ALGONQUIN PARK'S UNPROTECTED OLD-GROWTH FOREST AND ROADLESS AREAS

A status report

MICHAEL HENRY, 2025

SUMMARY

Between 2022 and 2024 we used rapid survey methods and volunteer data collection to confirm five unprotected old-growth forests in the park, including an intact 427-year-old forest at Cayuga Lake, and a 354-year-old forest at Brain Lake that is allocated to be logged by 2031. We also confirmed that the Hurdman Creek roadless area, which is over 6000 ha in size and only 13% protected, appears to be largely pristine and contains significant old-growth stands. The Brain Lake old-growth forest, currently allocated for logging, is within the Hurdman Creek roadless area.

Average ages from our five old-growth site surveys range from 187 to 276 years. Maximum ages (the oldest tree aged in the forest) range from 254 to 427 years. An average age of at least 150 years and a maximum age of at least 250 years should be considered as indicators of high quality old-growth forest.

Basal area for our stands ranges from 30 to 38 m^2/ha. Basal areas in old-growth forests of eastern North America are extremely variable, ranging from under 23 to 48, but 29 m^2/ha has been suggested as indicative of primary old growth forest. However many factors other than stand age affect basal area of a site.

Log volume tends to increase with stand age and can be a good indicator of old-growth forest. Volume of dead wood in forests is correlated with biodiversity and presence of rare species, and logs sequester large amounts of carbon both directly, and by increasing soil organic matter as they decay. We found log volumes between 58 and 137 m^3/ha. Log volumes are highly variable in old-growth forests, but a volume of over 40 m^3/ha is likely a good indicator of old growth.

All the inventoried sites had at least a few century-old white pine stumps. Virgin, undisturbed forest have no stumps; but based on our results and a review of the literature, less than 6 stumps/ha indicates an intact forest with very low human disturbance. Between 6 and 50 stumps/ha may qualify as old-growth forest with human disturbance if other characteristics of old-growth forest are present. Only one of our sites had over 6 stumps/ha.

There are 163,508 ha of roadless area in Algonquin Park (21.4% of the park). Of this 40,746 ha is unprotected, which is 5.3% of the park. It seems likely that expanding from the current 35% protection to 40-45% protection would adequately protect the remaining roadless and intact old-growth forest areas.

In our surveys hemlock was a dominant tree at Brain Lake, Cayuga Lake West and Longboot Lake. Algonquin Park bears a disproportionate responsibility for the conservation of hemlock forests in Ontario, with 60% of the hemlock forest over the age of 140 in the province found in the park. Even under climate change models the Park will remain a rare climatic refuge from hemlock woolly adelgid for the foreseeable future and therefore has tremendous significance for the conservation of eastern hemlock globally.

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 more than half the park available for logging would be a compromise that could hopefully find support from resource managers, local communities, environmental NGOs, and the public at large.

INTRODUCTION

The Algonquin Park Old-Growth Forest Project was officially launched in 2022, but it has its roots as far back as 2006, when we realized that centuries-old unprotected old-growth forest is found in Ontario's flagship park and is very poorly documented. Forest Resource Inventory and historic logging maps tell us where old-growth forest may occur, but because map data can be undependable, we needed to conduct field studies to ground truth the maps. Research in 2006 and 2018 showed that we were on the right track (Henry & Quinby, 2006; Henry et al., 2018; Henry & Quinby, 2018), but was too anecdotal to prove the existence of intact old-growth forest.

Between 2022 and 2024 we used rapid survey methods (Henry, 2023a) and volunteer data collection to confirm five unprotected old-growth forests in the park. The results show that Algonquin Park's unprotected forests include the internationally significant, intact old-growth forest found at Cayuga Lake, with tree ages up to 427 years old. Old-growth forests up to 354 years-old are found at Brain Lake, which is allocated to be logged by 2031. Brain Lake is also within the Hurdman Creek roadless area, which is over 6000 ha in size, and only 13% protected.

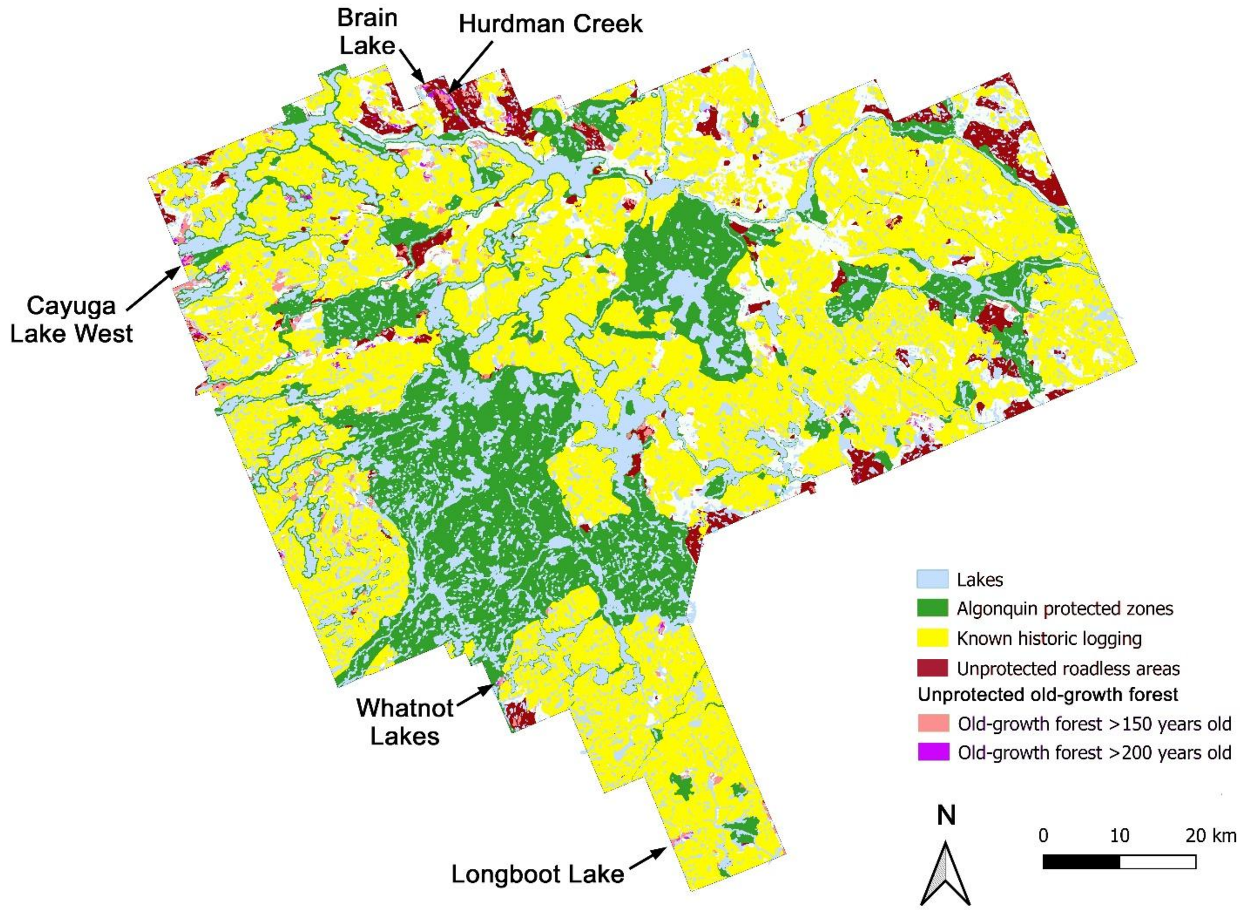
More than 30 other potential old-growth sites are found in the park.

