071-2100 (MCAVOY ET AL. 2017)



Trotter (2010), in an analysis of 49 years of weather data, found that "2.2 percent of the eastern hemlock population range in the continental United States occurs in regions in which none of the included 49 years were well suited for adelgid survival; these regions are found in northern Maine, New Hampshire, and Wisconsin." However, he warned that even these refugia could be at risk due to climate change. Paradis et al. (2008) found that conditions that limited HWA spread in Massachusetts included mean winter temperature of −5°C or lower, minimum winter temperature of −35°C or lower, or when there are at least 79 days in which the average daily minimum temperature is below −10°C.

However, due to a combination of latitude and the elevation of the unique Algonquin Dome, western Algonquin Park is likely to remain a climatic refuge from HWA for decades, maybe indefinitely, and therefore has an important international role in eastern hemlock conservation. Many parts of Algonquin Park experience minimum winter temperatures of -35 to -40 degrees Celsius, which are sufficiently extreme to limit establishment, survival and spread of HWA (Paradis et al., 2008). Climate change and evolution of cold tolerance could at some point in the future make colonization of Algonquin Park by HWA possible; however even under climate change models the Park will remain a rare climatic refuge from HWA for the foreseeable future (Figure 6; McAvoy et al., 2017). Algonquin Park therefore has tremendous significance for the persistence of eastern hemlock in North America.

CARBON SEQUESTRATION

Given that the surveyed forests have high basal area of live trees, fallen logs (estimated 65 tonnes per hectare at Longboot and 28 tonnes per hectare at Cayuga Lake West), and centuries of accumulated soil carbon, significant amounts of sequestered carbon would be released if the forest was logged on a short rotation.

Old-growth forests contain centuries of accumulated soil carbon, and significant amounts of sequestered carbon would be released if the forest was logged. Since logging removes tree boles, any logging will reduce the carbon banked in live trees, logs and snags, and forest soils. Spetich et al. (1999) found a sharp decline in down wood volume from stand age 10 to 70 years as logs inherited from the previous forest decayed, followed by increasing volume between 80 and 200 years (the maximum of their study). Other authors have found continuous increases well beyond 200 years (Tyrrell & Crow, 1994; Ziegler, 2011).

The current scientific literature clearly shows that leaving old-growth forests unlogged is the best way to maximize carbon sequestration. The now debunked prediction that carbon accumulation levels off in older forests was derived largely from outdated models rather than experimental data (Lichstein et al., 2009). Over the past two decades numerous scientific studies using newly available data have made it clear that old growth forests store a large bank of carbon, and that ageing forests continue to fix significant quantities of carbon for centuries, well after entering the old-growth stage (Curtis & Gough, 2018; Gough et al., 2016; Lichstein et al., 2009; Luyssaert et al., 2008).

Curtis and Gough (2018) conclude that "new observations, ecological theory and our emerging biological understanding of temperate forest ecosystems point to sustained NEP [Net Ecosystem Production] in aging temperate

deciduous forests." In an analysis of carbon sequestration forestry in the boreal region, Pukkala (2018) concluded that low rates of cutting or no cutting were the optimal strategies to sequester carbon, and that it was not optimal to commence cutting in older forests, even after the carbon biomass stopped increasing.

Luyssaert et al. (2008) report that "The currently available data consistently indicate that carbon accumulation continues in forests that are centuries old. In fact, young forests rather than old-growth forests are very often conspicuous sources of CO2 because the creation of new forests (whether naturally or by humans) frequently follows disturbance to soil and the previous vegetation, resulting in a decomposition rate of coarse woody debris, litter and soil organic matter (measured as heterotrophic respiration) that exceeds the NPP [net primary productivity] of the regrowth."

Stephenson et al. (2014) noted that "large, old trees do not act simply as senescent carbon reservoirs but actively fix large amounts of carbon compared to smaller trees; at the extreme, a single big tree can add the same amount of carbon to the forest within a year as is contained in an entire mid-sized tree."

The scientific consensus indicates that the best way to mitigate climate change and meet Canada's international commitment to reduce greenhouse gas emissions is to leave old-growth forests undisturbed. Because Algonquin Park has a disproportionate share of old-growth forests in south and central Ontario, it bears an equally large responsibility to conserve these large carbon banks.

DECLINE OF OLD-GROWTH FOREST IN ONTARIO

Forests dominated by hemlock, sugar maple, yellow birch, and other shade tolerant species are relatively stable ecosystems that are not prone to frequent catastrophic disturbance. Stand-replacing disturbances commonly have return intervals of over 1000 years (Bormann & Likens, 1979; Frelich & Lorimer, 1991; Lorimer & White, 2003; Seymour et al., 2002; Ziegler, 2002), although non-catastrophic surface fires may have been more common than previously believed (Payette et al., 2015).

Old-growth forests have broadly declined in Ontario. In southern Ontario only trace amounts remain of this once-common forest condition (Suffling et al., 2003). In the eastern United States less than 0.5 percent of the original forest remains, not all of which is old growth. (Davis, 1996).

Western Algonquin Park would once have been dominated by old-growth forests. Within the protected zones of Algonquin Park, and scattered within the recreation-utilization zone, many old growth forests are still found with tree ages up to 400 years or more (Henry & Quinby, 2006; Henry et al., 2018; Henry & Quinby, 2018; Henry & Torenvliet, 2023; Henry, 2023b; Martin & Martin, 2009). Repeated selective harvests likely reduce the average stand age of managed forests in Algonquin Park well below historical norms – however the question of the presettlement condition of forests in the park should not be the central argument in deciding the fate of Algonquin's old-growth forests. The importance of Algonquin Park in a landscape context, as a rare (almost unique) reserve of old-growth forests in central Ontario and eastern North America as a whole, should preclude logging of any remaining old-growth forest within the park, and support a policy of allowing more mature forest to enter the old-growth stage.

