Establishment of Long-term Terrestrial Monitoring Sites in the Boreal Forest of Eastern Manitoba Year II:

A Report to the EMAN Coordinating Office and The Manitoba Model Forest

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Manitoba Model Forest Report 06-5-06

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Executive Summary:

During the summer of 2006, data was gathered from six study sites near the Hollow Water First Nation and in Nopiming Provincial Park, located in the Manitoba Model Forest of eastern Manitoba. Using Ecological Monitoring and Assessment Network (EMAN) Terrestrial Vegetation Monitoring Protocols, canopy-tree stratum information was collected, including abundance, basal area, density, relative density, dominance, relative dominance, frequency, relative frequency, importance, tree health, crown class and crown rating. Data was also gathered from shrub and ground vegetation strata.

Additional information such as downed woody debris, light transmission, tree height, tree age and air and soil temperature were also collected in these stands. Stands were chosen according to their forest type, age and origin (fire or harvest). Four and two jack pine stands were chosen in the Hollow Water area and in Nopiming Park, respectively, as well as two black spruce stands in Nopiming Provincial Park.

As their names imply, the Hollow Water and Nopiming North jack pine sites were dominated or co-dominated by jack pine. The basal area and abundance of jack pine were the greatest of all species in the stands. In the younger stands, jack pine had a high abundance but small basal area. As the stands matured, abundance diminished. However, the overall basal area increased, and stabilized relative rapidly. As the stands aged, the basal area of individual trees increased in size. The decrease in abundance and the increase in individual basal area demonstrated the process of self-thinning. Tree health, crown class and crown rating changed with age of the stand. Almost all species and individuals in the young stands had a healthy crown. As the stands matured, variability in crown health increased. Taking in consideration the age and origin of each stand, downed woody debris followed an anticipated pattern. With the exception of the youngest stand of harvest (logged) origin, in which there was a large number of downed woody debris (probably due to logging slash, branches), the amount of downed woody debris increased with age. The ground herb vegetation between stands was fairly similar, although frequency and percentage of cover did vary from stand to stand.

The tree stratum of the Nopiming North and Flintstone Lake black spruce (also located in Nopiming Provincial Park) stands were dominated by black spruce and jack pine, respectively. Jack pine was the only tree species in the Flintstone Lake 1993 Black Spruce stand and black spruce was the only tree species in the Nopiming North 1900 Black Spruce stand. The former situation (jack pine dominating in a young black spruce stand) may seem counter-intuitive: jack pine was the only tree species found in the Flintstone Lake 1993 Black Spruce site and yet it was classified as a black spruce stand according to the Tembec Forest Resource Inventory. This stand was originally mature black spruce, but was burned in a recent forest fire. Subsequent to the fire, jack pine germinated and invaded the site the quickest. However, jack pine was clearly struggling in this site (likely due to the wet, saturated conditions) and there were hundreds of healthy black spruce seedlings per plot, in full regeneration. This site will eventually return to a black spruce stand as a result of forest succession. Since there was only one species in both stands, black spruce had the greatest abundance and basal area in the Nopiming North 1900 Black Spruce stand and in the Flintstone Lake 1993 Black Spruce stand, jack pine held the greatest values. The additional information demonstrated a very healthy Nopiming North mature black spruce stand; there was very little downed woody debris and canopies were healthy. Downed woody debris in the young Flintstone Lake stand was present in high numbers which was to be expected for a young fire origin site. Ground vegetation in jack pine stands was more diverse and differed greatly from black spruce stands. Both black spruce sites proved to be very healthy based on the parameters we assessed.

Along with the establishment of long term permanent terrestrial monitoring plots, the project included an educational aspect. High school students from two schools in the Manitoba Model Forest area and one school from Winnipeg were taken on field trips, taught how to establish monitoring plots and then assisted in data collection. Students learned how to use a GPS, lay out study quadrats, and identify tree, shrub and herb species. They also learned how to estimate basal area (from diameter as breast height measurements, tree height and tree age, as well as assess crown class, tree health and

crown rating. They also took other environmental measurements such as soil and air temperature, relative humidity and light transmission.

This report can be downloaded from the Manitoba Model Forest website (www.manitobamodelforest.net).

Introduction:

The world we live in today is not the same as it once was. Air quality, water quality, animal populations and forest health are a few aspects of the environment that have changed. Some of these changes have been induced by humans, while others are simply part of nature's cycle. Nevertheless, the environment is indisputably in constant transformation. For this reason, monitoring programs, and in particular, monitoring networks such as Environment Canada's Ecological Monitoring and Assessment Network (EMAN) are indispensable. Long term terrestrial monitoring will not only warn of any negative or even positive impacts on the environment, but will also aid in decision-making that affects the environment.

As part of our Manitoba Model Forest project, 35 twenty-by-twenty stand-alone terrestrial plots have been established to monitor the health of the boreal forest in eastern Manitoba. Our biomonitoring project has also evolved over the last few years by adopting the national monitoring protocols of EMAN. Considering the general lack of vegetation monitoring in eastern Manitoba, this program is of immense value not only to the scientific world, but also to industries and the communities in the region.

The Biomonitoring project also comprised an educational facet. Its objective consisted of introducing local high school students to environmental monitoring. Students were taught sampling techniques and assisted in the collection of data. These students are the decision makers of tomorrow and having a better understanding of the environment makes for wiser choices in the future.

In addition to data collected in study plots in the Manitoba Model Forest area (eastern Manitoba), preliminary terrestrial monitoring work was also initiated in the Assiniboine Forest within the city of Winnipeg. This forest is one of the largest urban forests in North America and is located in a very different ecological context to the boreal forest plots we have established. Dominant tree species in the Assiniboine Forest plots include Bur Oak and Trembling Aspen. Given that only a small amount of data was collected by the end

of the summer of 2006, this site will not be part of this report but will be included in future reports.

Along with the information gathered during the summer of 2006, this report includes data collected from a site located near Hollow Water First Nation site in 2005. Because all plots were established within the last 12 months, no attempt is made to determine year to year changes in plots. Instead, the data collected will serve as a baseline against which future changes can be assessed. This report will simply present a glimpse or snapshot of the current conditions within the study sites and compare similarities and differences between sites.

Methods:

Site Selection:

All seven long term sites are within the Manitoba Model Forest in eastern Manitoba. Three forested stands are in the Nopiming Provincial Park and four stands are located close to the community of Hollow Water First Nation. They are all easily accessed by road.

Two different forest types were chosen; those dominated by jack pine and those by black spruce. The four sites in the Hollow Water area along with one site in the Nopiming Provincial Park are in jack pine-dominated forests. The two remaining sites in the Nopiming Provincial Park are both black spruce dominated forests. These sites were chosen because of the different forest types, ages and origins (fire and logging).

Sampling Techniques:

EMAN protocols were followed for the monitoring of all three vegetation layers; the canopy-tree stratum biodiversity monitoring protocols, shrub and small-tree stratum biodiversity monitoring protocols and ground vegetation stratum biodiversity monitoring protocols. Detailed descriptions of the sampling techniques can be found in the EMAN

Terrestrial Vegetation Monitoring Protocols manual (Roberts-Pichette, Gillespie, 1999). The manual is also available on-line at the EMAN website (www.eman-rese.ca).

Five twenty-by-twenty metre (20m x 20m) stand-alone quadrats were used for each forest stand in this report with the exception of two; the Flintstone Lake 1993 Black Spruce stand and Hollow Water 2000 Jack Pine stand. Due to their young age, these stands had a large number of seedlings and saplings, some reaching four hundred per plot. Due to time constraints associated with assessing such a large number of seedlings in these two stands, five ten-by-ten metre (10m x 10m) stand alone quadrats were used. Apart from modifying the size of the plots for these two stands, the only other change in the EMAN protocols was the use of two five-by-five metre (5m x 5m) seedling/shrub quadrats compared to the normal number of four per plot. This change was due to the reduced size of these specific plots. The first five-by-five metre seedling/shrub quadrat was placed in corner A of each plot and the second in corner C.

Trees were tagged with an aluminum tag on which was written the stand name, plot number and tree number. This will facilitate locating individual trees in future years of monitoring. The exact location of each tree in the plots was determined by measuring the distances from each tree to two boundaries of the plot (lines 1 and 4), in essence, giving an X and Y coordinate for each tree. This was done to facilitate data entry into the EMAN site so that accurate maps of each plot could be produced. The maps will aid in locating trees in the plots in future years, should individual tree tags go missing. IN addition to showing the location of each tree in a plot, the EMAN mapping software also shows the different species and the approximate dbh of the tree. The maps showing the location of trees in each plot are found in Appendix I. Also note that the EMAN website software produces twenty-by twenty metre plot maps. For plots in the Hollow Water 2000 Jack Pine stand and Flintstone Lake 1993 Black Spruce stand, which were ten-by-ten metre plots, trees show up as being concentrated in the bottom left corner of the map.

The data was collected between May and September, 2006 by research technicians employed by Miette Environmental and the Manitoba Model Forest. Although, the

majority of the data was gathered between the months of June and August, students from the Wanipigow, Oak Park and Lac du Bonnet schools also helped collect data at various site during spring and fall. The information gathered in the spring at the Assiniboine Forest was not used in this report since these plots were temporary, and more for training purposes. However, students were once again brought to the Assiniboine Forest during the fall and this time gathered data from permanent plots. On the other hand, the information collected by students at the Nopiming North site was used in this report.

The data from six of the seven stands (Hollow Water 1983 Jack Pine, Hollow Water 1992 Jack Pine, Hollow Water 2000 Jack Pine, Nopiming North 1900 Black Spruce, Nopiming North 1920 Jack Pine and Flintstone Lake 1993 Black Spruce) included in this report was collected during the summer of 2006. The information for the Hollow Water 1912 Jack Pine stand and part of the Hollow Water 1983 Jack Pine stand was collected during the summer of 2005. Appendix II provides GPS locations of every plot in each stand.

Methods of Analysis:

Canopy-Tree stratum:

According to the EMAN Canopy-Tree Stratum Biodiversity Monitoring Protocols, a tree is defined as having a diameter at breast height (dbh) of at least 10 cm. This definition was used for all plots except for the two youngest stands: Flintstone Lack 1993 Black Spruce and Hollow Water 2000 Jack Pine plots. These two stands are very young, and did not have many, if not any trees with a dbh greater than 10 cm. Therefore, to be able to track the self-thinning process as these stands age, a minimum 4 cm in dbh limit was used to define a tree.

Tree Calculations: Trees were assembled according to their species. Calculations determining the abundance, basal area, density, relative density, dominance, relative dominance, frequency, relative frequency and importance value were made for each species in all plots. The average of each parameter for every plot was then grouped to form an average and standard deviation for each forest stand. The abundance, basal area,

density and dominance calculation are expressed on a per hectare basis to facilitate comparisons between stands and other data.

Abundance is the measurement of the total number of individuals of each species in the total area of the sample. Basal area is calculated by determining the cross-section area of tree stems. Density is defined as the average number of individuals of a species on a unit area basis. Relative density can be calculated by measuring the density of one species relative to all species. Dominance is the measurement of the area a species occupies in a stand on a unit area basis. Relative dominance is calculated by determining the area a species occupies in a stand as a percentage of the total area occupied by all species. Frequency is defined as the distribution of a species through a stand. In this report, frequency is expressed as the percentage of plots in which a given species occurs in a stand. Relative frequency is the measurement of the distribution of one species relative to all species. Importance Value is an index made up of the sum of relative density, relative dominance and relative frequency, and gives an indication of the structural role of a species in a stand. It is useful for making comparisons among stands in reference to species composition and stand structure (Roberts-Pichette, Gillespie, 1999).