FIGURE 1 NATE TORENVLIET AGEING A HEMLOCK AT CAYUGA LAKE WEST

OLD-GROWTH FOREST SURVEY RESULTS

Our rapid surveys collected data on tree basal area, diameters, and ages; snag basal area and diameter; fallen log volume and diameter; and stumps from historic logging. We then compared the data from our candidate forests with known old-growth forests in eastern North America. All five of these forests qualified as old growth using all of the metrics for comparison, sometimes ranking among the best quality old-growth forests in eastern North America.

FIGURE 2 SURVEY SITES, OLD-GROWTH FOREST AND ROADLESS AREAS IN ALGONQUIN PARK



Tree ages

Average ages from our rapid surveys in Algonquin Park's unprotected forest were calculated by aging at least one tree, selected for age characteristics, every 150 meters along one or more transects in the stand. Averages from the five old-growth sites range from 187 to 276 years. Maximum ages, the oldest tree aged in the forest, range from 254 to 427 years (table 1). While these were the oldest trees they were not isolated individuals, but rather were part of a cohort of similarly aged trees. For this reason the maximum age is likely the best indicator of stand age, or year of origin. However all stands were complex, often patchy, with variation across topographic gradients and likely multiple localized disturbances over centuries, so both maximum and average age provide valuable information.

By comparison stand ages from more than 80 old-growth forests in the northeastern United States and Canada are shown in table 1, ranging from 124 to more than 400 years old. The method of aging the forest is always influential on the resulting age determination, and makes comparison difficult, however it seems conservative to suggest that an average age of at least 150 years and a maximum age of at least 250 years should be considered as indicators of high quality old-growth forest.

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

Source	Max. age	Mean age	Location	
(Henry & Torenvliet, 2024)	354	273	Brain Lake, northern Algonquin Park, ON	Algonquin Park Old-growth Forest Project
(Henry, 2024)	254	187	Hurdman Creek, northern Algonquin Park, ON	
(Henry & Torenvliet, 2023)	427	263	Cayuga Lake, NW Algonquin Park, ON	
(Henry, 2023b)	338	211	Longboot Lake, south Algonquin Park, ON	
(Henry, unpublished data)	313	276	Whatnot Lakes, southwest Algonquin Park, ON	
(Henry et al., 2018)	408	294	Cayuga Lake, NW Algonquin Park, ON (preliminary results)	
Henry & Quinby, 2018)	295	232	Hurdman Creek, N Algonquin Park, ON (preliminary results)	
(Després et al., 2014)	272	141	11 hardwood forests in Temiskaming, QC, Canada	
(Ziegler, 2011)	253-390		12 OG hemlock forests in Adirondack Park, NY, USA	
(Keeton et al., 2007)		205-410*	10 old-growth forests in western Adirondack Park, NY, USA	
(Henry & Quinby, 2006)	433	287	6 old-growth sites in Algonquin Park, ON	
(Stewart et al., 2003)	333	188	4 old-growth forests in NS, Canada	
(Hale et al., 1999)		124-172	11 maple-basswood forests > 120 years old in MN, USA	
(Hale et al., 1999)		128-164	7 oak forests >120 years old in MN, USA	
(Vasiliauskas, 1995)	454	154	1,576 hemlock tree cores in Algonquin Park, ON	
(Tyrrell & Crow, 1994)	374	267	25 OG hemlock forests in WI, MN, USA	

* Due to the methods used this may represent maximum ages better than average age

BASAL AREA OF TREES AND SNAGS

Basal area was surveyed using a prism (BAF2), with results ranging from 30 to 38 m^2/ha. Basal areas in old-growth forests of eastern North America are extremely variable, ranging from under 23 to 48, with 28 to 36 being more typical. Keddy and Drummond (1996) reviewed 10 studies in old growth forests from 1958-1991 and proposed basal area over 29 m^2/ha as being the normal condition of primary old growth forest. Many factors other than stand age affect basal area of a site: conifers typically have higher basal area than hardwoods, and growing conditions also affect basal area, including latitude. The five sites that we surveyed all have a varying proportion of conifers, especially hemlock, and are also farther north and may have worse growing conditions than many of the sites in the literature. It's hard to know the extent to which these variables may each other out.

TABLE 2 BASAL AREA OF OLD-GROWTH FORESTS IN EASTERN NORTH AMERICA

Source	Tree BA (m^2/ha)	Snag BA (m^2/ha)	Location	
(Henry & Torenvliet, 2024)	30	3	Brain Lake, northern Algonquin Park, ON	Algonquin Park Old-growth Forest Project
(Michael Henry, 2024)	34	3	Hurdman Creek, northern Algonquin Park, ON	
(M Henry & Torenvliet, 2023)	37	6	Cayuga Lake, NW Algonquin Park, ON	
(Henry, 2023b)	30	3	Longboot Lake, south Algonquin Park, ON	
(Henry, unpublished data)	38		Whatnot Lakes, southwest Algonquin Park, ON	
(Després et al., 2014)	22.6	10.1	11 OG hardwood forests in Temiskaming, QC, Canada	
(Shuter et al., 2010)	27.5	5.7	Haliburton Forest, ON	

(Keeton et al., 2007)	33	8	10 old-growth forests in Adirondack Park, NY
(Stewart et al., 2003)	48	4.9	4 old-growth forests in NS, Canada
(Spetich et al., 1999)	28	3	12 old-growth sites in IN, IL, MO, and IA
(Larson et al., 1999)	36		35 heritage (OG) woodlands in southern Ontario
(Hale et al., 1999)	31		11 OG maple-basswood forests >120 years in MN
(Hale et al., 1999)	32		10 oak forests >120 years old in MN
(Keddy & Drummond, 1996)	29		Average from 10 studies in eastern North America
(Leak & Leak, 1987)	36		5 old-growth forests in NH, USA

Fallen Logs

Log volume tends to increase with age in old-growth forests and can be a good indicator of old-growth condition.

