Evaluating a stand of potential old growth white pine-hemlock forest

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ABSTRACT

An old growth forest is a stand of forest that has escaped the direct influence of humans following European settlement in North America, contains multiple snags and trees of a relatively old age, pit and mound topography due to decaying tree stumps and logs, and high shade. White pine (*Pinus strobes)* and hemlock (*Tsuga canadensis)* are commonly found together in northern hardwoods forests. Because of the white pines high timber value, the Northwoods of Wisconsin and the Upper Peninsula of Michigan were cleared by loggers in the late 1800s and early 1900s. Following this, forest fires decimated what little forest was left. Sometime in the early 1900s, Martin J. Gillen bought several thousand acres of land along the Michigan and Wisconsin border, which he later donated to the University of Notre Dame. That property is now the University of Notre Dame Environmental Research Center (UNDERC) and is closed to logging. However, the forest reflects the past logging history. A patch of white pine-hemlock forest exists near Plum Lake and Brown Creek that contains, according to the UNDERC website, old growth white pines. This study investigated that claim by looking at forest layer composition, tree age, and stumps. Because of the young age of the hemlock trees, the presence of cut stumps, and logging related artifacts, the site is not an old growth forest.

INTRODUCTION

An old growth forest – more than just old age

Old growth. Virgin. Primeval. Pre-European settlement. These are several terms used interchangeably to describe a distinctive type of forest characterized by relatively old trees, little direct human disturbance post-European settlement, multiple snags, a stable forest community, and characteristic mounds and pits created by decayed logs and stumps (Kricher 1988; Tyrrell and Crow 1994; Foster et al. 1996). Though trees in old growth forests often can be large in height and trunk width and are spaced relatively far apart, they do not necessarily have a large diameter nor are they particularly tall (Henry and Quinby 2006). Instead, they have numerous growth rings to indicate an age greater than half of the possible maximum age for that tree species (McCarthy 1995). The trees in an old growth forest frequently create a dark and heavily shaded understory (Kricher 1988).

Some trees, like the late successional Eastern Hemlock trees (*Tsuga canadensis*), are shade tolerant, slow growing, and long lived, allowing them to persist in the shaded understory until a gap provides enough light and space to grow into the canopy (Barnes 2002). As a result, the outer physical characteristics of a hemlock – short in height with a narrow diameter – can make it appear younger than if it is accurately aged (Kricher 1988). The early growth rings in hemlock trees usually are small (1 to 2 millimeters), but the older trees can exhibit wider rings – growth releases when the tree suddenly gained light and space – up to 8.8 millimeters (Abrams and Orwig 1996).

Contrarily, White Pine (*Pinus strobes*) is an early successional tree that usually requires high light and large disturbances in order to regenerate and grow successfully (Barnes 2002). The growth rate of early rings of an immature white pine varies based on the forest conditions at the time of establishment; trees that begin growing early on the emergent stand grow 3 to 4 millimeters a year, but trees that establish later with less light only grow 1 to 2 millimeters per year (Abrams and Orwig 1996). Nevertheless, white pine can be an important component of old-growth forests, and are commonly found in hemlock and hemlock-hardwood stands (Smith 2002; Barnes 2002). One report considers all white pines over 120 years old to be old growth trees (Wilkins 1994).

However, the term “old growth” describes an entire ecosystem that exemplifies the forest before European settlement, rather than describing the specific age of one tree (Wilkins 1994). Also, the degree of old-growth qualities within a forest can be measured along a continuum; in a hemlock dominated stand, the forest with the most “old growth quality” contains hemlock greater than 275-300 years, diameters greater than 70 centimeters, a strong correlation between age and tree diameter, and a low tree density across forest layers (Tyrrell and Crow 1994). As the stand age increases, hemlocks have a decreasing density, reaching a minimum density of 100 trees per hectare at about 300 years (Tyrrell and Crow 1994). For these reason, an examination and inquiry into the old growth status of a forest must examine not just the ages of the trees but also the forest composition.

Importance of old growth forests

Old growth forests are an important element of forest ecology because they can provide a view of the forests that existed before European influence (most importantly caused by settlement and logging). Because so much of the Great Lakes area was extensively logged and burned in the late 19^{th} and early 20^{th} century, only 5.2 to 8.3% of the remaining forests are old-growth (Frelich 1995). Old growth forests can provide a baseline for which to compare current forests in order to understand and analyze continuing ecological changes and processes (Henry 2006; Foster et al. 1996). Because of their remoteness from direct human influence, old growth forests can be indicators of changing biotic and abiotic factors (Foster et al. 1996). Studying these habitats provides unique opportunities to study natural disturbance processes, vegetation distribution, soil development, biogeochemical cycling, and ecosystem dynamics (Foster et al. 1996).

Mature trees are important sources of seeds for regeneration and genetic diversity for developing and maintaining resistance to adverse conditions (Dickmann and Leefers 2003; Henry and Quinby 2006). Without a diverse gene pool, a tree species can lose its ability to extend its geographic range and adapt to different climates and habitats (Dickmann and Leefers 2003), which is ever more important in light of global climate change. When a forest is logged, all seeds regardless of fitness are removed along with the tree, failing to pass along and enhance the genetic diversity and fitness of the species; however, when a tree falls naturally due to wind, fire, or a pathogen, the seeds of the surviving trees pass along the favorable qualities. The diverse gene pool that can accumulate in old growth stands, forests untouched by loggers or settlers, is important for continued regeneration (Henry and Quinby 2006).

Likewise, unique and specialized animal species can develop and find their niche in old growth forests (Kassulke 2004). The white pine, unlike other tree species, shows greater diameter growth as it grows older (Abrams and Orwig 1996) and can grow two and a half feet or more in a good year (Smith 2002), often pushing the crown of a mature white pine above the tree line. This prominent canopy position is a preferred nesting spot of bald eagles, in particular (Smith 2002). Old-growth white pine, as well as red pine, is the preferred habitat of the pine warbler (Carmean 2004).

The largest living white pine in Michigan is in the Porcupine Mountains along Lake Superior and has a diameter of 140 centimeters at 2 meters from the base and rises 39.6 meters above the ground (Dickmann and Leefers 2003). More often, white pine reaches a breadth of 79 to 106 centimeters and a height of 21 to 32 meters, though loggers used to report trees 132 to 185 centimeters in diameter and from 40 to 53 meters tall (Smith 2002).

Forest history – logging, fires, and regrowth

The land of northern Wisconsin and the Upper Peninsula of Michigan was carved by the receding glaciers 14,000 years ago (Flader 1983; Dickmann and Leefers 2003). The glacial outwash left behind a rocky and sandy soil marked by distinct ridges, lakes, and bogs, formed from the glacial moraines and the kettle lakes (Flader 1983). White pine made its way northwest from the Appalachian mountains, establishing its present range around 4,000 years ago (Delcourt and Delcourt 1987). Hemlock was centered around what is now Tennessee at the end of the last ice age, and then migrated northeast into New England and then across Michigan to Wisconsin before reaching its current spread about 500 years ago (Delcourt and Delcourt 1987).