Tree Health: Trees were separated into species and then further classified according to their health condition; alive broken, alive leaning, alive standing, dead broken, dead leaning or dead standing. The percentage of trees in each category by species was calculated for every stand.

Crown Class: Trees were grouped according to their species and further classified according to their crown class, which is determined by the amount of sunlight each tree receives. There are four different crown classes; dominant, co-dominant, intermediate and suppressed. Dominant trees are above the canopy and receive direct sunlight from the top and sides of its crown. Co-dominant trees are level with the canopy and receive direct sunlight from the top and very little from the sides. Intermediate trees are shorter and obtain very little direct sunlight from the top and none from the sides. Suppressed trees are entirely below the canopy and receive no direct sunlight.

Crown Rating: Trees were grouped according to their species and further sorted according to their crown rating which is based on their percentage of crown in a recently dead state. According to the percentage of branch mortality, trees were placed in one of five categories; 1-healthy (less than 10% branch mortality), 2-light-moderate decline (between 10-50% branch mortality), 3-severe decline (greater than 50% branch mortality), 4-dead natural and 5-dead human.

Shrub and Small-Tree Stratum:

According to the EMAN Shrub and Small-Tree Stratum Biodiversity Monitoring Protocols, a shrub is defined as usually being a multi-stemmed woody plant less than 4 cm dbh with most of the stems originating at or near the ground. A small tree is defined as usually being a single-stemmed woody plant between 4 and 10 cm dbh. Seedlings were grouped with the shrubs, and saplings with the small trees. Seedlings were included if they were 36 cm or greater in height. These definitions were used for all plots except for the two youngest forest stands: Flintstone Lake 1993 Black Spruce and Hollow Water 2000 Jack Pine plots. These two stands are relatively young, and did not have many trees with a dbh greater than 10 cm. As mentioned previously, trees in these two plots were considered as having a dbh of 4 cm and greater. Therefore, shrubs and small trees in these two stands were considered as having a dbh less than 4 cm.

Shrubs and small trees were grouped together by species and an average number of individuals were calculated.

Ground Vegetation Stratum:

According to the EMAN Ground Vegetation Stratum Biodiversity Monitoring Protocols, the vegetation layer is form by ground layer vegetation (which includes mosses, lichens, fungi growing on the ground, small trailing and rosette plants) and field layer vegetation (which comprises all herbaceous vegetation regardless of height and all woody plants

under 36 cm in height). The percentage of cover of each species was determined in four one-by-one metre quadrats per tree (20m x 20m) plot. An average of the percentage of cover of every species was calculated for each stand.

Downed Woody Debris:

Downed woody debris is defined as logs lying on the ground with a dbh greater than 4 cm. For each 20m x 20m plot, three transects were created. Each transect extended from a plot corner post to a distance of 45.15m away from the corner post. Each downed woody debris piece crossing a transect was rated on a scale from 1 to 5, based on the degree of decomposition; 1 being the least decomposed (bark intact, twigs present, log elevated by twigs, wood original color) and 5 being the most decomposed (no bark or twigs, soft and powdery, log entirely on the ground, light yellow-grey color). Along with the decomposition class, the average volume and average number of pieces per transect were also calculated. The formula used to calculate the volume goes as follows:

Downed Woody Material Volume (m3/ha) = $10{,}000 * (\pi^2 * \Sigma(d^2)/(8L))$
Where d = diameter (m) of piece, L = length of DWM transect (m). (Ehnes, 2000)

Light Transmission:

Light transmission was measured using a GE Light Meter Model 217. Light measurements were made at five random locations within each plot and at five unshaded locations outside each plot. The percentage of light reaching the ground layer was then calculated based on the two types of measurements. The average percentage of light transmission was then calculated for each stand.

Tree Height:

The height of five co-dominant trees per plot was estimated using a Suunto clinometer model PM-5/360PC. Trees with a height less than five metres were measured using a measuring tape. An average was determined for each stand.

Tree Age:

The age of five trees (the same trees for which height measurements were estimated) was determined using an increment borer. An average tree age for each stand was then calculated. Due to the small dbh of trees in the Flintstone Lake 1993 Black Spruce and Hollow Water 2000 Jack Pine sites, the trees were not cored.

Air Temperature:

Air temperature was recorded every hour using a StowAway Tidbit Temperature Logger. Air temperature was monitored only in the Nopiming North 1920 Jack Pine stand. The logger was attached to the shaded side of a tree using aircraft cable. The logger collected data from May 11, 2006 to September 19, 2006.

Soil Temperature:

A StowAway Tidbit Temperature Logger was also used to monitor hourly soil temperature. The logger was buried 10 cm into the soil and attached with aircraft cable to the same tree holding the air temperature logger. The soil temperature logger was deployed and retrieved at the same time as the air temperature logger.

Results and Discussion:

General Description of Study Sites:

All seven study sites are located within the Manitoba Model Forest in eastern Manitoba, approximately 100km northeast of the City of Winnipeg (Fig 1). The Manitoba Model Forest is approximately 1 million hectares in size and is bordered to the east by the Manitoba-Ontario border and to the west by Lake Winnipeg (Fig 1).

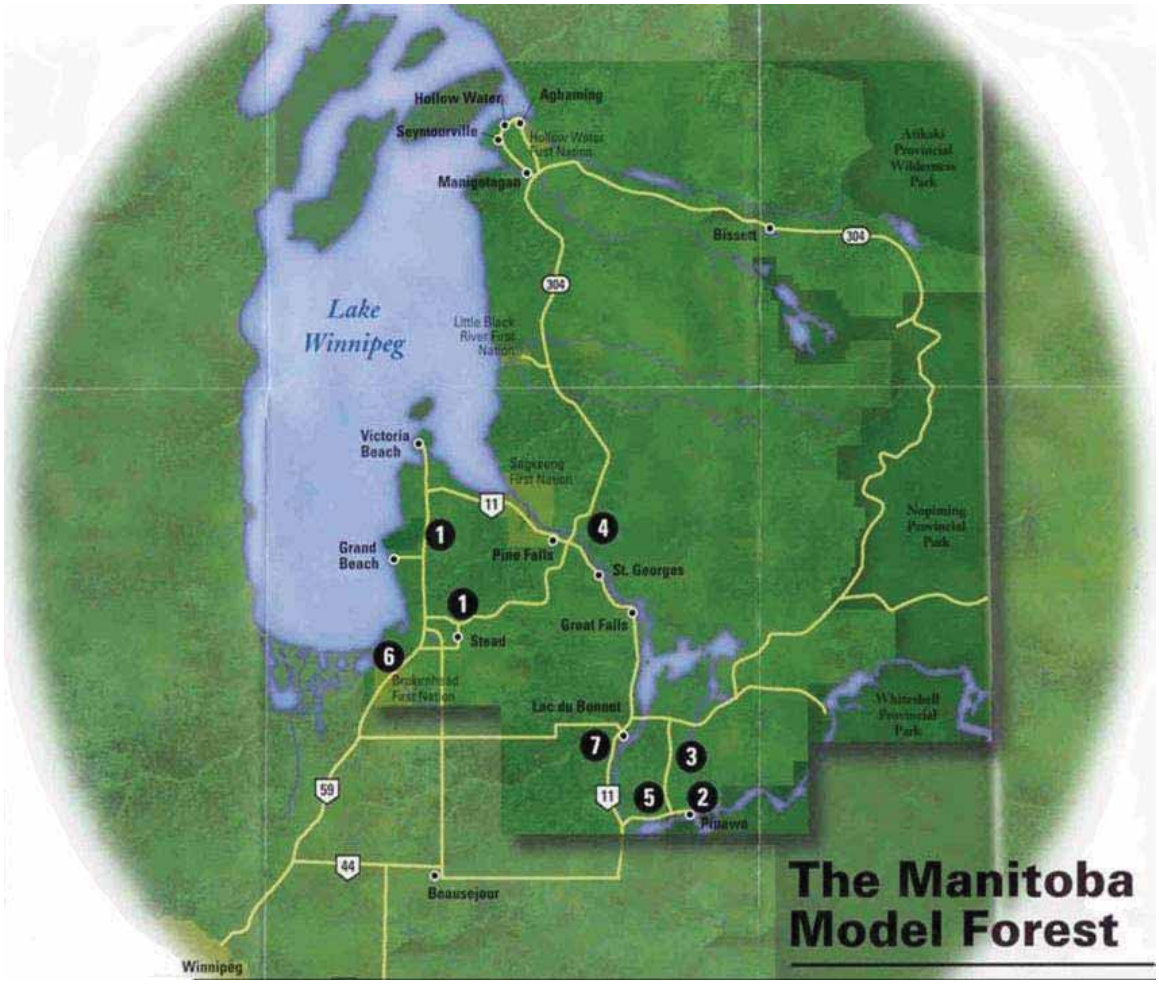


Figure 1: Map of eastern Manitoba showing the Manitoba Model Forest

The climate in the Model Forest is characterized by warm summers and cold winters. The mean summer temperature for the area is 13.5 to 15.5°C, although days where the temperature exceeds 30°C in July and August are not uncommon. The mean winter

temperature is -14.5°C but it can drop as low as -40°C at night; however this is a rare occurrence. Precipitation ranges from 500 to 600 millimeters, with approximately 1/3 of it falling as snow. The annual precipitation can vary significantly from year to year. There is also a wide variation in soil types in the region. In general, the soils in the east by the Ontario border are dominated by exposed bedrock with little surficial deposits. As you move further west the soils change to level or gently undulating organic peat deposits overlying lacustrine clay sediments. There are also areas of sand deposits, mostly near Lake Winnipeg. These deposits are the relics of the former beach ridges from glacial Lake Agassiz.

Some characteristics of the Assiniboine forest site within the city of Winnipeg are described below, although no data from those plots are included in this report. The Assiniboine forest is the largest urban forest in Canada, encompassing 700 acres of upland aspen and oak forest and marsh (www.winnipeg.ca/publicworks/naturalist/ns/AF/index.asp). The Winnipeg region has an extreme continental climate with warm summers and cold winters for there are no large bodies of water or mountains nearby. During winter, the mean maximum temperature is -10.3°C, while the mean minimum is -20.2°C. As for summer, the mean maximum is 23.3°C and the mean minimum is 10.2°C. The annual average precipitation received is 514 mm including 110 mm of snow. Of all Canadian cities, Winnipeg is the sunniest with an average 2,372 hours of sunshine per year. The city is situated in low-lying flat land in the middle of the country (www.en.wikipedia.org/wiki/Winnipeg_Geography_and_Climate).

All of the study sites in this report are located within the boreal forest of eastern Manitoba (Fig 2). The sites near the community of Hollow Water First Nation and in Nopiming Provincial Park are located within the Lac Seul Upland Ecoregion (Ecoregion 90). The Lac Seul Upland ecoregion covers the majority of the east side of Lake Winnipeg and east as far as the Albany River in northwestern Ontario.