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). Kunttu et al. (2015) examined several approaches to using deadwood as a measure of "naturalness" and found that volume of dead wood is the most reliable measure overall.

Volume of dead wood in forests is not just a convenient indicator of old growth (or naturalness) but is also correlated with biodiversity and presence of rare species (Martikainen et al., 2000; Parajuli & Markwith, 2023; Stokland et al., 2012; Thompson et al., 2003). Logs also sequester large amounts of carbon both directly, and by increasing soil organic matter as they decay (Błońska et al., 2019; Lutz et al., 2021; Magnússon et al., 2016; Russell et al., 2015).

TABLE 3 LOG VOLUME AND DIAMETER IN OLD-GROWTH FORESTS OF EASTERN NORTH AMERICA

<table>
<tr><th>Source</th><th>Volume (m³/ha)</th><th>Mean Dia. (cm)</th><th colspan="2">Location</th></tr>
<tr><td>(Henry & Torenvliet, 2024)</td><td>70.3</td><td>24</td><td>Brain Lake, North Algonquin Park, ON</td><td rowspan="5">Algonquin Park Old-growth Forest Project</td></tr>
<tr><td>(Henry, 2024)</td><td>93.4</td><td>30</td><td>Hurdman Creek, North Algonquin Park, ON</td></tr>
<tr><td>(Henry & Torenvliet, 2023)</td><td>57.9</td><td>26.4</td><td>Cayuga Lake, Northeast Algonquin Park, ON</td></tr>
<tr><td>(Henry, 2023b)</td><td>137</td><td>32.7</td><td>Longboot Lake, Southern Algonquin Park, ON</td></tr>
<tr><td>(Henry, unpublished data)</td><td>113</td><td>36</td><td>Whatnot Lakes, southwest Algonquin Park, ON</td></tr>
<tr><td>(Shuter et al., 2010)</td><td>58.5</td><td></td><td colspan="2">Haliburton Forest, ON</td></tr>
<tr><td>(Keeton et al., 2007)</td><td>163.6</td><td></td><td colspan="2">10 old-growth forests in Adirondack Park, NY</td></tr>
<tr><td>(Stewart et al., 2003)</td><td>66.3</td><td></td><td colspan="2">4 old-growth forests in NS, Canada</td></tr>
<tr><td>(Ziegler, 2000)</td><td>126</td><td></td><td colspan="2">12 OG hemlock forests in Adirondack Park, NY</td></tr>
<tr><td>(Spetich et al., 1999)</td><td>60.4</td><td></td><td colspan="2">12 old-growth sites in IN, IL, MO, and IA</td></tr>
<tr><td>(Larson et al., 1999)</td><td></td><td>31.7</td><td colspan="2">35 heritage (OG) woodlands in southern Ontario</td></tr>
<tr><td>(Hale et al., 1999)</td><td>55 (12-121)</td><td></td><td colspan="2">11 OG maple-basswood forests >120 years in MN</td></tr>
<tr><td>(Hale et al., 1999)</td><td>48 (21-68)</td><td></td><td colspan="2">10 oak forests >120 years old in MN</td></tr>
<tr><td>(Tyrrell & Crow, 1994)</td><td>54</td><td></td><td colspan="2">25 OG hemlock forests in WI, MN USA</td></tr>
</table>

STUMPS IN OLD-GROWTH FORESTS

All of the inventoried sites had at least some 80-100+ year-old white pine stumps, while two sites had more recent (60-90 year-old) stumps. The average is 7.2 stumps/ha for all sites (table 4), with the lowest being Hurdman Creek (2.7), and the highest Longboot Lake (19.2), which was the only site that had more than 6 stumps/ha.

There is a relative paucity of comparative data on cut stump density in old-growth forests, but some studies are summarized in table 4. Tyrrell & Crow (1994) selected 25 old-growth hemlock-hardwood stands based on several criteria including relative lack of human disturbance, and surveyed an average density of cut stumps of 16.5 stumps/ha, with a range from 0 to 44.4 stumps/ha. Only 5 stands (20%) had no stumps. Kuusinen & Siitonen (1998) found that old-growth forests had between 0 and 6 stumps/ha, with an average of 2.8; by contrast managed late mature forests had an average of 247 stumps/ha. Kunttu et al. (2015) found 5.8 stumps/ha in the top 10% most "natural" of the sites that they surveyed; the average from all sites was 40.2 stumps/ha.

Virgin, undisturbed forest should have no stumps; but based on the limited data, fewer than 6 stumps/ha likely indicates an intact forest with low human disturbance. Between 6 and 50 stumps/ha would be compatible with old-growth forest under some definitions but indicates a moderate level of human disturbance. Stump density is most useful in forests with a limited window of logging history, or that are relatively dry and conifer dominated. Conifer stumps will persist for at least a century and potentially much longer on dry sites. Large hardwood stumps will remain for 60-90 years or more, smaller stumps will decay sooner. Algonquin Park has a relatively short history of hardwood logging, starting in 1913 but increasing in the 1930s for yellow birch, and the 1940s for sugar maple, so stumps should be visible from most of the logging that has occurred in the park. Early hardwood logging, where stumps would be highly decayed, was often concentrated along railways.