BIODIVERSITY CONSERVATION IN ONTARIO

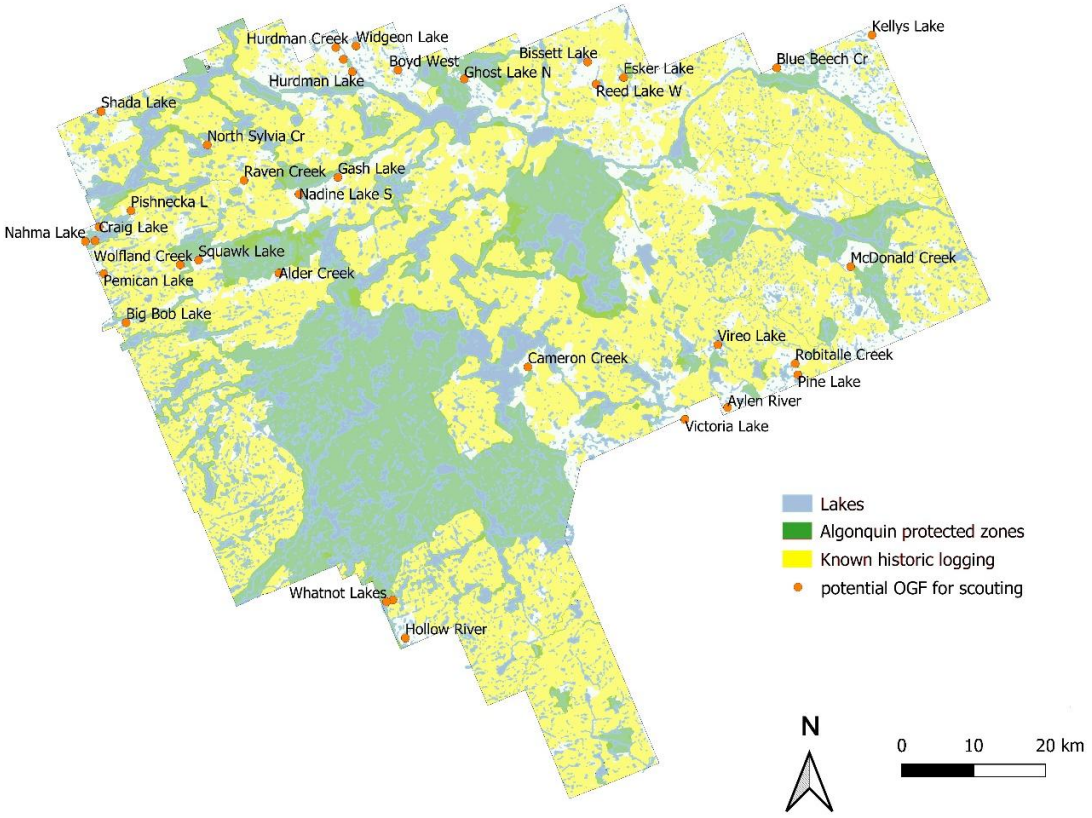
For Canada to meet its international obligations under the Convention on Biological Diversity we need to act with vision. Canada failed to meet Target #1 of its 2020 Biodiversity Goals and Targets, that "By 2020, at least 17 percent of terrestrial areas and inland water, and 10 percent of coastal and marine areas, are conserved through networks of protected areas and other effective area-based conservation measures." By 2020 only 13 percent of Canada's land was protected, with wide variation between provinces. Ontario and Newfoundland both received the lowest grade (F) In a report card by the Canadian Parks and Wilderness Committee (CPAWS, 2021), with Ontario adding less than one percent protected area, for a total of 10.7 percent. In 2020 the Auditor General of Ontario found that "the province is

not identifying lands and establishing new provincial parks and conservation reserves in fulfilment of its legislative responsibilities under the Provincial Parks and Conservation Reserves Act, 2006" Adding the remaining unprotected roadless areas and intact old-growth forest to the protected zones of Algonquin Park would only increase the protected area of the park from 35% to around 40% which represents the minimum commitment to protecting biodiversity in the park and meeting Ontario's obligations under the Convention on Biological Diversity.

FUTURE RESEARCH

While large portions of the park are known to have been historically logged, many potential old-growth forests remain. Figure 3 shows some potential old-growth forests that were selected based on absence of known roads or railways, lack of known logging, and old-growth age on 1987 forest resource inventory maps. This does not represent all potential old growth, but rather a selection of some of the most promising candidates for scouting.

FIGURE 3 SOME POTENTIAL OLD-GROWTH FOREST SITES IN ALGONQUIN PARK



CONCLUDING THOUGHTS

Logging of old-growth forest and roadless areas in Algonquin Park clearly undermines the ecological integrity of the park. A strategy for protecting remaining old-growth forest and roadless areas in the park should be included in the next review of the Algonquin Park Management Plan. Adding the remaining unprotected roadless areas and intact old-growth forest to the protected zones of Algonquin Park would likely increase the protected area of the park by only five to six percent, from 35% to around 40%.

A review of the Algonquin Park Management Plan was scheduled for 2018 (ECO, 2014) but has not occurred. When this review occurs a strategy for properly identifying and protecting remaining old-growth forest and roadless areas in the park should be included. Protection of extremely high-quality old growth such as is found at Cayuga Lake West should not be at the discretion of forest managers; this and other high value areas should be identified and incorporated into the protected zones of Algonquin Park.

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