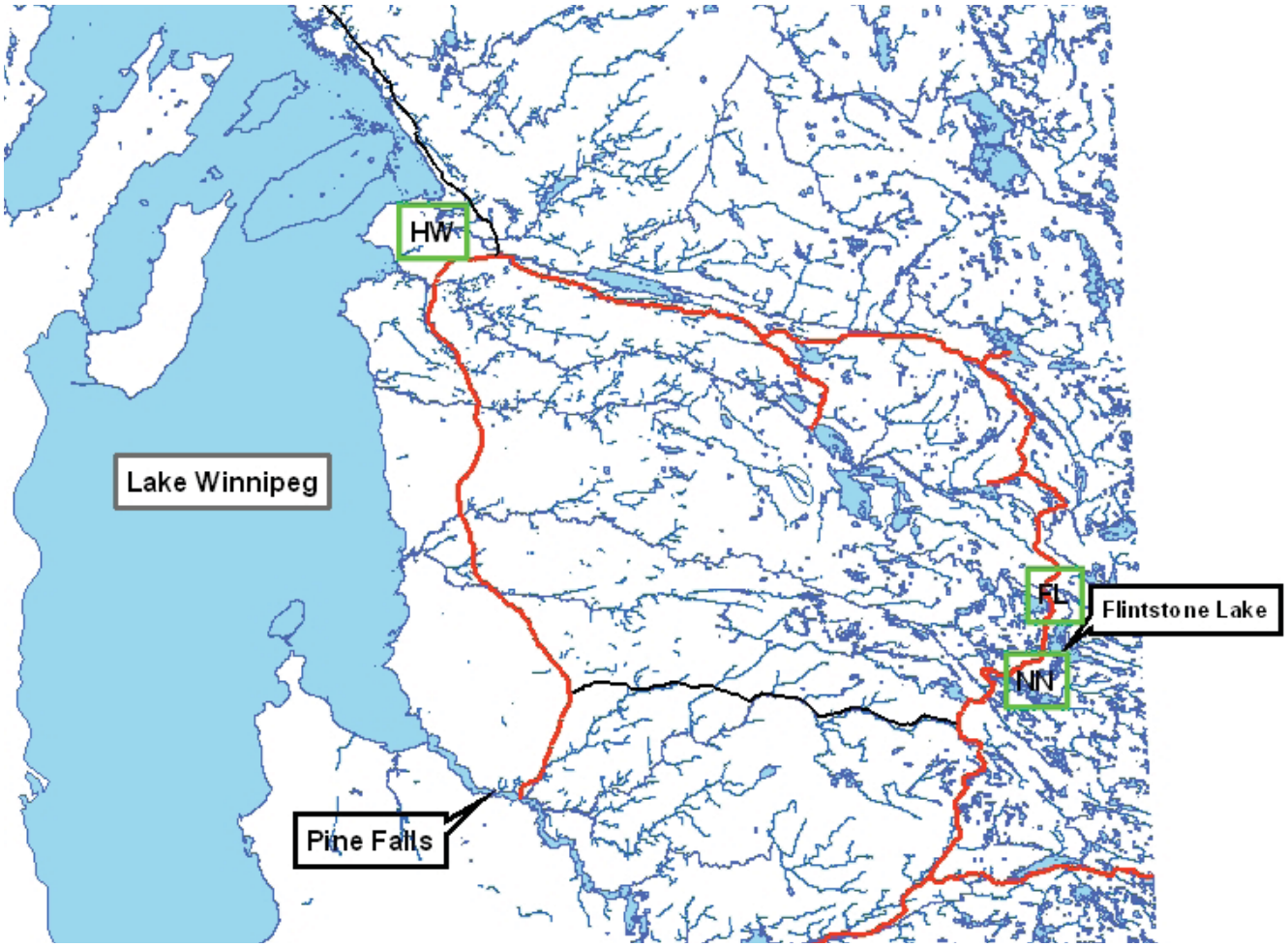


Figure 2: Map of eastern Manitoba showing the location of study sites. HW = Hollow Water study plots, FL = Flintstone Lake study plots, NN = Nopiming North study plots

The sites at Hollow Water are all dominated by jack pine forests underlain by sandy soils. The soil in the area is sandy because the region is a former beach ridge of glacial Lake Agassiz.

The following information is based on the Tembec Forest Resource Inventory (FRI). Tembec owns a pulp and paper mill in the town of Powerview-Pine Falls. Figure 3 shows the location of the Hollow Water sites relative to each other. According to the FRI, the Hollow Water 1912 Jack Pine site is 6.7 hectares in size and is dominated by jack pine, making up approximately 70% of the trees in the site; the remaining trees are trembling

aspen (20%) and balsam fir (10%). It is a fire-origin stand with a 1912 year of origin. Presumably, a fire burned the area sometime prior to 1912 (the exact fire history for the area is not known prior to 1912). The Hollow Water 1983 Jack Pine site is 14.2 hectares in size. The site was harvested in 1983. It is dominated by jack pine, making up approximately 90% of the trees in the site. The remaining 10% of the trees are trembling aspen. The Hollow Water 1992 Jack Pine site is 11.3 hectares in size and is dominated by jack pine, making up roughly 80% of the trees in the stand. The remaining 20% of trees is composed of trembling aspen. This site was also harvested, in 1992. The last site in this area is the Hollow Water 2000 Jack Pine stand. The composition of the stand is entirely made up of jack pine; therefore jack pine covers 100% of the site. The size of this stand is 31.1 hectares. It was harvested in 2000.

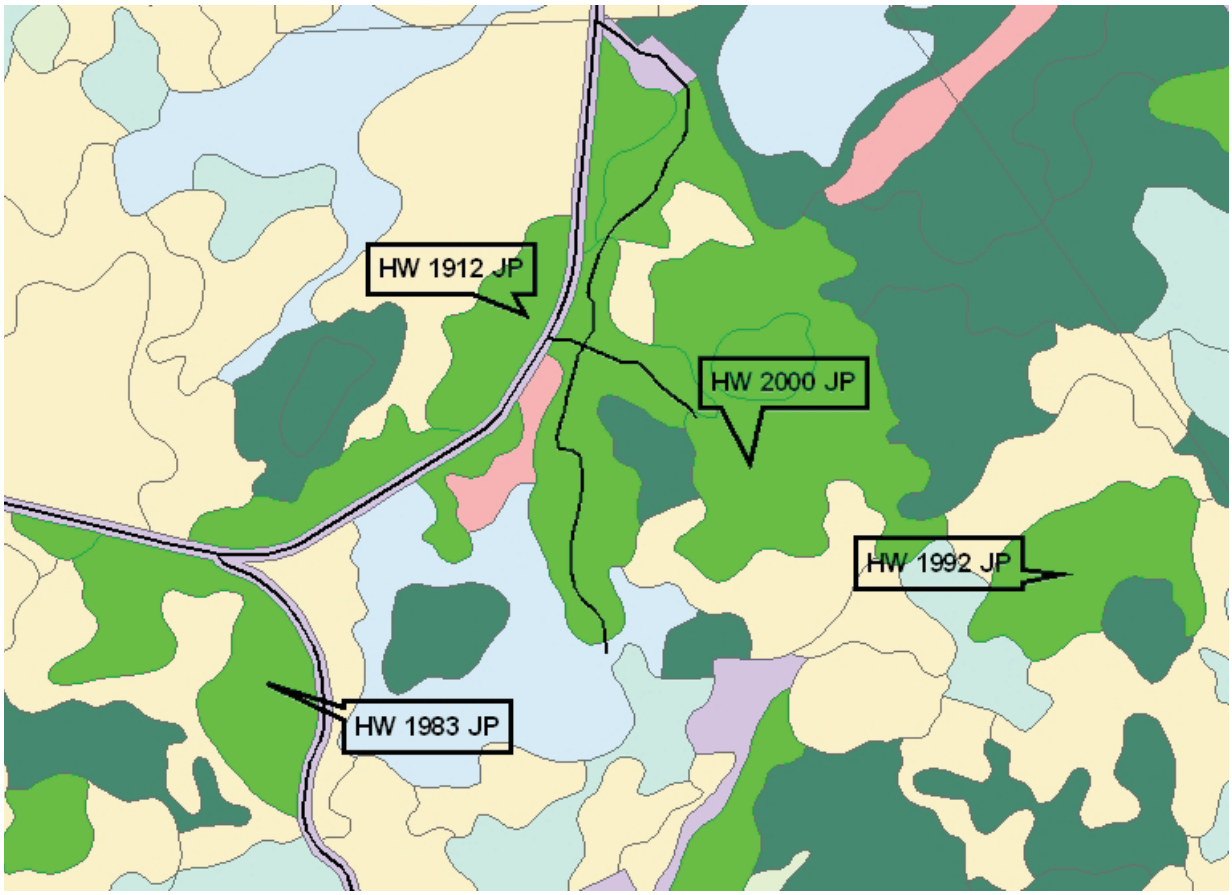


Figure 3: Species composition map of the jack pine study sites in the Hollow Water area, based on the Tembec Forest Resource Inventory.

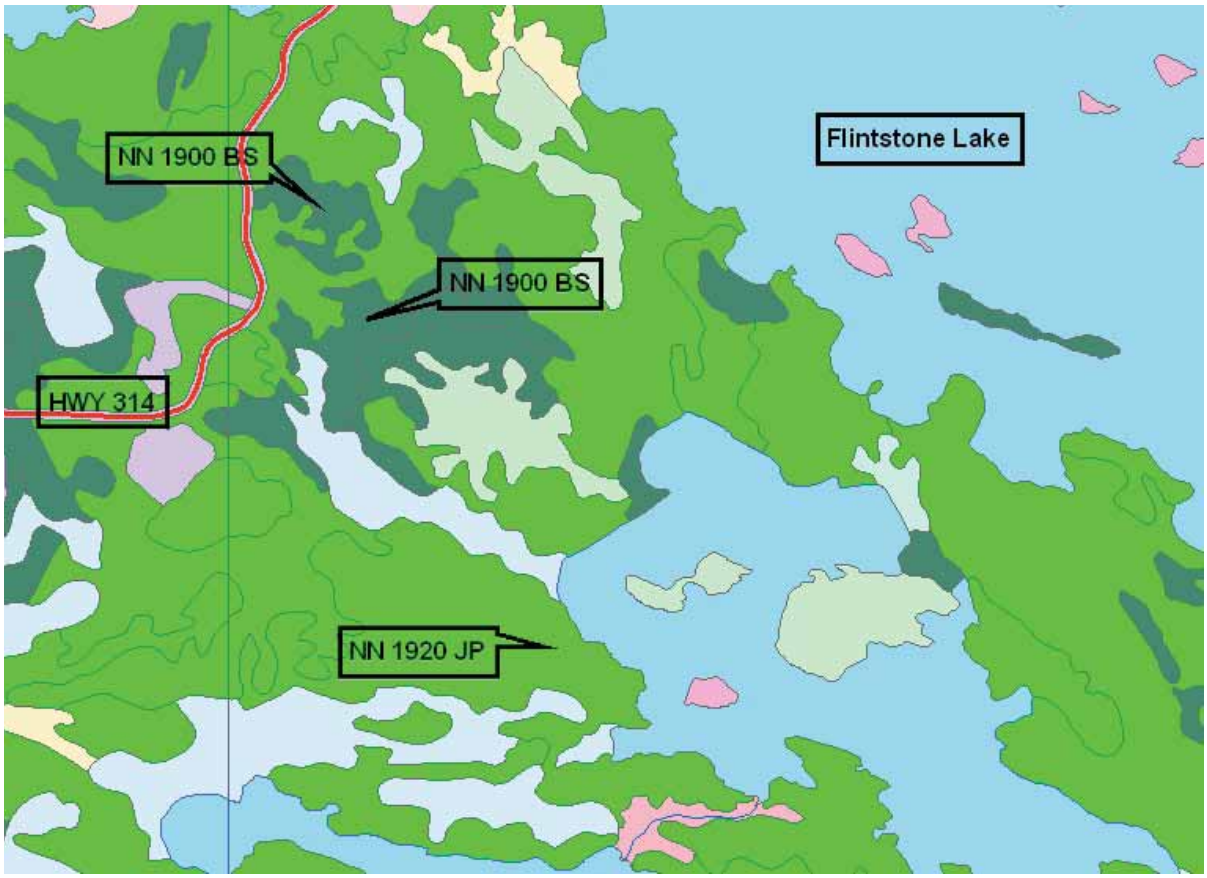


Figure 4: Species composition map of the jack pine and black spruce study sites in Nopiming Provincial Park, based on the Tembec Forest Resource Inventory.