White pine first became popular in the old world in the 1800s for its sailing ship potential. With its long slender trunk and crown limited to the highest branches, white pine was ideal for the ship masts. The royal crown of England exploited the white pines of the new colonies in North America to build and stock their armadas, so much so that the tree became known as “mast pine” (Wilkins 1994).

The extensive trunk made white pines valuable as timber as well because a high percentage of the tree was free of branches and usable for logs. 500 board feet of timber could be harvested from a mature white pine (Wilkins 1994). When loggers discovered the vast quantities of white pine available in the Northwoods of Wisconsin and Michigan, logging camps and companies rushed to the area beginning in the late 1800s. Because of its high timber value, whole stands of hardwood forests were sometimes cleared to reach a few white pines (Visitors Guide).

Loggers did not care as much about hemlock. The bark was used for tanning leather, but the rest of the tree was often wasted, left rotting in the forest, until the abundance of more preferred tree species became limited (Barnes 2002; Dickmann and Leefers 2003).

Along with the rejected branches and stumps, the hemlock trunks formed piles of slash across northern Wisconsin and Michigan. Settlers set fire to these piles of slash in order to clear the land and make it farmable. Fires were also set inadvertently by wood-powered steam engine trains as sparks flew from the metal tracks or embers belched out of the smokestack, lighting upon the dry and flammable slash. The slash was like a kindling box, and forest fires commonly burned across Wisconsin and Michigan. This hindered the self-reforestation because the intensely hot fires burned up the seed bank that was left sitting amongst the slash. The charred earth took a while to recover.

Logging history of UNDERC

Martin J. Gillen was a prominent economist and lawyer in the early part of the 20th century (Gillen 1943; Belovsky 2008). Reports conflict on when Gillen first acquired the property that now makes up the University of Notre Dame Environmental Research Center. His obituary says that he arrived in northern Wisconsin in 1906 and purchased the property, which at that time (1943) consisted of 6,000 acres (Gillen 1943). Another source says that he bought the land in 1913 from Marathon Lumber Company (Belovsky 2008). He closed the land to the public and only logged what he selectively chose for his private buildings clustered around Kilarney Point (Belovsky 2008). In 1936, he gave Notre Dame 500 acres of forested land in Wisconsin and “5,000 acres of timber and cutover land” in the Upper Peninsula of Michigan (Gillen 1943). In 1936, the University bought 1,863.85 acres from the William Bonifas Lumber Company (Schidel 1995). It is unclear from these limited records how much timber had been logged from these lands or what the original extent of the plots was.

A 1949 paper by Forest Stearns compares the white pine-hemlock area south of Plum from 1946 to the original surveys taken from 1857-59 by Surveyor James McBride. Stearns found only two white pines in the stands in 1946, but both were 25 inches or greater in diameter. The land surveyor's results in 1857-9, however, showed a diversity of white pine diameters: 2 trees were 7-12.9inches, 2 trees were 13-18.9inches, 4 trees were 19-24.9inches and 4 trees were 25in.and over (12 trees total). He describes the strong influence that windfall has on stand composition, but does not mention any stumps, cut or otherwise. Therefore, it seems that Stearns did not find evidence of white pine logging.

Notre Dame Archives reveal that logging took place at several stands on the UNDERC property between 1955 and 1967; one of these stands is located along Plum Lake, but the exact date is unclear (See Figure) (Holland 2006). The archival documents mention eastern hemlock and white pine, among other species, as being cut in 1958, 1960, 1961, 1963, and 1964 without specifying where or when these specific cuts occurred (Holland 2006).

A 2003 study of the UNDERC property logging history found that an even-aged stand of sugar-maple dominated forest located 0.3 miles east of the intersection of the Plum Lake road and the main road and along an old logging road was approximately 90 years old (Mahon), suggesting that it was clear cut in 1913. The study also found a patch of hemlock dominated forest about 75 years old located on Plum Lake road. The oldest hemlock in this stand was 100 years old, and the oldest red pine was about 70 years old. Possible old logging roads were considered to be any cleared area that reached far into the tree line, overgrown with tall grasses, ferns, and successional trees like *Populus tremuloides,* Quaking Aspen (Mahon 2003).

Site description

According to its information page and ArcView habitat diversity map, the University of Notre Dame Environmental Research Center (UNDERC), located on both sides of the border of Vilas County, Wisconsin, and Gogebic County, Michigan, has a stand of approximately 20 old-growth white pines that were never cut. However, according to UNDERC records, the area referred to in a 1951 property map as the “Native Big Pines” (see Figure --) originally had more than 80 old growth white pines when the University acquired the property from economist, lawyer, and Notre Dame fan, Martin J. Gillen. Nowadays, this area on the west of Brown Creek and southeast of Plum Lake is referred to by the director as “the old growth forest,” a white pine-hemlock-northern hardwoods forest that shows what the area was like before logging.

Hypothesis and predictions

My hypothesis was that the stand of white pine-hemlock northern hardwood forest that exists at UNDERC is not an old-growth forest. I predicted that I would see cut stumps wherever I found a patch of potential old growth forest (multiple white pines among hemlock and hardwood trees). I also predicted that the ages of white pine and hemlock trees would be less than 120 years.

MATERIALS AND METHODS

Finding the potential old growth forest

In order to sample and describe the potential old growth forest at UNDERC, I had to find the stands of white pine trees. According to personal communications with the UNDERC director (Belovsky 2008), the UNDERC informational website, and ArcView habitat diversity map, the old-growth forest is located within the land area triangle formed by Brown Creek on the

East, the main road to the South, and Plum Creek on the Northwest. On the GIS Forest Habitat Map, the old-growth stand forms a T-shaped area just straddling the state line and is west of Brown Creek (Underwood 2005). This coincides with a map circa 1951 of the UNDERC property that has a label, "Native Big Pines," in the same region off of a north-south road that intersects the main road (called Fire Lane Road) at almost a right angle (see figure 8).

In order to insure that I had found all of the potential white-pine and hemlock old growth trees, I explored the whole triangle of land. I searched from Plum Lake east to Brown Creek, north through the bogs around the Hellenthal Bog and south to the main road. I flagged all of the white pines greater than 25cm DBH (at 1.2m) and recorded the DBH and GPS units. The location of interesting land monuments and anthropogenic artifacts were recorded as well. Because I was looking to study the white pine-hemlock forest, I searched for stands containing multiple white pines surrounded by hemlocks. From this exploration, I found only two clusters of white pines; the other white pines stood alone or in pairs and were scattered throughout the bogs around Brown Creek or along the Plum Lake Road.

A picture of the forest

At the two clusters of white pines, I set out plots in order to sample the forest composition. The white pine-hemlock clusters were located on ridges of different lengths and widths, bordered by sugar maple forests and/or conifer swamps. The length and width of the ridges limited the area of the plots.