TABLE 4 STUMP DENSITY IN OLD-GROWTH FORESTS

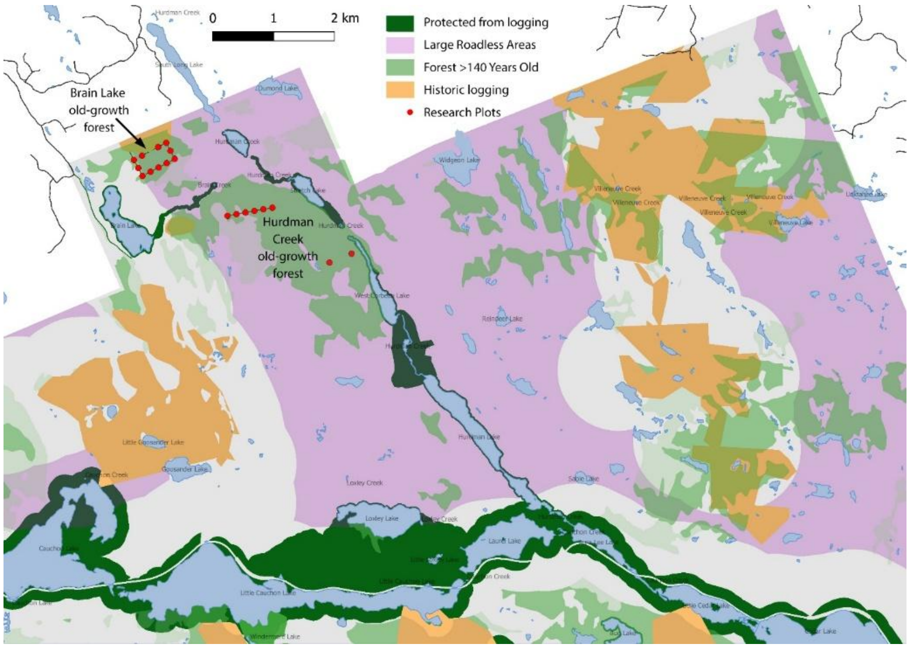
Source	Stumps/ha	Location	
(Henry & Torenvliet, 2024)	5	Brain Lake, North Algonquin Park, ON	Algonquin Park Old-growth Forest Project
(Henry, 2024)	2.7	Hurdman Creek, North Algonquin Park, ON	
(Henry & Torenvliet, 2023)	5.2	Cayuga Lake, Northeast Algonquin Park, ON	
(Henry, 2023b)	19.2	Longboot Lake, Southern Algonquin Park, ON	
(Henry, unpublished data)	5	Whatnot Lakes, southwest Algonquin Park, ON	
(Kunttu et al., 2015)	5.8	Top 10% "naturalness" index, of 40 islands in Finland	
(Kunttu et al., 2015)	15.2	Top 20% "naturalness" index, of 40 islands in Finland	
(Kuusinen & Siitonen, 1998)	2.8	Average from 5 OG spruce forests in Finland	
(Tyrrell & Crow, 1994)	16.5	Average from 25 OG hemlock forests in WI, MN USA	

BRAIN LAKE AND HURDMAN CREEK

Brain Lake has high quality old-growth forest that is allocated for logging in the 2021-2031 forest management plan. The average age from plots at Brain Lake is 270 years while the maximum age is 354 years. It is at the leading edge of the largest unprotected roadless area remaining in Algonquin Park. The majority of the transects had no stumps, but stumps from multiple species estimated to be >60 years old were found at the north end, closest to the park boundary.

Hurdman Creek old-growth forest is part of a very extensive roadless area at the north end of Algonquin Park, containing large tracts of old-growth forest. We inventoried stands within the unprotected forest in 2024 and found an average age of 187 years and maximum age of 254 years old. A 2018 preliminary survey in nearby stands found trees up to 295 years old, and the oldest black ash tree on record for Ontario at 219 years old (Henry & Quinby, 2018). The Hurdman Creek old-growth forest is part of a 6600 ha roadless area, the fifth largest roadless area in Algonquin Park and the only one over 5000 ha that is almost entirely unprotected. The surveyed areas are within 377 hectares of contiguous old growth adjacent to Hurdman Creek. This large old-growth forest within a very large roadless area is highly significant.

FIGURE 3 BRAIN LAKE AND HURDMAN CREEK SURVEY SITES

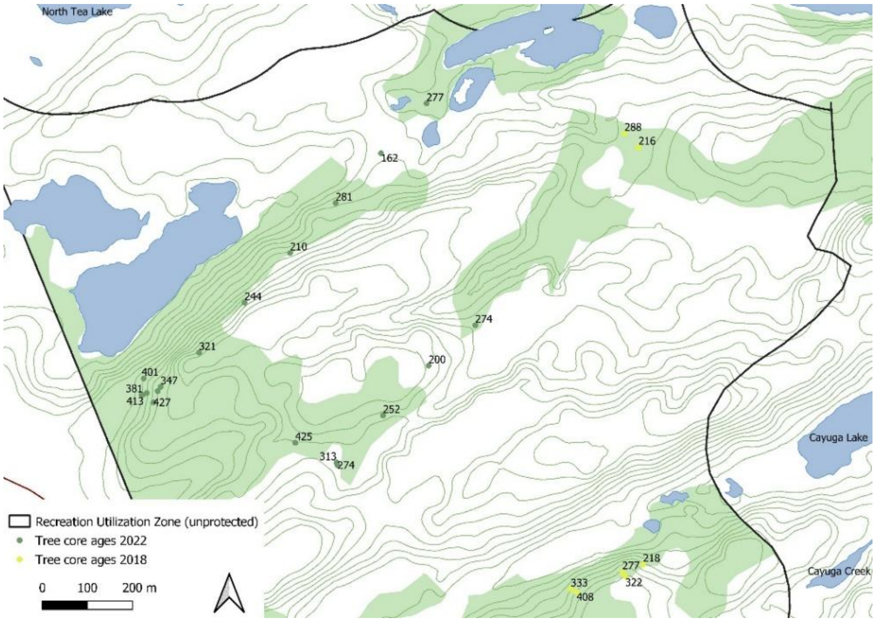


WHATNOT LAKES

This pocket of unprotected old-growth forest east of Dividing Lake has old-growth forest reaching at least 313 years old, with basal areas of 38 and few signs of historic logging. Only three plots were surveyed, so results aren't conclusive, but suggest that a remnant of old growth should be added to the Dividing Lake nature reserve. Historic wind events have impacted parts of the old-growth forest (Henry, unpublished data).

CAYUGA LAKE

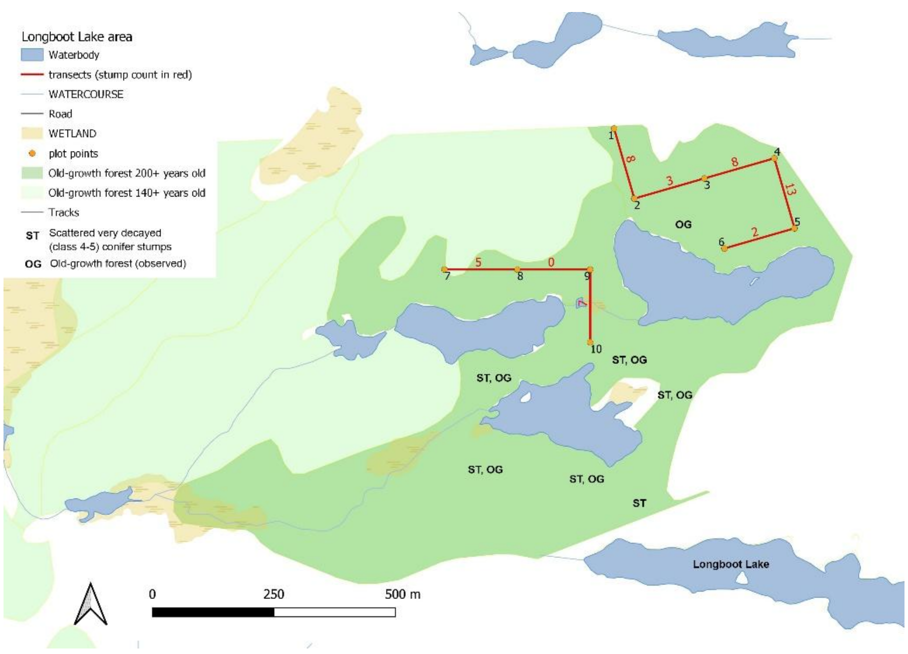
FIGURE 4 TREE AGES IN CAYUGA LAKE OLD-GROWTH FOREST