Figure 4 shows the location of the mature (1920) jack pine and mature (1900) black spruce stand sites in the Nopiming Provincial Park. The sites in Nopiming Provincial Park (Nopiming North and Flintstone Lake) are dominated by either jack pine or black spruce forests. The soils in this region are either exposed bedrock with little surficial deposits or level undulating organic peat deposits overlying lacustrine clay sediments.

The Nopiming North 1920 Jack Pine site is 47.5 hectares in size and dominated by jack pine making up approximately 80% of the trees in the stand. The remaining trees are composed of 10% black spruce and 10% balsam fir. The site is of fire origin and the year of origin is 1920. The Nopiming North 1900 Black Spruce plots occur in two almost adjacent sites. Figure 4 shows the first three plots are in the more southern site, while the

remaining two plots are in the more northern site. These sites are of fire origin. The fire passed through this area in 1900. The first site is 15.3 hectares in size and black spruce dominates this area making up 90% of the trees. The remaining 10% of the trees are tamarack. The second site is composed of 100% of black spruce. This site is 6.3 hectares in size.

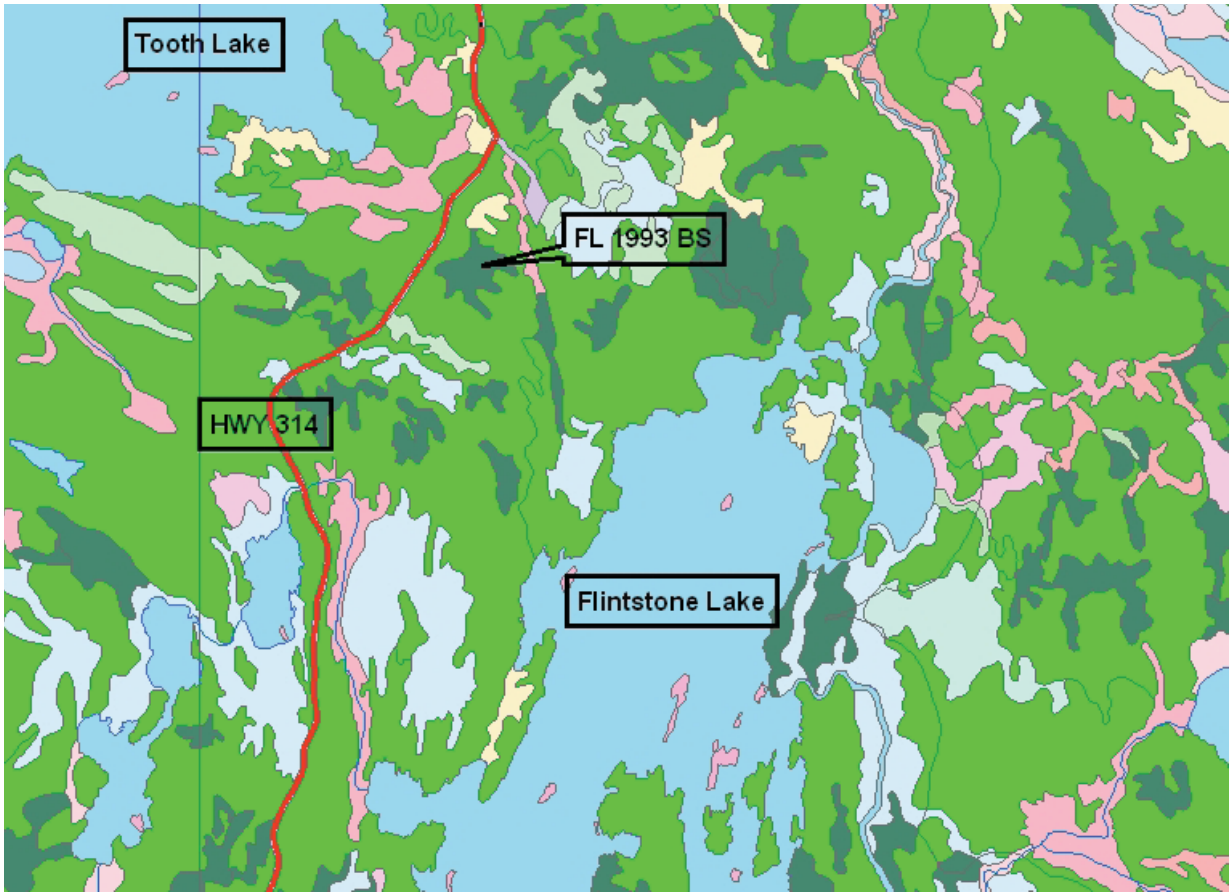


Figure 5: Species composition map of the black spruce study site in the Flintstone Lake area (Nopiming Provincial Park), based on the Tembec Forest Resource Inventory.

The last study site, which is the Flintstone Lake 1993 Black Spruce stand (Fig 5), is 6.4 hectares in size. According to the FRI, the site is dominated by black spruce making up 100% of the trees. A fire passed through this area in 1993, making this stand of fire origin.

Participation of High school Students:

As part of the objectives of the Manitoba Model Forest program, students from Lac du Bonnet, Oak Park and Wanipigow High Schools were brought for a field trip to a study site. Miette Environmental and the Manitoba Model Forest provided students with training required to establish and monitor a twenty-by-twenty stand-alone quadrat. This was the third year of participation for the Lac du Bonnet and Wanipigow schools.

During the sessions with the schools, students learned how to set up a twenty-by-twenty metres plot, use a GPS, identify tree species, measure dbh of trees and assess tree health, crown class and crown rating. In addition students learned how to use a clinometer to estimate tree height, an increment borer to estimate tree age, a sling psycrometer to measure relative humidity and a hand held digital thermometer to measure air and soil temperature. The students also learned how to measure light transmission in forests using a light meter.

Data was collected during the spring and fall of 2006. Lac du Bonnet high school helped collect data at the Nopiming North 1920 Jack Pine site in the spring. The information gathered during spring at the Assiniboine Forest by Wanipigow School was not used in this report since these plots were only temporary at that point in time and this session was used more for training. Students from Wanipigow School once again visited to the Assiniboine Forest during the fall and gathered data on permanent plots. Information on plots from the Assiniboine Forest is not presented in this report, as data collection is not completed.

Figure 6: Students and staff from Oak Park school (left) and Wanipigow School (right) participating in field research.

Figure 7: Lac du Bonnet School students and staff assisting in data collection.

Analysis of Results

Canopy-Tree Stratum

Tree Calculations:

Hollow Water Jack Pine:

According to the Tembec Forest Resource Inventory (FRI), the percentage of jack pine in the Hollow Water 1912 Jack Pine, Hollow Water 1983 Jack Pine, Hollow Water 1992 Jack Pine and Hollow Water 2000 Jack Pine was 70, 90, 80 and 100%, respectively. The FRI was relatively accurate with the exception of the Hollow Water 1912 Jack Pine site, which the measured percentage of jack pine was nearly a split with trembling aspen (Fig 8). For the other three stands, jack pine was by far the most abundant species and dominated in terms of abundance.