I laid out three 40-by-40 meter plots on one ridge (see the circle in Figure 1). Within each plot, I identified and recorded the DBH of all trees larger than 25cm DBH. I also quantified the white pine snags. This provides a picture of the canopy. In the center of these plots, I plotted a

20-by-20 meter area and recorded all trees with a DBH of 5 to 25cm DBH in order to form a picture of the midstory. I then examined two 5-by-5 meter plots and recorded the quantity and identity of all tree seedlings and saplings less than 5cm DBH (these two categories were combined into one all inclusive category to sample the understory). Though there is no significant relationship between density of saplings or seedlings and stand age (Tyrrell and Crow 1994), this information gives a picture of the understory and possible clues about the future of the forest.

In the other sections of white pine-hemlock forest, the ridges were narrower so the plots were of different sizes: one 15-by-15 meter, one 10-by-40 meter, and three 10-by-30 meter plots. Within these plots, I identified and recorded all trees of DBH 5cm and greater. I also examined one to two 5-by-5m plots to study the understory. In total, I had eight large plots (to study the canopy and midstory) and fifteen small plots (to study the understory).

In addition, I studied all stumps within the large plots. I classified the cause of the stump (obviously cut, fell, or undecipherable). In order to classify a stump as cut, it had to have smooth portions on its cross-sections; jagged bark indicated it fell naturally. Squirrel caches could hide the surface of the stump, causing the method of disturbance to be undecipherable.

Aging the trees

Although I recorded the diameter at breast height (DBH) of all trees greater than 5cm in diameter, this measurement could not be used as a correlation for tree age because white pine and hemlock do not show regular incremental growth (Abrams and Orwig 1996; Musicka 2008). For hemlocks, tree diameter can only be used to estimate the tree age if the tree is greater than 300 years old (Tyrrell and Crow 1994).

Therefore, I used core samples to estimate tree age. Though tree cores have the potential to expose the innards of the tree to pathogens and insects, tree coring is considered a nondestructive sampling technique (van Mantgem and Stephenson 2004). Conifers are less vulnerable to fungal infections than hardwoods following tree coring that could lead to tree mortality (van Mantgem and Stephenson 2004).

From each of the eight plots, I cored at least one white pine and one hemlock tree. I avoided snags and aimed for the trees with the largest DBH. However, using a 20 inch (44cm) increment corer, the length of core I could extract was limited to 44 centimeters. Therefore, the core did not go to the center of all white pine trees, and therefore a minimum age was recorded rather than an approximate age. I glued the cores to plywood, dried them, and sanded them. Then, I used a dissecting microscope to count the tree rings and estimate the age. I found that the rings were easier to see when the core had been wetted with a damp sponge.

Statistics

Because the plots could not be randomly selected (I had to find a specific type of forest – areas of multiple white pines – to use for the sample plots), I could not statistically compare tree species composition, abundance, or the differences between plots. Instead, I calculated the density of tree stems by species per hectare in each layer of the forest at the plots. (I grouped plots two, three, and four as well as plots seven and eight because of their adjacent locations.) Tree core ages were averaged by plot and species (either hemlock or white pine). I also calculated the percentage of cut stumps (from the total).

RESULTS

Locations of all white pine trees

The whole area southeast and east of Plum Lake, north of the main road, and west of Brown Creek was explored and all white pine trees were flagged and the location noted (see Figure 1). In total, 109 white pines with a DBH greater than 25.0cm were located. Many white pines were located along the Plum Lake road or isolated on ridges amongst the mixed swamp conifer land around Brown Creek. However, two large stands of white pine trees became evident and that was where the sample plots two, three, four, seven, and eight were centered. These two stands are close to each other, with shallow marsh areas in between them. However, moving between the stands was possible through a bordering sugar maple-dominated forest via a deer trail or another path that appears to be an old logging road. Using this deer trail, plots one and six were found. These appear to be extensions of the other stands, with white pine islands separated only by balsam fir regeneration. Plot five was found by walking further along a deer trail that runs through plots seven and eight. It is possible that all eight of these plots were at one time one continuous stand of white pine-hemlock hardwood forest, now separated by the regeneration of other tree species.

Snapshot of the forest: canopy, midstory, and understory

Plot one showed a high proportion of hemlock and some white pine in the canopy. The midstory was dominated by balsam fir and sugar maple. The understory was completely dominated by sugar maple, with an almost negligible proportion (in comparison) of hemlock seedlings. (See Figure 3). Because five stumps were found at plot one and one of those was cut, 20% of the stumps were cut at plot one. Cores showed one white pine to be 203 years old and one hemlock to be 110 years old.

Because plots two, three, and four were all located next to each other on the same continuous ridge, I combined the tree data to give a picture of the stand as a whole. Hemlock was prominent in the canopy with a small proportion of white pine, yellow birch, and sugar maple. The midstory was composed of almost equal proportions of hemlock and sugar maple with a minor amount of yellow birch and balsam fir. Sugar maple dominated the understory, with a high proportion of hemlock and balsam fir as well. (See Figure 4). I found 41 stumps and 12 of those were cut. Therefore, 29% of the stumps were cut. Seven white pine trees were cored showing a mean age of 161 years old (standard deviation 38.3, standard error 14.5, n=7). Six hemlock trees were cored with a mean age of 139 years (standard deviation 47.8, standard error 19.5, n=6).

Plot five was located on a ridge separated from the hemlock-hardwood forest on one side and Brown Creek and its swampy embankments on the other. Plot five had a higher proportion of white pines compared to hemlock trees. The midstory was composed of equal proportions of balsam fir and sugar maple. Interestingly, the understory was dominated by red maple, and this was the only site where red maple was present at all. Sugar maple was present to a very minor extent in the understory. (See Figure 5). Only one stump was found and it was cut; the percentage of cut stumps was 100%. Two white pines were cored, with a mean age of 174 years old (standard deviation 55.9 years, standard error 39.5, n=2). One hemlock was cored, revealing an age of 119 years.

In plot six, the canopy and midstory were composed primarily of hemlock. The canopy also had a lesser amount of sugar maple and white pine trees, and the midstory had a minor proportion of sugar maple. The understory was dominated by hemlock, but showed a large number of white pine as well. This was the only site where white pine was seen in the understory. A smaller number of balsam fir and sugar maple also composed the understory. (See

Figure 6). Three stumps were found, one of which was cut. The percentage of cut stumps is 33%. Plot six was the location of the largest white pine (105.8cm DBH), but the increment borer was not long enough to reach the center of the tree. Therefore, the tree rings only provide a minimum age (180 years). One hemlock was also cored and was 101 years old.

Plots seven and eight were adjacent to each other and together composed one stand of potential old-growth forest. This stand had a high proportion of balsam fir across all forest layers. Sugar maple also had a high presence in the understory. White pine and hemlock were also present in the canopy, but only hemlock had a presence in the midstory. (See Figure 7) Nine stumps were found, seven of which were cut. Therefore, 78% of the stumps were cut. Three white pines were cored, revealing a mean age of 157 years (standard deviation 96.6 years, standard error 55.2, n=3). Three hemlock were cored, which gave a mean age of 96 years (standard deviation 30.9 years, standard error 17.9 years, n=3).