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).

Longboot Lake

FIGURE 5 LONGBOOT LAKE PLOTS AND TRANSECTS



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). Although this forest has limited logging history, it is much older and more intact than surrounding forests and is a rare remnant of old-growth forest in the Algonquin panhandle. Longboot Lake also has good growing conditions, large trees (many over 70 cm diameter), and a high volume of fallen logs, making it feel more like old growth to the casual observer than some of our older, more pristine forests on poorer sites.

FIGURE 6 UNPROTECTED OLD-GROWTH HEMLOCK FOREST NORTH OF LONGBOOT LAKE

QUALITY OF DATA

When the Algonquin Old-Growth Forest Project was initiated, we were working with historical logging data with many holes in it, which resulted in us identifying candidate areas that had been impacted by logging. We've received better data since, but logging from before around 1950-1960 is spotty or absent from GIS records. Some of the smaller roadless areas we've visited have signs of logging more than 60 years ago, while others such as Cayuga Lake and Hurdman Creek have turned out to be pristine and very old. Most of the large roadless areas still need ground truthing.

The 1987 FRI data has been surprisingly accurate when compared to average stand ages, but the newer 2021 FRI data dramatically underestimates stand ages for all our old-growth sites. Stand ages on the 2021 FRI data are often half of the average stand age from field studies, and can be as low as one quarter of the maximum age, making it all but useless in locating the oldest forest stands in Algonquin Park. The older FRI data should be the benchmark for locating and describing old-growth forest in Algonquin Park.

Because road data for Algonquin Park is carefully guarded, the roadless areas provided by Ted Elliott (from Quinby et al. 2022) is the best available to us. It is generally accurate, but seems to omit some roads that occur outside the park, so roadless areas along the park boundary merit extra scrutiny. In rare cases records of logging within the park overlap with roadless areas.

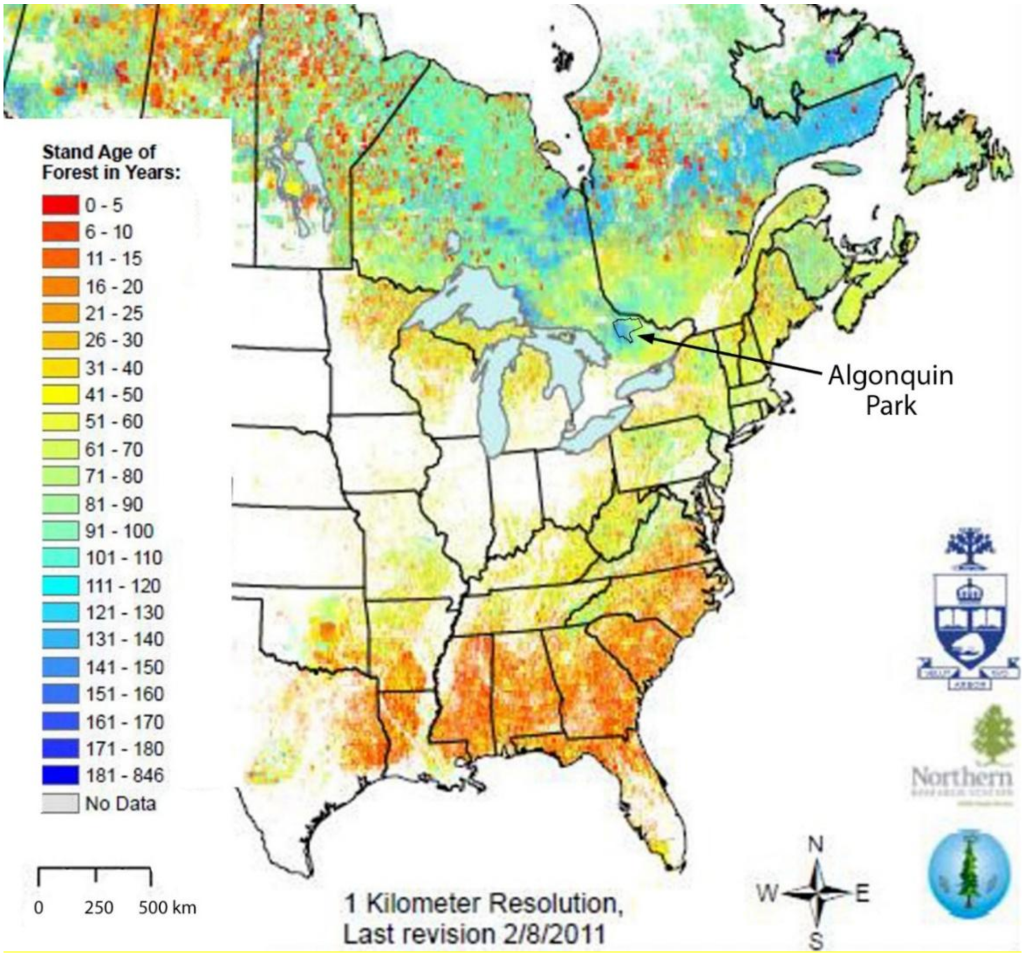
ALGONQUIN PARK OLD-GROWTH FOREST IN A NORTH AMERICAN CONTEXT

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, even unique reserve of old-growth forests in central Ontario and eastern North America as a whole (see Figure 7), 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.

FIGURE 7 STAND AGES IN EASTERN NORTH AMERICA, ADAPTED FROM PAN ET AL. (2011)



ROADLESS AREAS IN ALGONQUIN PARK

In 2006 the Ontario Parks Board stated that “the construction, maintenance and use of an extensive network of primary, secondary and tertiary roads, inevitably has significant impacts” on the environment of Algonquin Park, including the footprint of roads, and the impact of road construction; habitat fragmentation; creation of edge habitat; mining of large quantities of aggregate; introduction of invasive non-native species; pollution; animal mortality including species at risk; impairment of hydrological function; sedimentation of stream and lakes; and opportunities for unauthorized public access to fish and game (Ontario Park Board, 2006).