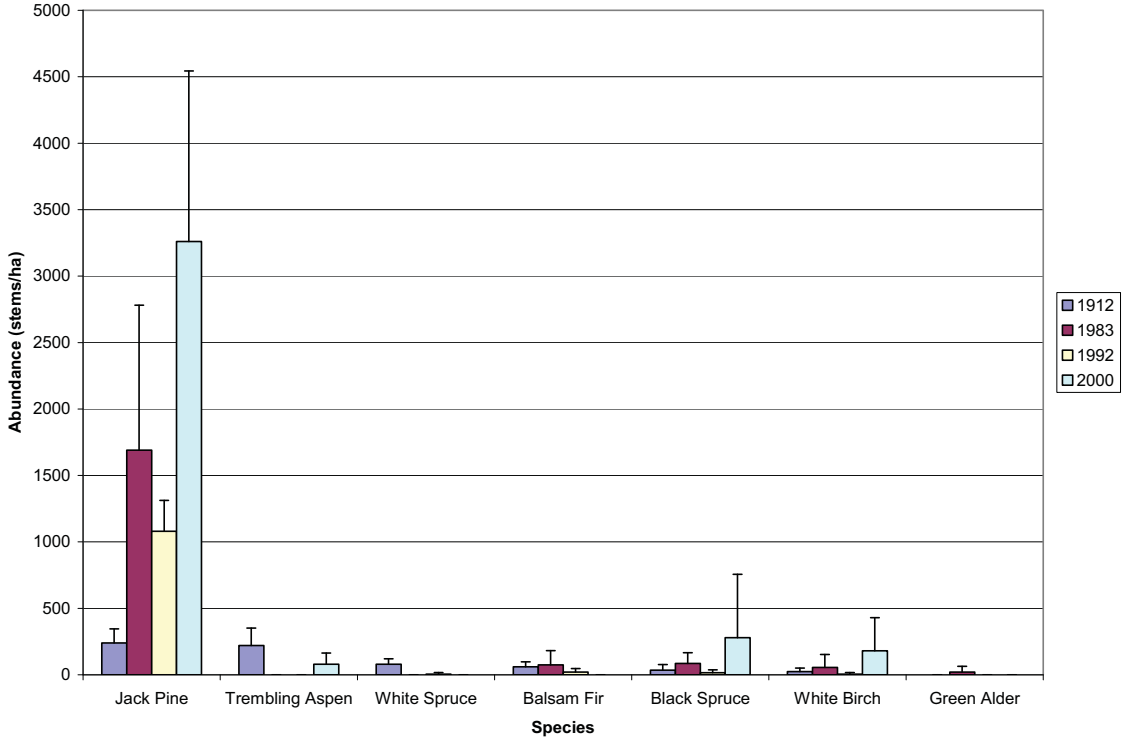


Figure 8: Abundance of live species in Hollow Water jack pine stands

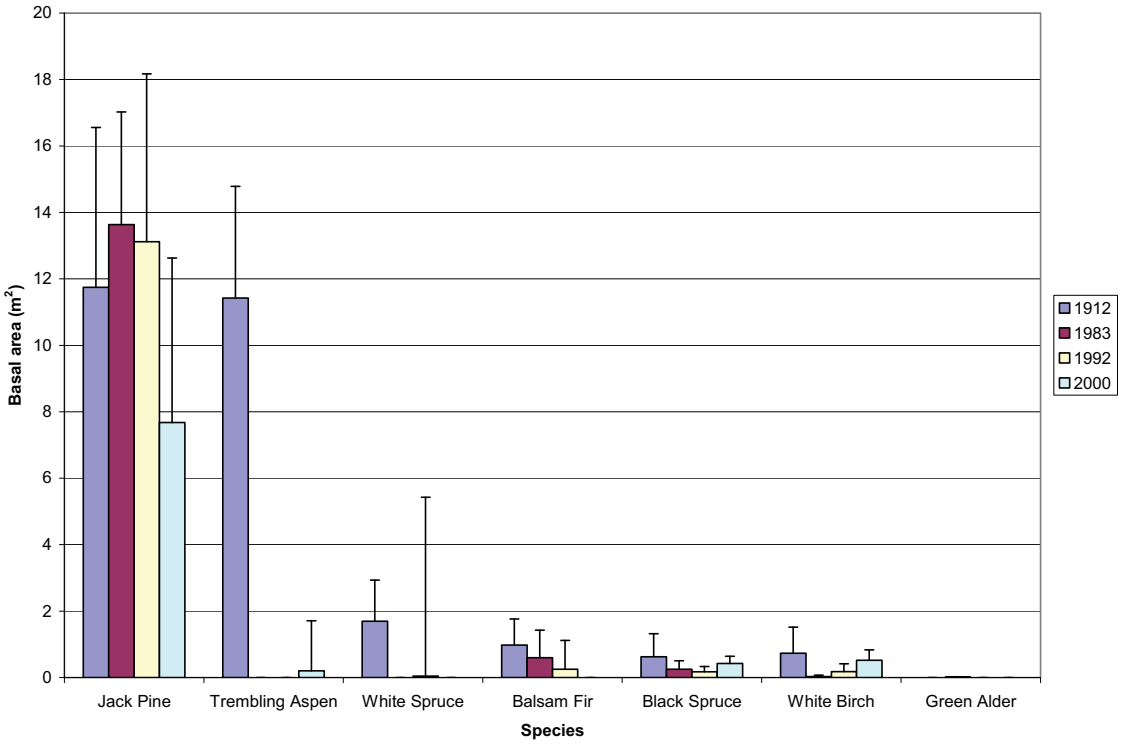


Figure 9: Basal area of live species in Hollow Water jack pine stands

It is not surprising to see the younger stands dominated by jack pine, given that these sites had been harvested 23 years ago or sooner. During its first 20 years, jack pine is one of the fastest growing conifers in its range (http://www.rook.org/earl/bwca/nature/trees/pinusbank.html). This may explain jack pine's large numbers in these three young stands. On the other hand, the mature jack pine forest had fewer stems than the younger sites. Jack pine begins to show signs of decadence by age 75, which would explain the great number of trembling aspen in this stand (http://www.rook.org/earl/bwca/nature/trees/pinusbank.html). Young stands of jack pine have very large numbers of stems. This number decreases substantially as the stand self-thins over time.

As shown in Figure 9, basal area in the youngest jack pine stand is lower than the older stands, which is most likely due to the fact that the vast majority of trees in the young stand have a dbh less than 4 cm. Basal area in the Hollow Water 1983 Jack Pine and

Hollow Water 1992 Jack Pine stands are greater than the mature jack pine stand, although there was a great degree of variability in the data.

The most abundant dead species in the Hollow Water 1912 Jack Pine stand was clearly balsam fir (Fig 10). It also is the only stand with dead balsam fir. Balsam fir is a late successional or climax species which would explicate it absence in the younger jack pine stands (http://www.rook.org/earl/bwca/nature/trees/pinusbank.html). The high number of dead balsam fir stems reflects a recent infestation of spruce budworm in the Hollow Water 1912 Jack Pine stand.

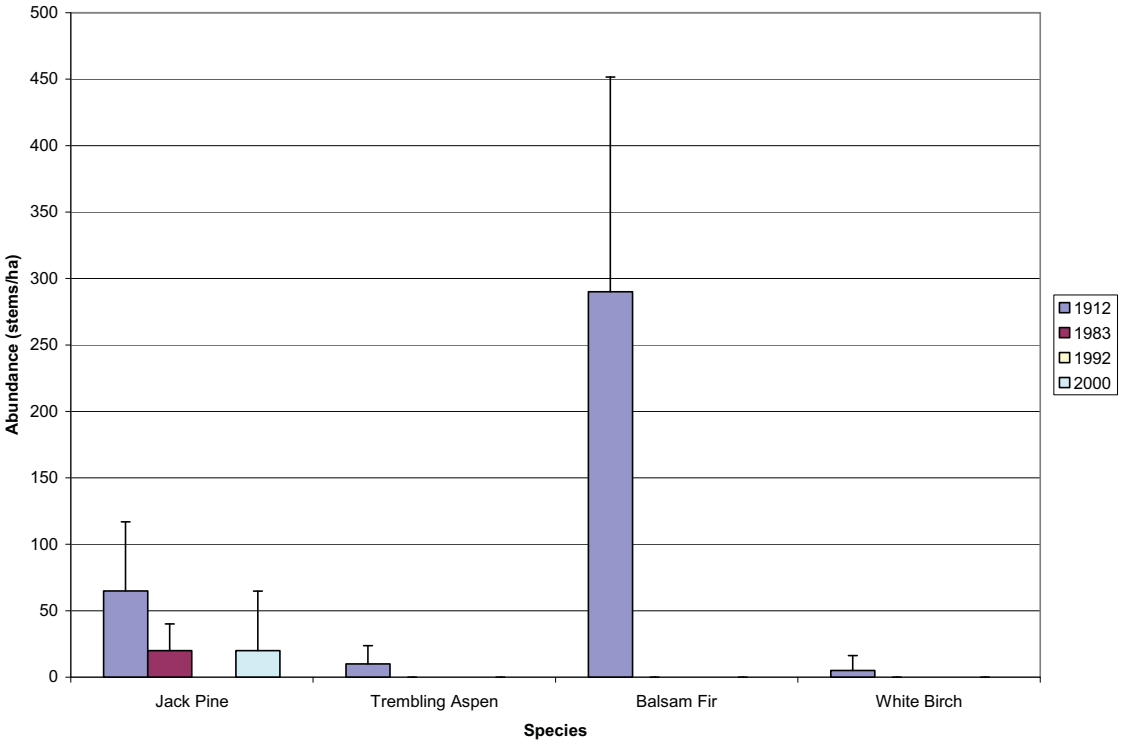


Figure 10: Abundance of dead species in Hollow Water jack pine stands

Figure 10 illustrates that the Hollow Water 1983 Jack Pine and the Hollow Water 2000 Jack Pine stands have a few dead jack pine, which is not out of the ordinary. The Hollow Water 1992 Jack Pine stand does not have any dead trees. The stand is in full regeneration, and doing very well.

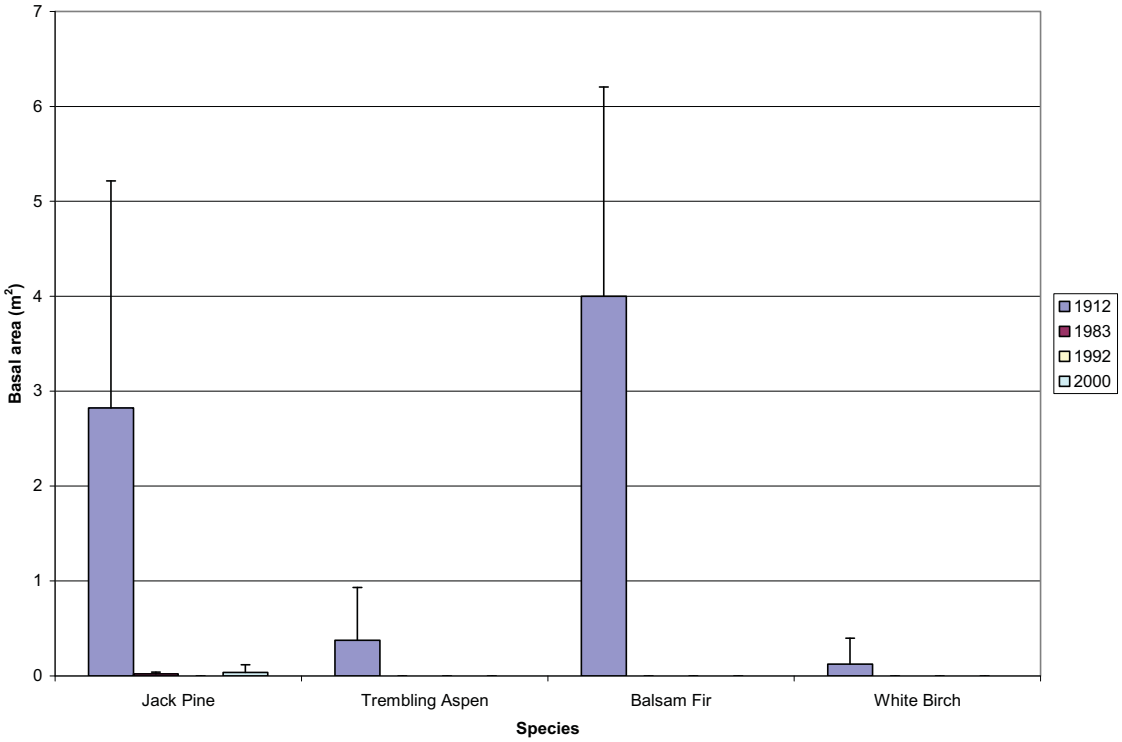


Figure 11: Basal area of dead species in Hollow Water jack pine stands

Although balsam fir was undoubtedly the most abundant dead species in the Hollow Water 1912 Jack Pine stand, Figure 11 illustrates that dead jack pine is also as dominant based on basal area. This is most likely due to the fact that the jack pine is mature and therefore possesses a greater dbh than the smaller balsam fir.

Figure 12 demonstrates that jack pine had the greatest density in all of the young plots. Hollow Water 1912 Jack Pine stand showed a division in density between jack pine and trembling aspen. Black spruce and white birch were found in all four stands, but their densities were minor compared to jack pine. The trend in density is similar to that of abundance (Fig 8).

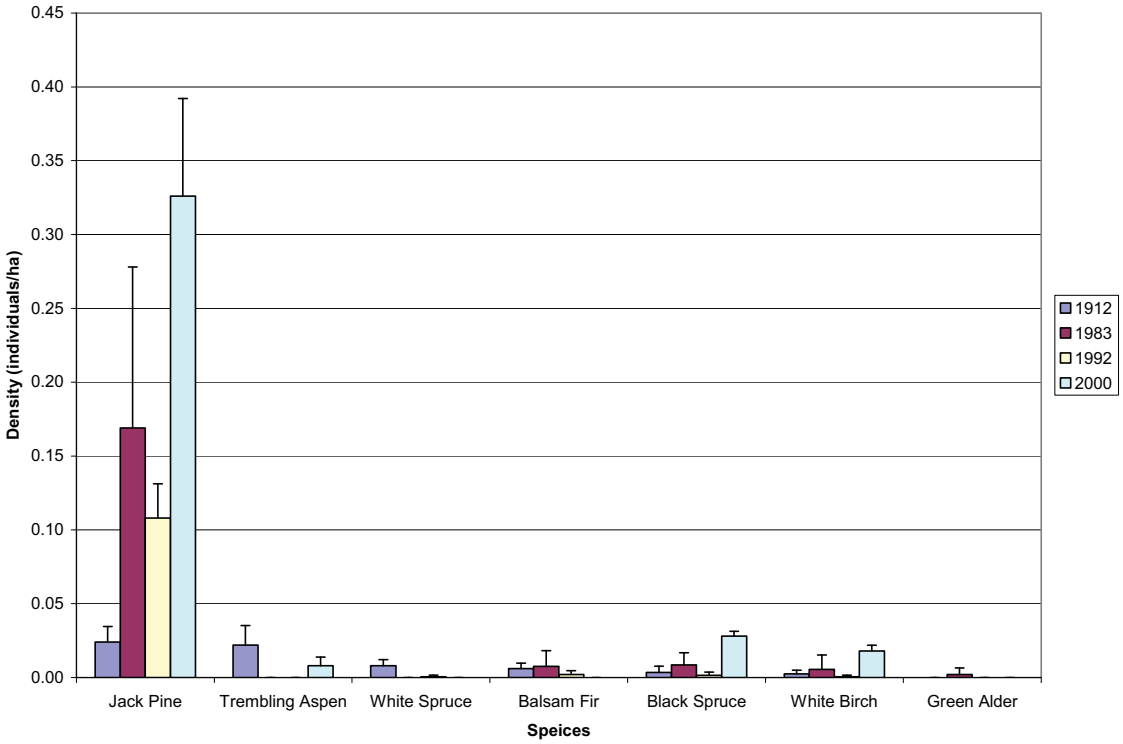


Figure 12: Density of live species in Hollow Water jack pine stands

As Figure 13 shows, the relative density of certain species was different than the density value. Since the relative density is the calculation of one species' density relative to all species, its value will show the weight of one species density specific to a stand.