Anthropogenic artifacts

Several anthropogenic objects (besides the cut stumps mentioned above) were found while exploring the forest (see Figure 1). An old cast iron stove with an image of burning logs in a fireplace on one side and what appears to be the name “Beechwood” beneath it was found south of plots seven and eight, right next to a cut stump and amongst balsam fir regeneration. In plot seven, within two meters of white pine 46, one full hook part and the handle of a second part of tongs were found amongst the leaf litter. A Mobil gas can halfway buried in soil and leaf litter was found in a sugar maple dominated stand north of the main road and east of the Plum Lake road.

DISCUSSION

Ages of trees

Just as the term “old growth” implies, the trees within an old growth forest must be of a substantial age. One report considers all white pines over 120 years to be old growth trees (Wilkins 1994). Trees over 120 years old would have started growing before 1888 and would have escaped the major logging of the late 1800s and early 1900s. Each of the plots has an average white pine age greater than this age: plot one – one tree, 203 years; plots two, three, and four – 161 years (n=7); plot five – 174 years (n=2); plot six – one tree, a minimum age of 180; plots seven and eight – 157 years (n=3). Only one of the plots of hemlock trees has trees older than 120 years (plots two, three, and four), though plots one and five are very close: plot one – one tree, 110 years; plots two, three, and four – 139 years (n=6); plot five – one tree, 119 years; plot six – one tree, 101 years; plots seven and eight – 96 years (n=3).

These ages suggest that the white pines, in general, are definitely old growth trees, survivors of the era of widespread logging and forest fires. However, the majority of the hemlock are not officially old-growth. Most sprouted after logging at the turn of the century. This confirms some of the information on the UNDERC website, which states that several old-growth white pines were not cut and exist in a stand of second-growth hemlock (Visitors Guide).

Cut stumps

Another distinguishing feature of an old growth forest to consider is the presence of cut stumps. Humans indirectly impact ecosystems and the environment on a regional and global scale. Direct human disturbance often refers to logging, settlements, and forest fires as a result of and following European settlement. Stumps with a smooth horizontal surface perpendicular to the tree trunk indicate that a person cut the stump either for logging or settlement. Within every plot, a percentage of the stumps were, according to this definition, obviously cut: plot one had 20% (n=5), plots two, three, and four combined had 29% (n=41), plot five had only one cut stump total, plot six had 33% (n=3), and plots seven and eight together had 78% (n=9). Therefore, the percentage of cut stumps present in all plots suggests direct human influence.

Anthropogenic artifacts

The saw is part of a two-man cross-cut saw used in the early 1900s (Connor 2008). It could not have been from the late 1800s because of the half-moon shape of the teeth, which was a new approach to the teeth style of the saw which allowed the sawdust to fall out when sawing back and forth (Connor 2008).

The stove is some kind of early camp stove; a patch of lichen growing on the ground nearby the stove on the edge of a circular clearing (approximately four meters in diameter) was probably the site of the coal pile used to feed the stove (Connor 2008). This circular clearing, characterized by a lack of regeneration, and small ground cover plants could have been the site of a logging camp structure (Connor 2008).

Tongs were used and continue to be used today to skid logs out of the stand (Connor 2008). The hooks were placed on either side of the log and automatically tightened, when the handles were connected by a chain and attached to a draft animal (Connor 2008). The hooks then grasped the log and lifted up its front, allowing it to be pulled or bucked to a landing to be loaded on a sled to carry it to the rollaway, a cleared stream embankment where logs were piled until spring came and they floated downstream (Dickmann and Leefers 2003).

The Mobil gas can is probably from the 1950s and could have been used to fill a chainsaw or Caterpillar tractor (Connor 2008). The site of this find was within a strip of forest that extends approximately 50 meters north away from the main road and about half a mile southeast along the road. This second-growth sugar maple forest has an abundant quantity of cut stumps, logs, slash, and sugar maple seedlings covering the ground but a limited quantity of midstory trees. According to Director Gary Belovsky (2008), a triangle of land in this strip of forest is owned by the state of Wisconsin, and following a huge wind fall, Wisconsin contracted a logging company to log the area. However, the company misunderstood the limits to the Wisconsin property, and as a result, logged some of the UNDERC property. The gas can could have been a remnant of this unintentional logging near the white pine-hemlock stands.

Conclusions of study

Adding up all of these factors (tree age, presence of cut stumps, and existence of anthropogenic artifacts), I concluded that my hypothesis was correct. The stand of white pine-hemlock northern hardwood forest that exists at UNDERC is not an old-growth forest. Though white pines of considerable age do exist in this stand of forest, these alone cannot classify a stand of forest as “old-growth.” The term describes and therefore must apply to the ecosystem as a whole, rather than just describing a few trees of a specific age (Wilkins 1994). Therefore, because most of the hemlock trees are less than 120 years old, cut stumps are present in every plot, and anthropogenic artifacts have been found amongst the plots and dated to the turn of the early 1900s, these two stands of white-pine hemlock northern hardwood forest are not old growth forests.

Managing to become and preserve old growth forests

Although the white pine-hemlock hardwood forest on the UNDERC property is not currently an old growth forest, it will grow older. The impact of logging that disturbed the forest composition in the early 20th century will become negligible as new trees establish and more trees already present will attain triple-digit ages. If direct human influence on the forest is limited, it can be managed to become an old growth forest in the future. Studying and reconstructing the histories of old-growth forests can guide the management of current forests to maintain and develop old growth forest characteristics within an area large enough to accommodate natural disturbances and organism dispersal (Foster et al. 1996). However, because forests are dynamic and changing ecosystems, the management and conservation of old growth forests must accept and anticipate future changes (Foster et al. 1996).

Composition of the midstory and the understory – a glimpse into the forest's future

Examining the composition and density of tree species in the midstory and the understory provides a glimpse into the possible future forest composition(Stearns and Likens 2002). Only one of the eight plots had white pines present in the understory, and the midstory layer was completely void of any white pines across all plots. However, a high proportion of sugar maple, balsam fir, and hemlock were observed in the midstory and understory layers. All three of these species are extremely shade tolerant and withstand low light conditions before reaching the canopy (Smith 2002; Barnes 2002). However, white pines require windfall gaps or fire to hinder competing species and provide ample light for regeneration. White pines do not grow well under their own dense canopies or dense forests of other species either; therefore, it is uncommon to find white pine saplings under mature white pines.

Similar patterns in the forest layers are seen in the 811 hectare old-growth white pine forest of the Greenwood Lake Conservation Reserve in Ontario, Canada. The forest canopy is predominantly white pines, all around 300 years old due to an intense fire around 1700 that created the openings necessary for white pine to gain hold (Carmean 2004). The only place where white pine regeneration is currently occurring in this white pine forest is a five hectare area where a fire burned in August 1991; elsewhere, the understory is composed primarily of white and black spruce, and balsam fir, with some white and yellow birch, and red maple (Carmean 2004).

Likewise, a study on the pattern and rate of forest succession 100 years after logging of and fire in an old-growth red and white pine forest revealed an understory dominated by balsam fir, sugar maple, and white spruce (Stearns and Likens 2002). Without fire to disturb the tree composition, the forest would likely become a balsam fir-sugar maple-white spruce forest rather than a pine forest (Stearns and Likens 2002).