All remaining roadless areas in Algonquin Park should be candidates for protection but priority areas should include those that contain old-growth forest; those that are large (>300 hectares cumulative); and connections between existing protected areas. Figure 8 and Table 5 show significant roadless areas in the park – some areas are omitted because they are very small islands in a sea of managed forest or because they are at the park boundary and are impacted by adjacent roads outside the park. These omitted areas may still have high conservation value. Of the 28 significant roadless areas identified, almost 78% is protected. This may seem like a conservation success but it is not; all of the park was roadless at one time, the lack of roadless areas in the managed part of the park highlights the connection between road construction and modern logging. As logging continues to penetrate the remaining roadless areas, the percent of unprotected roadless areas will shrink ever closer to zero.

Roads have a persistent impact over many decades and are often permanent where there are repeated cycles of selective logging. Figure 9 shows a road network in Algonquin Park that is essentially unchanged over a 20-year period.

FIGURE 8 SIGNIFICANT ROADLESS AREAS IN ALGONQUIN PARK

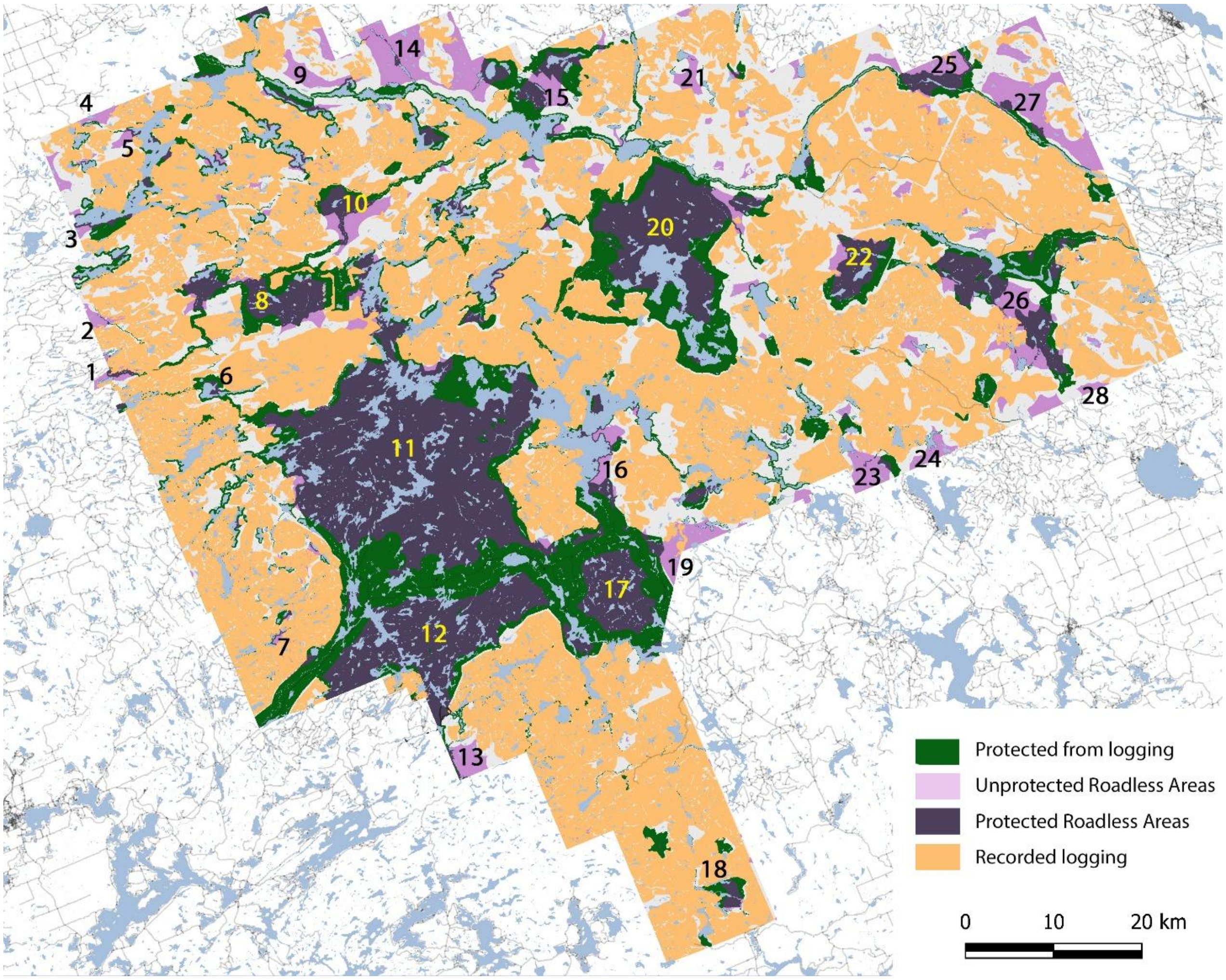


TABLE 5 SIGNIFICANT ROADLESS AREAS IN ALGONQUIN PARK

		Ha unprotected	Ha total	% Protected	Notes
1	Big Bob Lake	354	624	43.3	Some recorded logging in roadless area, but extensive old growth on FRI in remainder, needs ground truthing
2	Pemican Lake	491	517	5.0	Extensive old growth ~200 years old on FRI maps, **needs ground truthing**
3	Cayuga Lake	212	556	61.9	Extensive verified old growth, ages over 400 years (Henry and Torenvliet 2024)
4	Shada Lake	428	439	2.5	Old growth >200 years (FRI) adjacent to a canoe lake, **needs ground truthing**
5	Manitou Lake	264	326	19.0	Some old growth