The relative density for jack pine in the Hollow Water 1992 Jack Pine site was much higher compared to its density, showing its density is quite significant in that stand compare to other species. The same was true for jack pine in the Hollow Water 1983 stand, but the difference between density and relative density was not quite as dramatic. All relative density values were higher than the density values for the Hollow Water 1912 Jack Pine stand. This was simply due to the number of individuals being distributed more evenly between species. Extreme relative density values frequently occur when a species is exceedingly more abundant than other species or with less diversity of species.

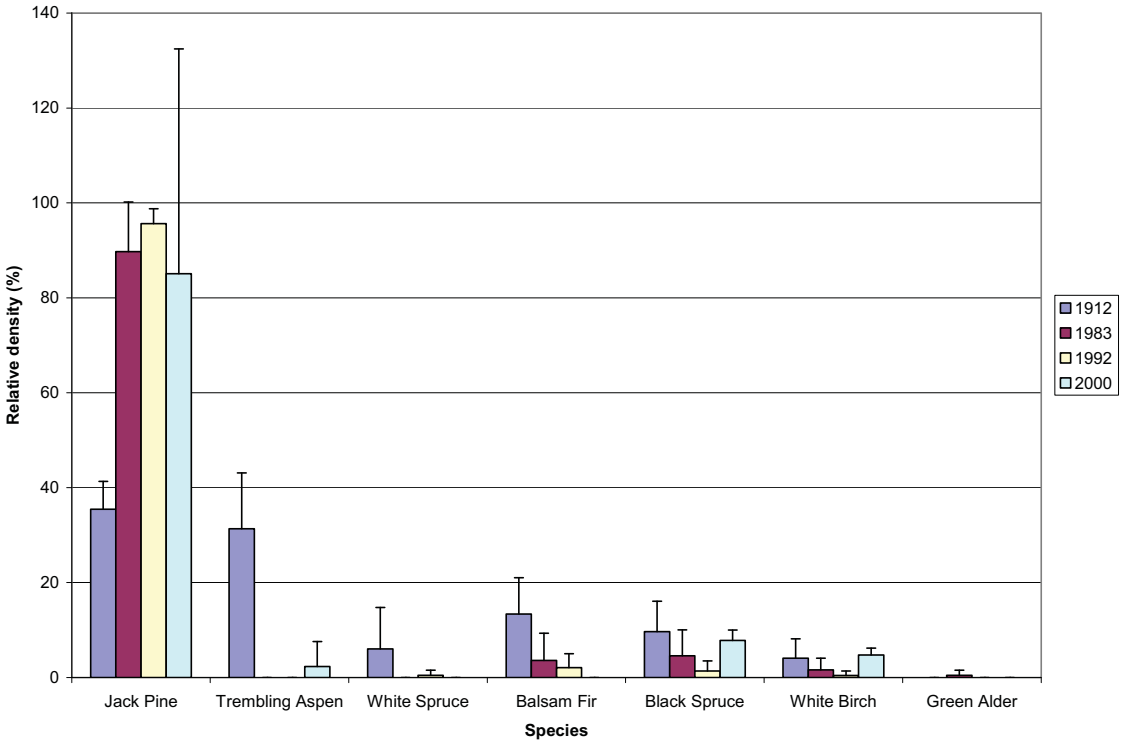


Figure 13: Relative density of live species in Hollow Water jack pine stands

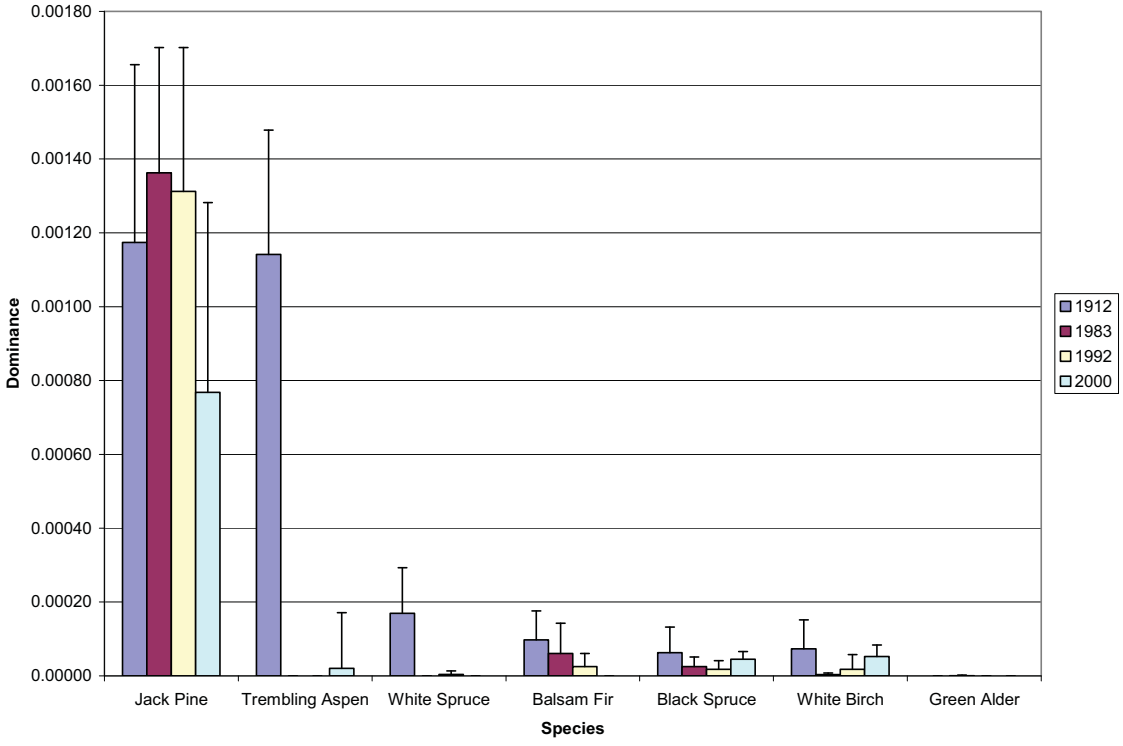


Figure 14: Dominance of live species in Hollow Water jack pine stands

Figure 14 shows that in all three young jack pine stands, jack pine had the greatest dominance values. Once again, the Hollow Water 1912 Jack Pine stand differed from the other three due to the relatively equal basal area of jack pine and trembling aspen. In this stand, jack pine and trembling aspen are co-dominant. The dominance value of jack pine and trembling aspen individually are equal to the dominance value of jack pine in the younger stands. This could be explained by the fact that the Hollow Water 1912 Jack Pine stand is mature, and therefore trees have a greater dbh in this stand in comparison with the younger ones. The dominance value in all stands for the rest of the species (white spruce, balsam fir, black spruce, white birch and green alder) are minor.

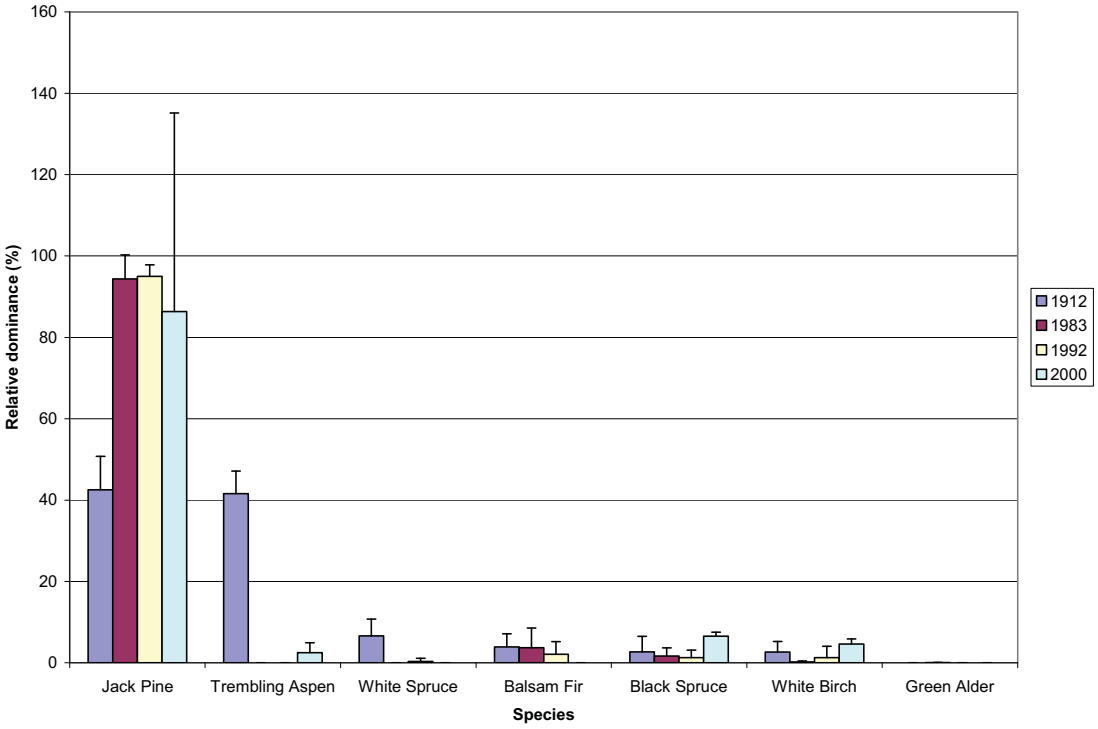


Figure 15: Relative dominance of live species in Hollow Water jack pine stands

According to Figure 15, the relative dominance values don't seem to differ significantly from the dominance values with the exception of the Hollow Water 1912 Jack Pine stand. Both jack pine and trembling aspen are dominant in this stand. Hence their relative dominance is half the value of the jack pine in the other three stands, because their dominance value is compared with the dominance value of species in the same stand.