The sugar maple, balsam fir, and hemlock, by dominating the midstory and understory, are setting up advance regeneration, ready to capitalize on a canopy opening. This advance regeneration beats foundling seedlings to the canopy in the race of tree succession following a tree fall gap and accounts for 83-97% of all trees greater than 1 meter in height four years after the gap formation (Uhl et. al. 1988). When a tree falls and opens a gap in the canopy, the sugar maple, balsam fir, or hemlock trees can quickly fill the gap because the recolonization stems are already in place to take advantage of the increased light availability (Heatwole 2007). Tyrrell and Crow found a significantly higher amount of canopy gaps in older stands (gaps were more than 10% of the stand area) compared to younger stands (gaps were less than 10% of the stand area) (1994).

Hemlock replace themselves through gaps from one or multi-tree falls (non-catastrophic disturbances) rather than catastrophic events like forest fire (Tyrrell and Crow 1994) as white pine prefer to do (Dickmann and Leefers 2003).

Future studies

Examining white pine regeneration and predicting its presence in future forest composition could be a relevant and interesting follow-up study. While in search of the old-growth white pines, I found a number of white pine saplings growing in the mixed conifer swamps surrounding Hellenthal Bog and Brown Creek. I also found two patches of white pine regeneration with approximately ten saplings in each at two surprising locations. One was underneath a sugar maple-hardwood canopy (near the location of the Mobil gas can) without a white pine in sight. The other was on the swamp-facing side of a ridge where plot number five and one very large white pine (DBH 105.8cm) were located. Future studies could examine the presence of white pine regeneration in relation to mature white pines (the seed bank). If this study examined the ages of the mature white pines, it should consider that as white pines age, the centers tend to rot and become hollow (Wilkins 1994); this provides a den for black bears, but can make a core incomplete and inaccurate.

White pine regeneration as many foresters fear that the white pine is slowly continuing to disappear from our forests as a result of the extensive logging and burning that happened at the turn of the 19th century, the fire suppression policy that followed, diseases like white pine blister rust, insects like the white pine weevil, and white tailed deer over browsing (Wilkins 1994; Smith 2002; Schumacher 2008; Abrams and Orwig 1996). Just as this study only found white pine regeneration in one of the eight plots, so too is white pine regeneration rare in white pine forests (Wilkins 1994; Abrams and Orwig 1996).

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APPENDIX

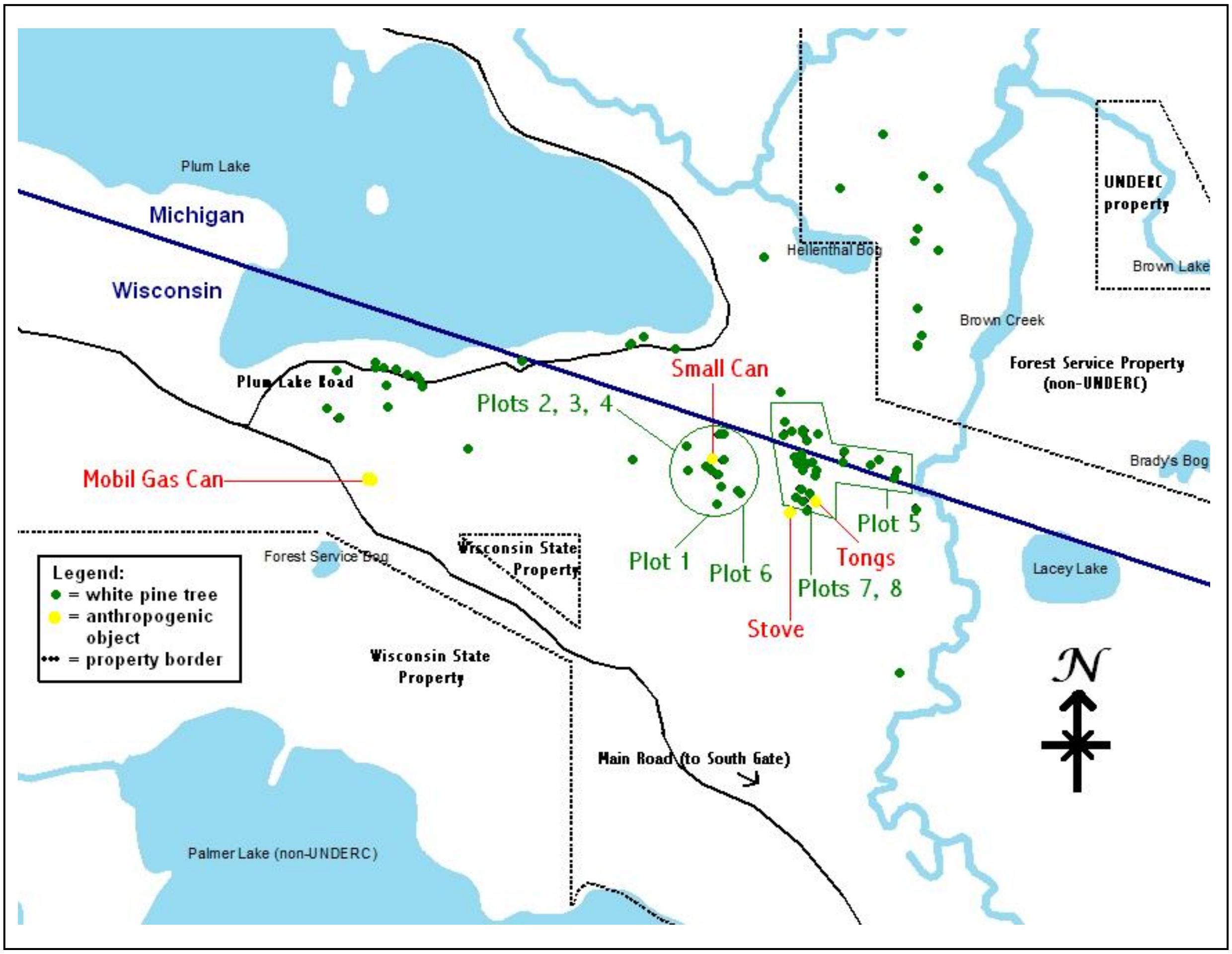

Figure 1: Map of all white pine trees and snags (DBH larger than 25.0cm) north of the main road, southeast of Plum Lake, and west of Brown Creek. Locations of anthropogenic objects (small can, stove, tongs, and Mobil can) are marked in yellow. The green circle and sideways "T" represent the two potential old growth stands where research was focused.