6	Rosebary Lake	208	208	0.0	Boundaries of Nature Reserve miss some old-growth forest outside roadless area
7	Minnow Lake	217	399	45.6	Part of the roadless area has records of logging. Remainder contains old growth
8	Coldspring Creek	891	**5429**	83.6	Boundaries could likely extend to catch some old growth and roadless areas
9	Cauchon Lake	1148	**1255**	8.5	
10	Nadine Lake	1373	**2787**	50.7	The nature reserve has some of the oldest forest in the park. The unprotected roadless area to the south has a limited amount of old growth, including white pine, which **needs ground truthing**. Should be a priority area due to high value of the nature reserve
11	Burnt Island Lake	1356	**51327**	97.4	Algonquin Park's largest roadless area
12	Smoke Lake	49	**16721**	99.7	Algonquin Park's second largest roadless area
13	Hollow River	1092	**1232**	11.4	Contains some old-growth forest
14	Hurdman Creek	5770	**6656**	13.3	The largest unprotected roadless area in the Park, has significant verified old-growth forest 250-350 years old, and extensive virgin forest (Henry 2024)
15	Ghost Lake	872	**2528**	65.5	Protecting remaining roadless area would **connect** Chela Lake and North River Lake nature reserves, and protect some additional old-growth forest
16	Opeongo Lake	873	**1896**	54.0	Some unprotected old-growth forest
17	Pinetree Creek	0	**5905**	100.0	Fully protected
18	Byers Lake	41	548	92.5	
19	McCauley Creek	2012	**2390**	15.8	Logging appears to bisect this roadless area
20	Lake Lavielle	601	**15892**	96.2	Protecting remaining roadless area would **connect** Eustache Lake Nature Reserve to the wilderness zone
21	Bissett Lake	789	840	6.1	Includes some old growth >240 years old on FRI. **Needs ground truthing**
22	Baron Lake	527	**3163**	83.3	
23	Aylen River	1492	**1719**	13.2	
24	Robitaille Lake	779	865	9.9	Roads outside park should shrink roadless area
25	Blue Beech Creek	1721	**3096**	44.4	Tracts of old-growth white pine, rare in the Park. **Needs ground truthing**
26	McDonald Creek	3022	**7873**	61.6	Protecting the roadless area would **connect** several reserves, greatly enhance ecological integrity
27	Duff Lake	4251	**4517**	5.9	A very large area, includes tracts of old-growth red oak and oak-pine forest. **Needs ground truthing**
28	McDonald Pond	266	266	0.0	Includes tracts of red oak ~130 years old on FRI maps
	Total	**31099**	**139974**	**77.8**	

	Roadless areas with unprotected old-growth forest that has been confirmed by field surveys		Partially protected roadless areas with high ecological value for connectivity, suspected old-growth forest, or size > 1000 ha

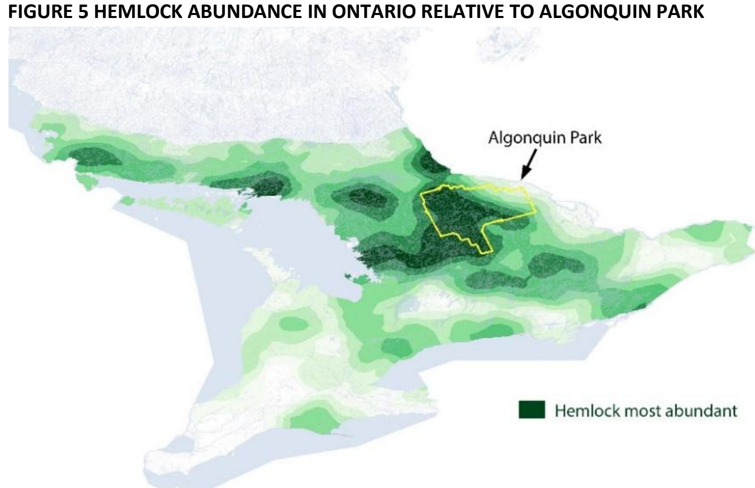
FIGURE 9 PART OF THE ROAD NETWORK NORTH OF LAKE OPEONGO, ALGONQUIN PARK, IN 2003 AND 2023.

An analysis of the roadless areas data provided by Ted Elliott shows that there are 163,508 ha of roadless area in Algonquin Park (21.4% of the park). Of this 40,746 ha is unprotected, which is 5.3% of the park, and roughly one quarter of the roadless area of the park. This presents an opportunity to address the ecological footprint of logging in Algonquin Park by protecting the remaining roadless and old-growth forest areas, while still leaving the majority of the park available for management to satisfy the needs of surrounding communities. Some very small roadless areas surrounded by logging may end up being sacrificed, while a buffer (up to 1 km) around roadless areas will prevent them from shrinking further. More work needs to be done to propose an expansion of the protected zones in Algonquin Park, but it seems likely that expanding from the current 35% protection to 40-45% protection would adequately protect the remaining roadless and intact old-growth forest areas.

HEMLOCK: A FOUNDATION SPECIES IN DECLINE

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). In our surveys hemlock was a dominant tree at Brain Lake (47% of basal area), Cayuga Lake West (47% of basal area) and Longboot Lake (63% of basal area).

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).

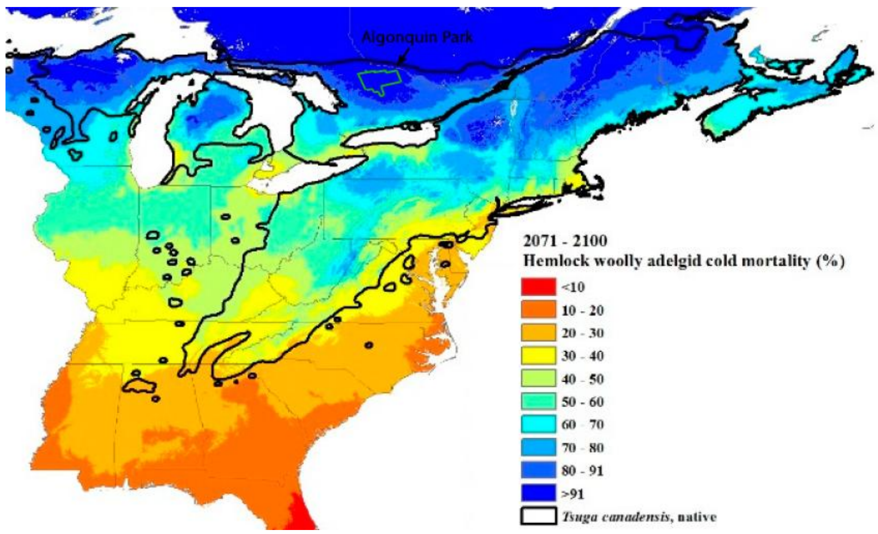
Eastern hemlock is considered a "foundation species" because of its strong influence on the environment and on other species (Martin & Goebel 2013). Although eastern hemlock can decrease productivity of terrestrial ecosystems, the unique vegetation communities found in hemlock forest understories can 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 IN ALGONQUIN PARK OLD-GROWTH FOREST

Algonquin Park’s old-growth forests store large quantities of carbon through high basal area of live trees and standing dead snags, large volumes of fallen logs, and centuries of accumulated soil carbon. In a review of forest carbon sequestration under various management scenarios, Ameray et al. (2021) conclude that “old-growth and intact forests are critical in stabilizing terrestrial C storage, maintaining biodiversity and providing other ecosystem functions.” The authors find that old-growth forests sequester large amounts of carbon in both living and dead trees, as well as in soil carbon (far more than is stored in younger forests), and that “numerous studies expect that much of this C will move back to the atmosphere if these forests are disturbed or replaced with younger forests.”