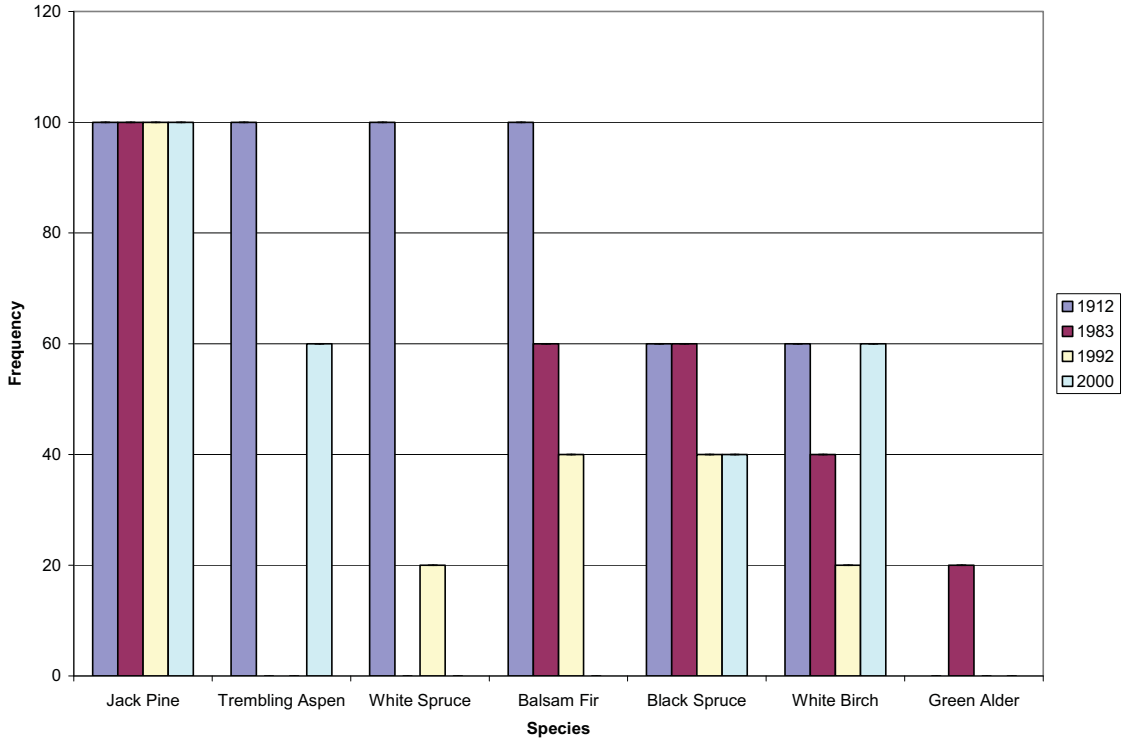


Figure 16: Frequency of live species in Hollow Water jack pine stands

As illustrated in Figure 16, the frequency of jack pine in all four stands was 100%, meaning jack pine was found in all five plots per stand. Trembling aspen, white spruce and balsam fir were also found in every plot of the Hollow Water 1912 Jack Pine stand and therefore had a frequency of 100%. Other species such as black spruce, white birch and green alder had a frequency of 60% or less depending on the stand. It is interesting to note that some of these other species are present in the younger jack pine stands (frequency between 20-60% - Fig 16), but these species are not very abundant (Fig 8) and do not have a high basal area (Fig 9).

The relative frequency values of the Hollow Water 1912 Jack Pine stand as shown in Figure 17 are well distributed among all species present in this site. In contrast, the Hollow Water 1992 Jack Pine stand's relative frequency values were concentrated with jack pine, counting for more than 45% of the stands relative frequency. This means species in the Hollow Water 1912 Jack Pine stand were found at the relatively same frequency, as opposed to the Hollow Water 1992 Jack Pine site where jack was noticeably more frequent than other species. For the Hollow Water 1983 Jack Pine and Hollow Water 2000 Jack Pine stands, jack pine had the greatest relative frequency, but species such as trembling aspen, balsam fir, black spruce and white birch were not too far behind.

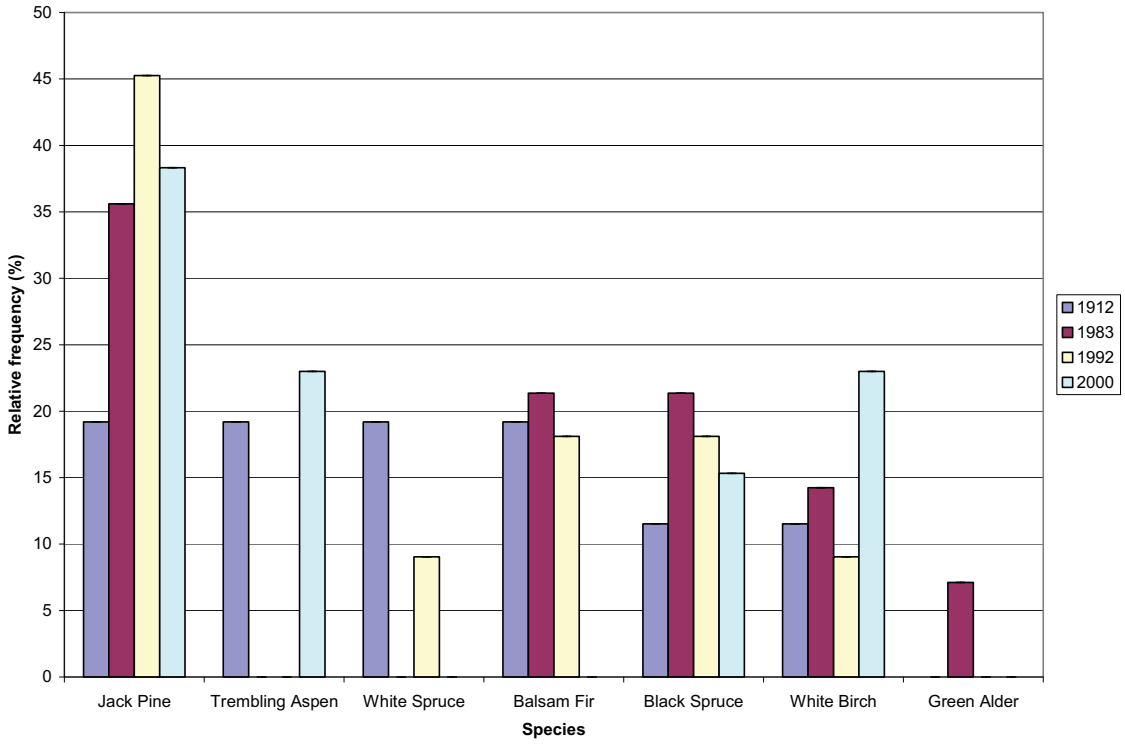


Figure 17: Relative frequency of live species in Hollow Water jack pine stands

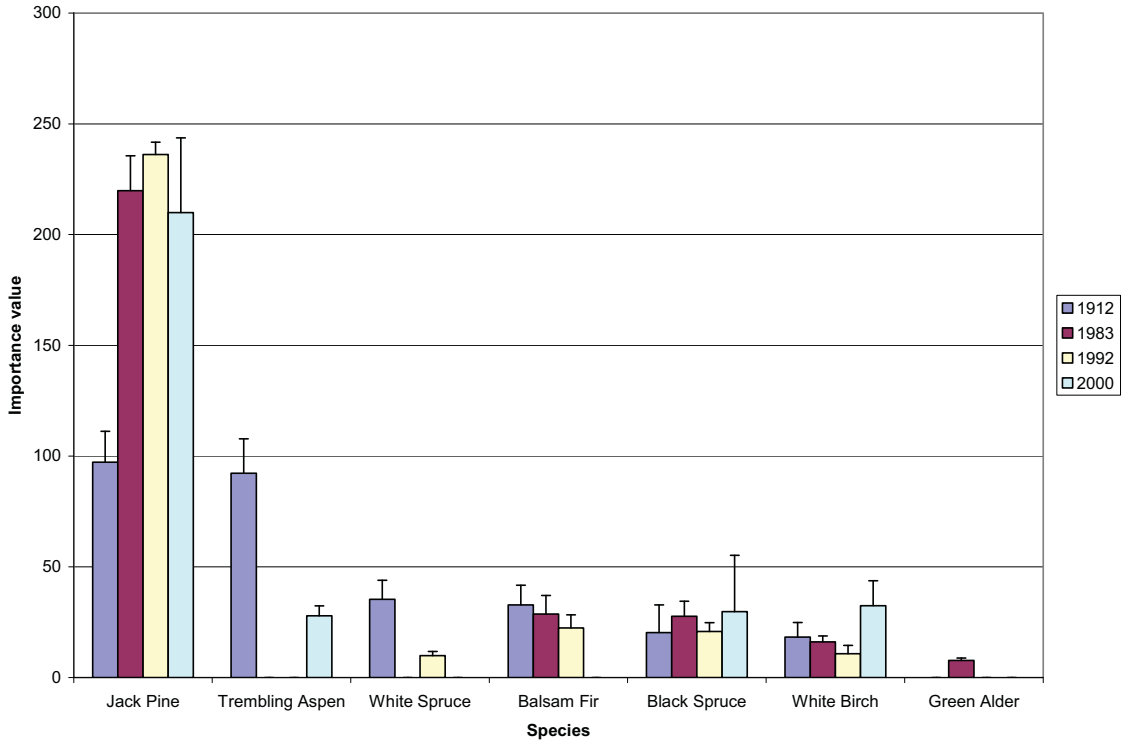


Figure 18: Importance value of live species in Hollow Water jack pine stands

Importance value is an index made up of the sum of relative density, relative dominance and relative frequency, and profiles the structural role of a species in a stand. It is useful for making comparisons among stands in reference to species composition and stand structure (Roberts-Pichette, Gillespie, 1999). Figure 18 illustrates that the three young jack pine stands share similar importance values. Jack pine's importance values in these stands added up to more than 200 of the possible value of 300 (total value of relative density, relative dominance and relative frequency per plot is 100). This would indicate that the species composition of these young stands is dominated by jack pine and therefore jack pine plays a vital structural role in these stands. On the other hand, Figure 18 shows that in the mature jack pine stand, both jack pine and trembling aspen have nearly the same importance value. Both species individually account for a third of the total importance value. This indicates both trembling aspen and jack pine share an essential part of the structural role of the stand. Other species in all four stands had an importance value lower than 35, which shows that although species such as balsam fir, black spruce and white birch are found in the majority of the stands, their structural role is still minor compare to jack pine and trembling aspen, in the case of the mature site.