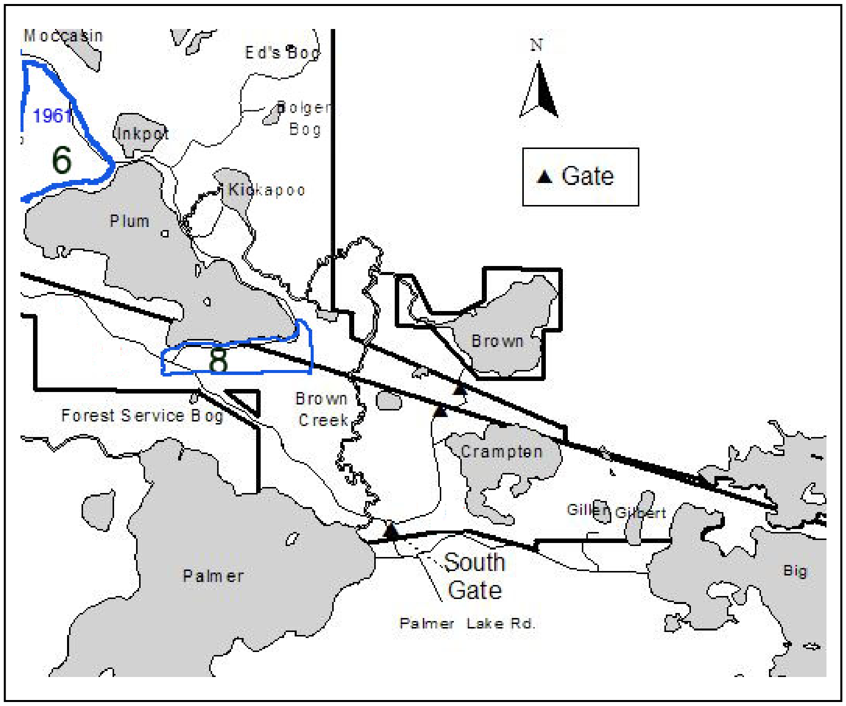

Figure 2: UNDERC property map that shows the location (#6 and 8 outlined in blue) of logging that occurred sometime between 1955 and 1967 according to the Notre Dame Archives (Holland 2006). The southeastern tip of site #8 is very close to the white pine-hemlock stands in this study.

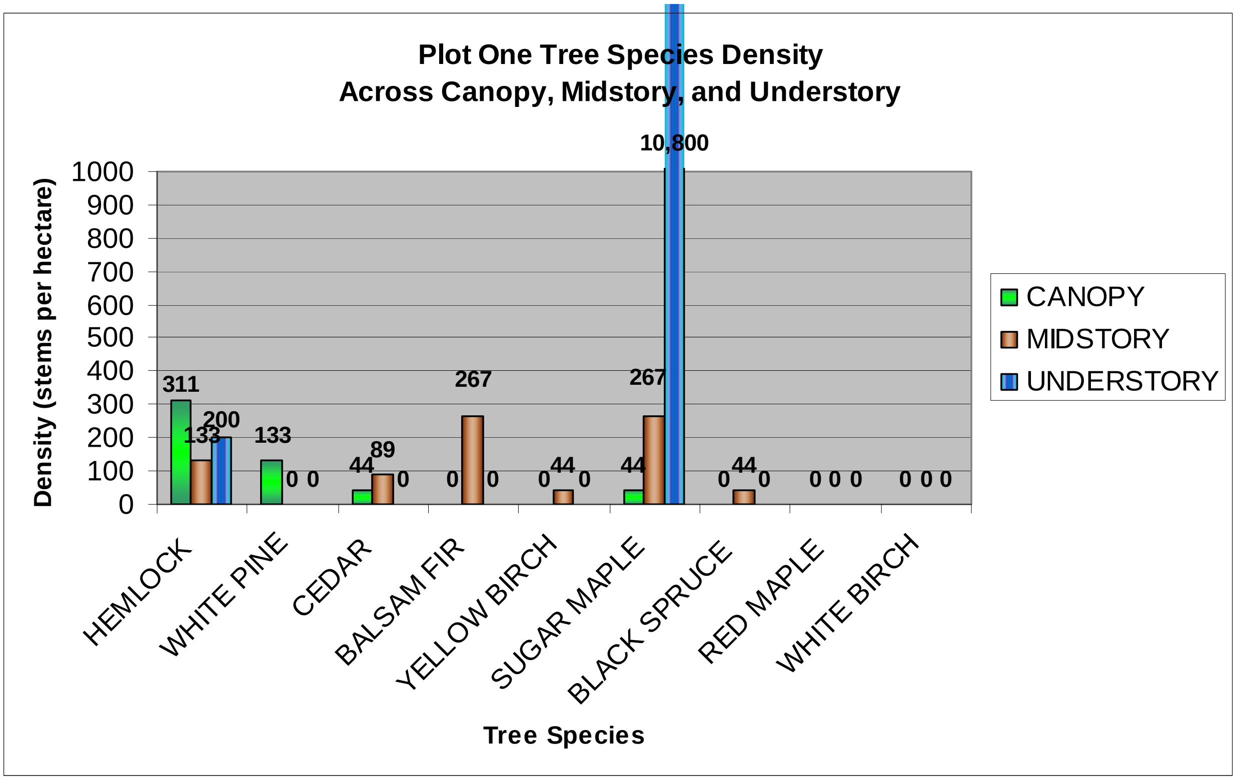

Figure 3: A snapshot of the forest layers in plot one (the location of the saw). The canopy had a high proportion of hemlock. The midstory was jointly composed mostly of balsam fir and sugar maple. The understory was dominated by sugar maple.