Over the past two decades many scientific studies 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.

Large roadless areas, typically dominated by mature forest that has not yet entered the old-growth stage, also store large amounts of carbon. Moomaw et al. (2019) promote proforestation as the most efficient means of sequestering carbon, which means allowing young and middle-aged forest to continue to grow into the old-growth stage. The authors state that "forestry models underestimate the carbon content of older, larger trees, and it is increasingly clear that trees can continue to remove atmospheric carbon at increasing rates for many decades beyond 100 years […] inefficient logging practices result in substantial instant carbon release to the atmosphere, and only a small fraction of wood becomes a lasting product." Models may also omit significant losses in carbon sequestration potential due to roads and landings, which averaged 14% of the formerly forested area in the Ontario's boreal forest (Hesselink, 2019).

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. 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(Ontario Park Board, 2006). 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).

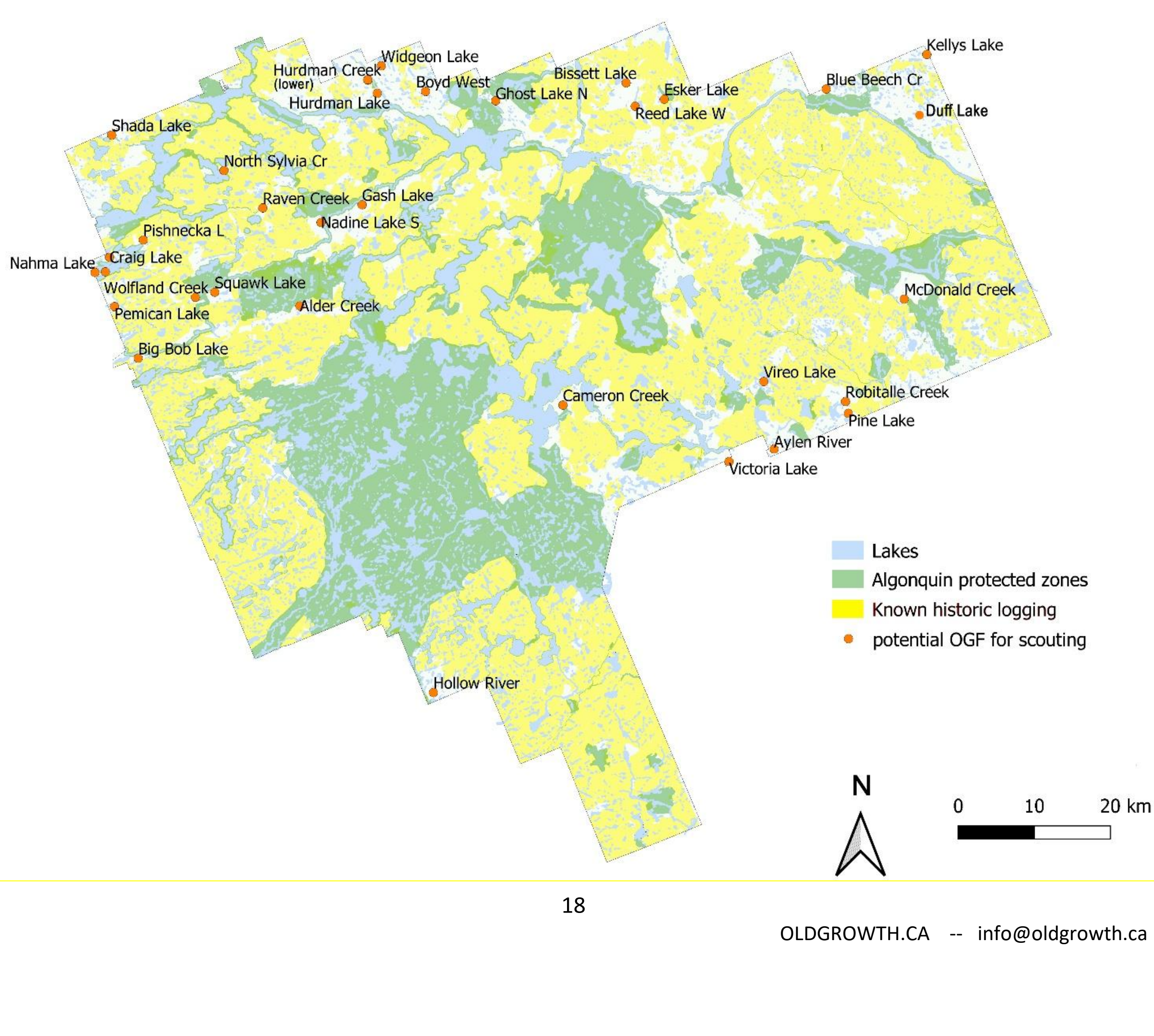
The joint proposal emphasized protection of recreational canoe routes, primarily creating a network of waterway parks within Algonquin Park, but added very little to the Nature Reserve and Wilderness zones of the park. The joint proposal also failed to identify and protect large tracts of pristine old-growth forest, or remaining roadless areas within the park. The joint proposal reduced the impact of logging on recreation in Algonquin Park but 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 has identified some of the highest priority forests for conservation, however a more comprehensive analysis should be undertaken.

FUTURE RESEARCH

While large portions of the park are known to have been historically logged, many potential old-growth forests remain. Figure 10 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 10 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 ten percent, from 35% to 40-45% protection.

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 more than half 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. Hopefully this compromise could find support from resource managers, local communities, environmental NGOs, and the public at large.

In 2022, Canada committed to protect at least 30 percent of its lands and waters by 2030, but to date Ontario has protected less than 11 percent of the province. Completing the protected areas network in Algonquin Park is a necessary step in meeting Canada's commitments under the Convention on Biological Diversity.

FIGURE 11 A TREE CORE EXTRACTED FROM A 425-YEAR-OLD TREE IN ALGOQNUIN PARK. THIS TREE IS AVAILABLE FOR LOGGING

ACKNOWLEDGEMENTS

This work would not have been possible without support from the Wilderness Committee, Nadurra Wood Corporation, Ian Jackson, Susan Gibson, numerous small donors, and the work of many fantastic volunteers.

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