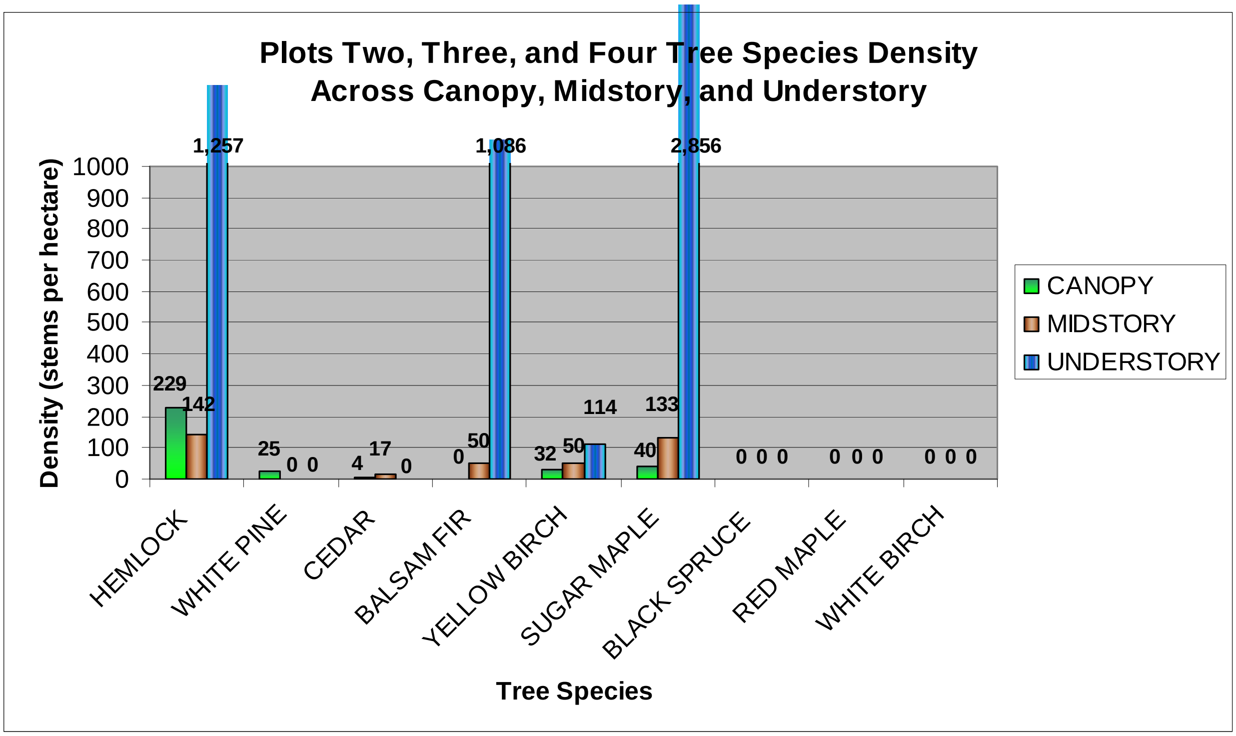

Figure 4: A snapshot of the forest layers in plots two, three, and four (all located adjacent to each other along a single ridge, composing one stand of potential old growth forest). The canopy was composed mostly of hemlock. The midstory had a high proportion of hemlock and sugar maple. The understory had a high number of sugar maples, with a lesser amount of hemlock and balsam fir.

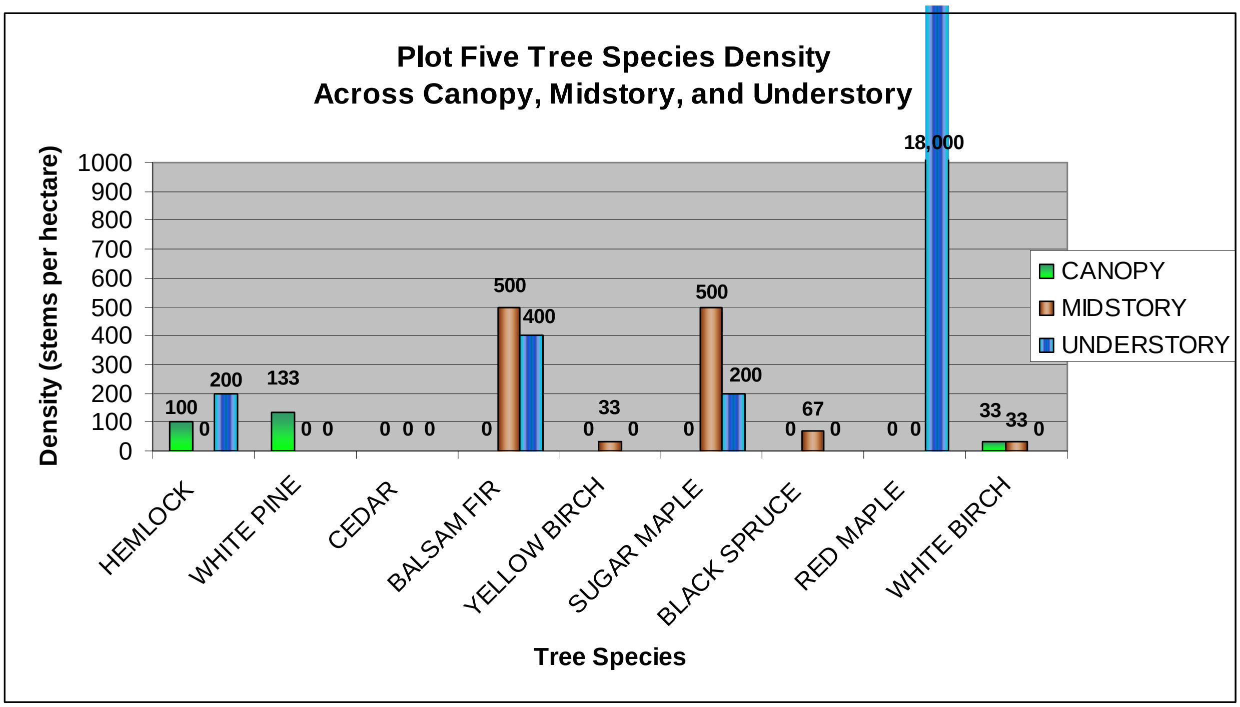

Figure 5: A snapshot of the forest layers in plot five (located on a ridge that jutted away from the main forested area into the boggy area that borders Brown Creek). The canopy had a high proportion of hemlock and white pine. The midstory was dominated by balsam fir and sugar maple. The understory had an extremely high number of red maples.

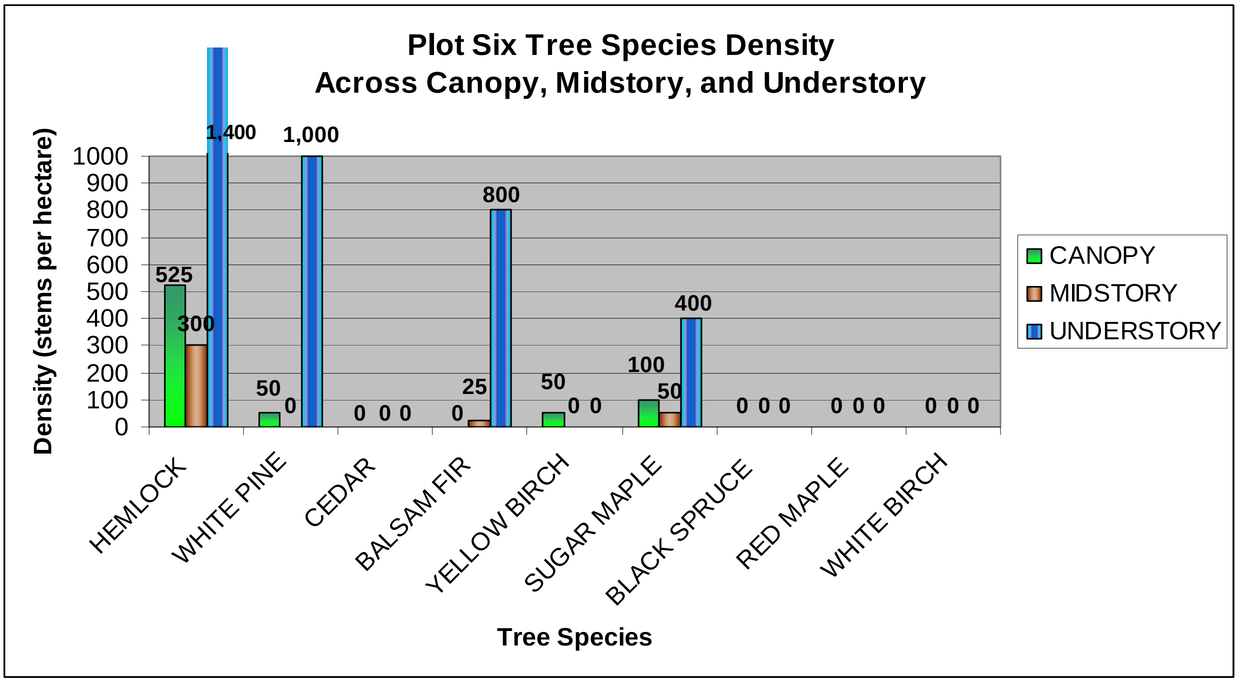

Figure 6: A snapshot of the forest layers in plot six (the location of the largest white pine tree at 105.8cm DBH). The composition of the canopy and the midstory were both mostly hemlock. The understory had a high proportion of hemlock, white pine, and balsam fir and a smaller amount of sugar maple. This was the only plot with white pine in the understory.

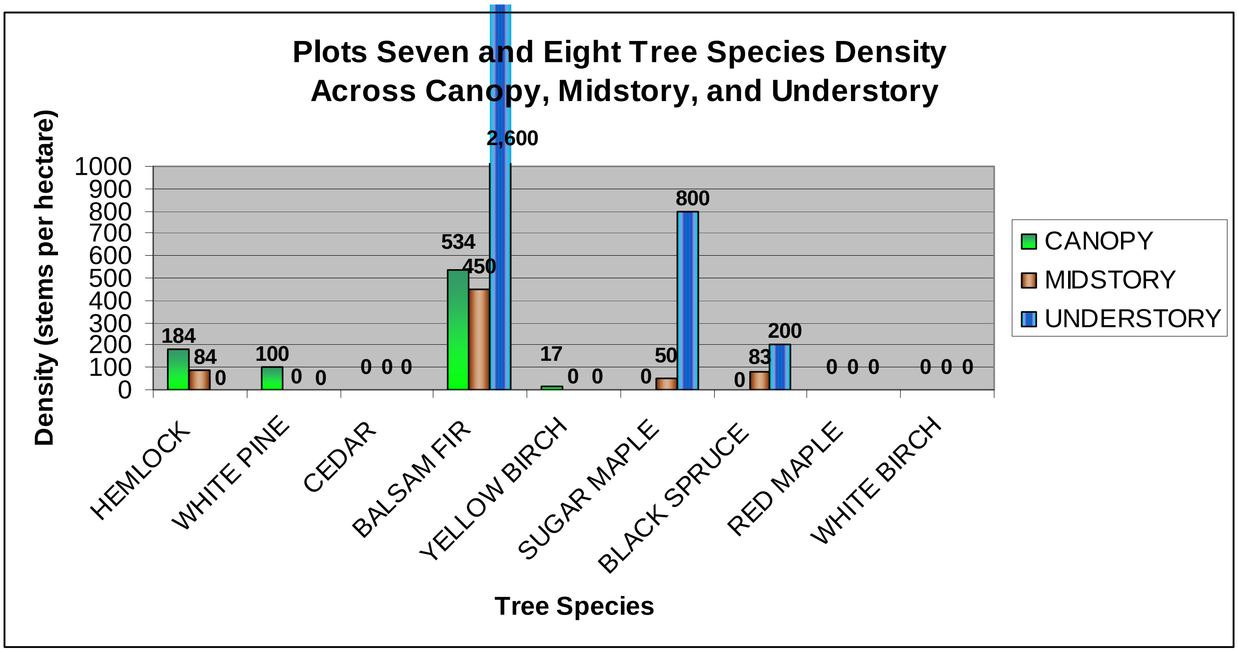

Figure 7: A snapshot of the forest layers in plots seven and eight (located adjacent to each other near where the stove was found). Balsam fir was prominent in the canopy and the midstory, with a smaller proportion of hemlock. The understory was dominated by balsam fir, with a lesser presence of sugar maple.

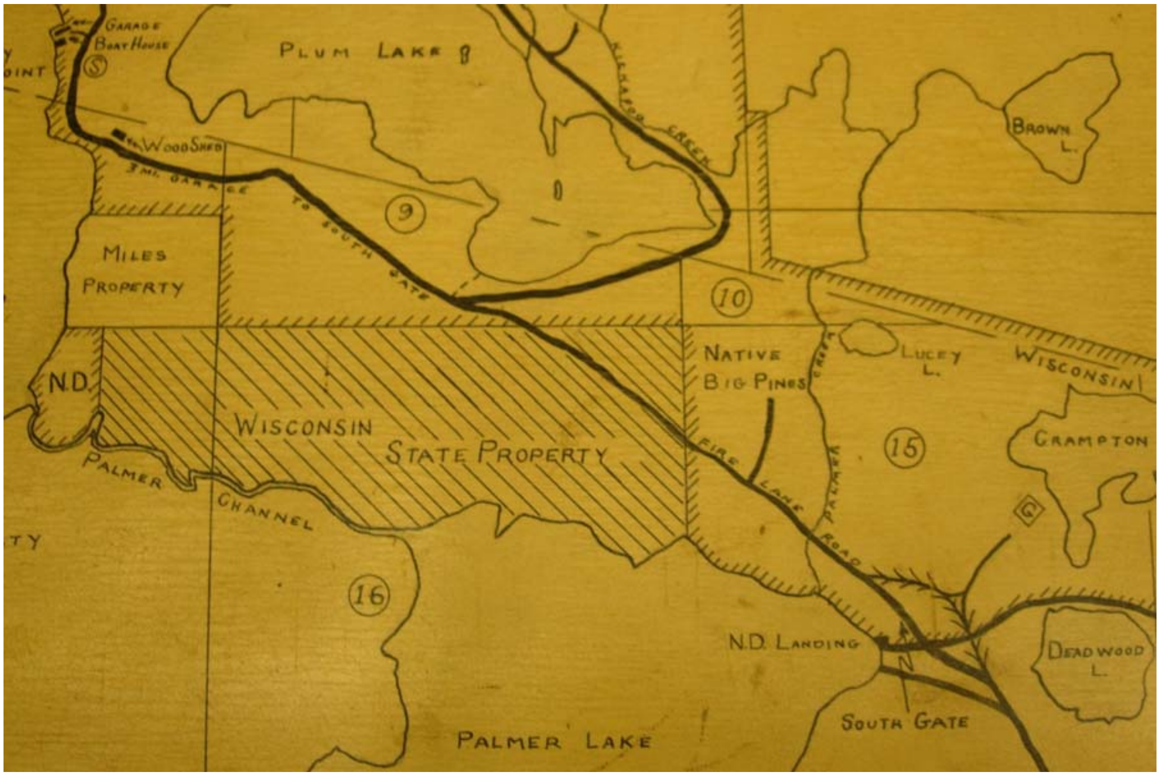

Figure 8: Map of the University of Notre Dame Environmental Research Property circa May 27th, 1951. On this map, “Palmer Creek” is what is now referred to as Brown Creek, and the main road to the south gate is labeled “Fire Lane Road.” The explored area (southeast of Plum Lake, north of the main road, and west of Brown/Palmer Creek) is labeled “10” referring to the official survey section of the map. Note the label “Native Big Pines” right beneath the number 10, adjacent to the “Wisconsin State Property.”