Nopiming North Jack Pine:

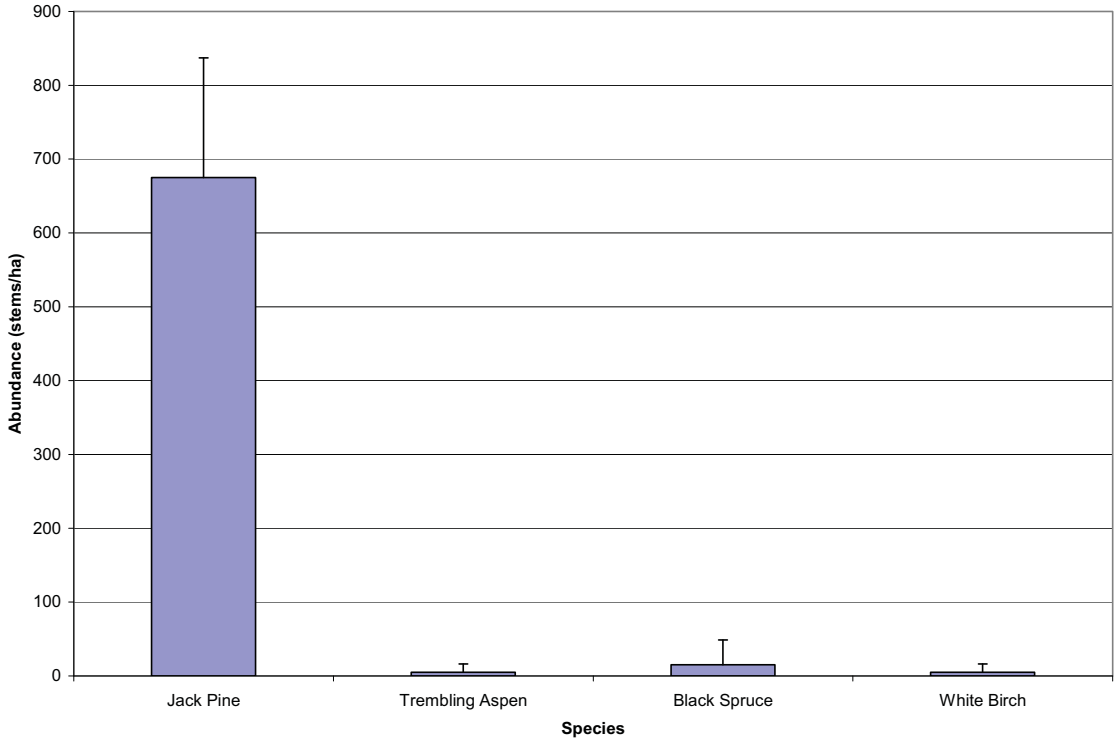


Figure 19: Abundance of live species in Nopiming North 1920 Jack Pine stand

According to the Tembec Forest Resource Inventory (FRI), the Nopiming North 1920 Jack Pine stand is composed of 80% jack pine, 10% black spruce and 10% balsam fir. The FRI values were only partially accurate as we did not find balsam fir in the plots of this stand. However, trembling aspen and white birch were one of four species present at this site. The sum of values of black spruce, trembling aspen and white birch did not reach 10% of the total value in the stand which indicates jack pine accounts for more than 90% of the trees. The difference between the FRI and what was actually encountered in the stand reflects the fact that we sub-sampled only a small portion of this 47.5 ha stand. Also, the FRI only provides an approximate estimate of species composition, as the FRI is based on interpretation of aerial photos. Not all stands in the FRI are ground-truthed for accuracy.

Figures 19 to 29 illustrate that jack pine had the greatest value in terms of abundance, basal area, density, relative density dominance, relative dominance, frequency, relative frequency and importance value. Trembling aspen, black spruce and white birch were also present in the stand, but their values were almost inconsequential compared to jack pine. The importance value of jack pine, along with all the other calculations, reflects jack pine's dominant structural role in this stand. Although, values for other species are minor, they had a frequency of 20%, which enhances their importance value through relative frequency.

Jack pine usually grows in dry, acidic sandy soils, but can also establish itself in thin soil over bedrock. The Nopiming North 1920 Jack Pine site is characterized by exposed bedrock with little surficial deposits. This may explain jack pine's clear dominance in this stand.

Figure 21 shows that jack pine was also the most abundant dead species. Its basal area was comparable to its abundance value seeing as they both are extensively greater than the other dead species, trembling aspen.

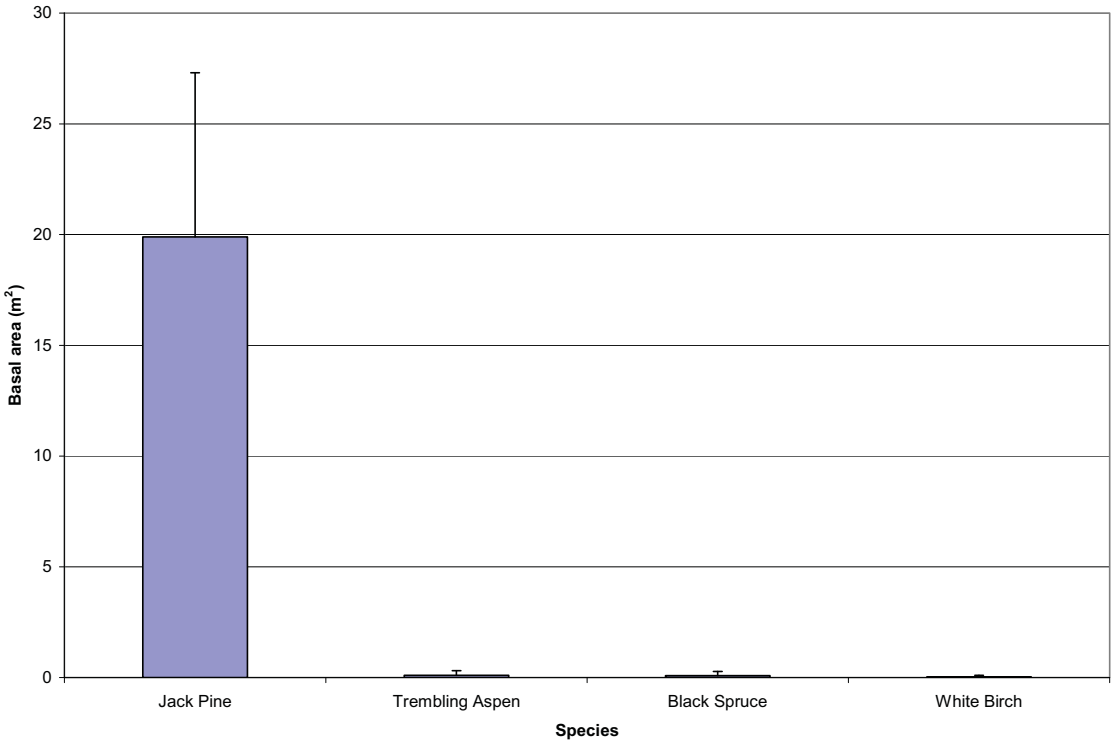


Figure 20: Basal area of live species in Nopiming North 1920 Jack Pine stand

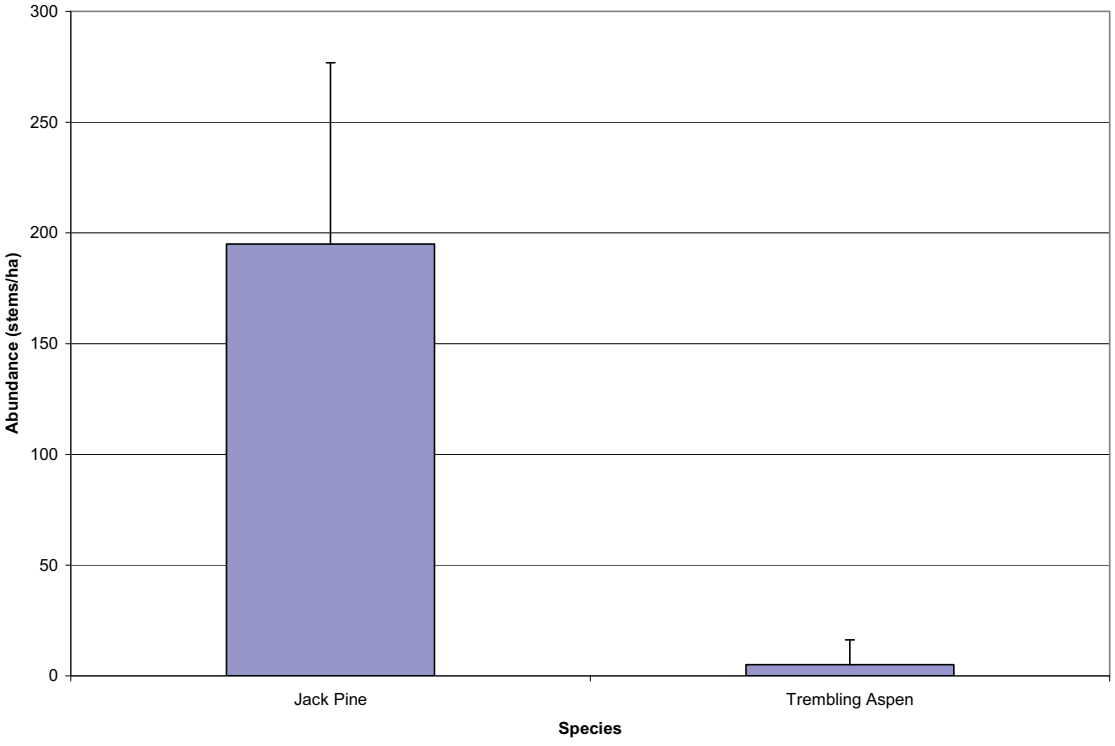


Figure 21: Abundance of dead species in Nopiming North 1920 Jack Pine stand

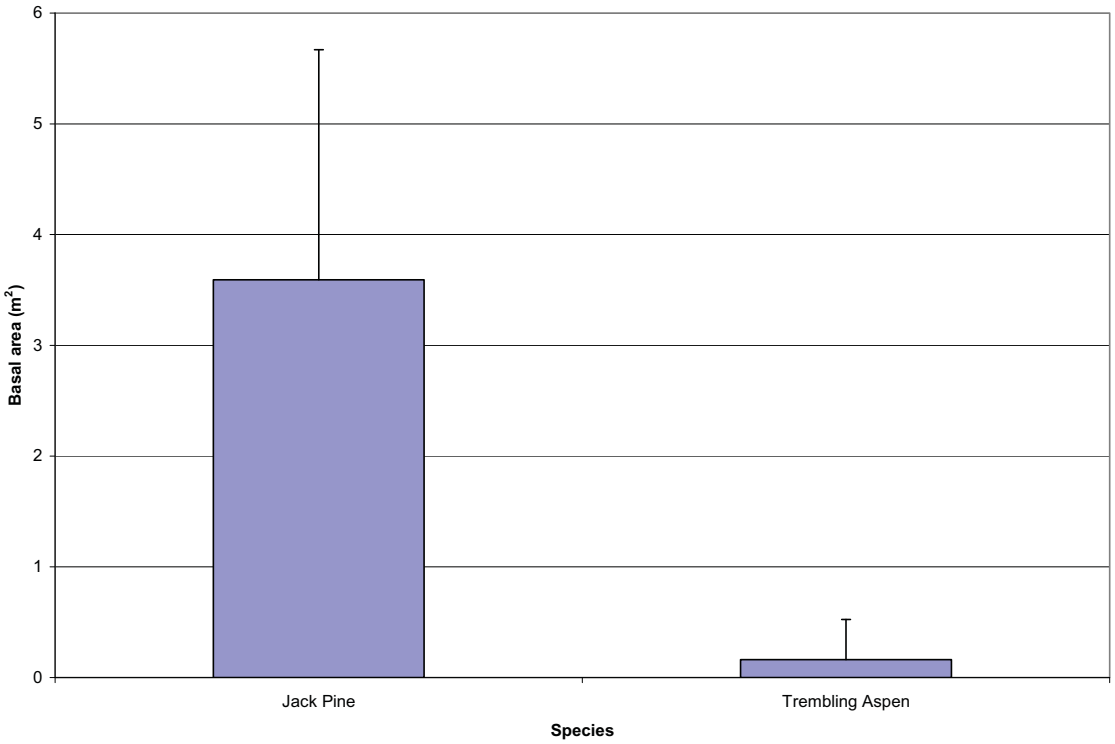


Figure 22: Basal area of dead species in Nopiming North 1920 Jack Pine stand

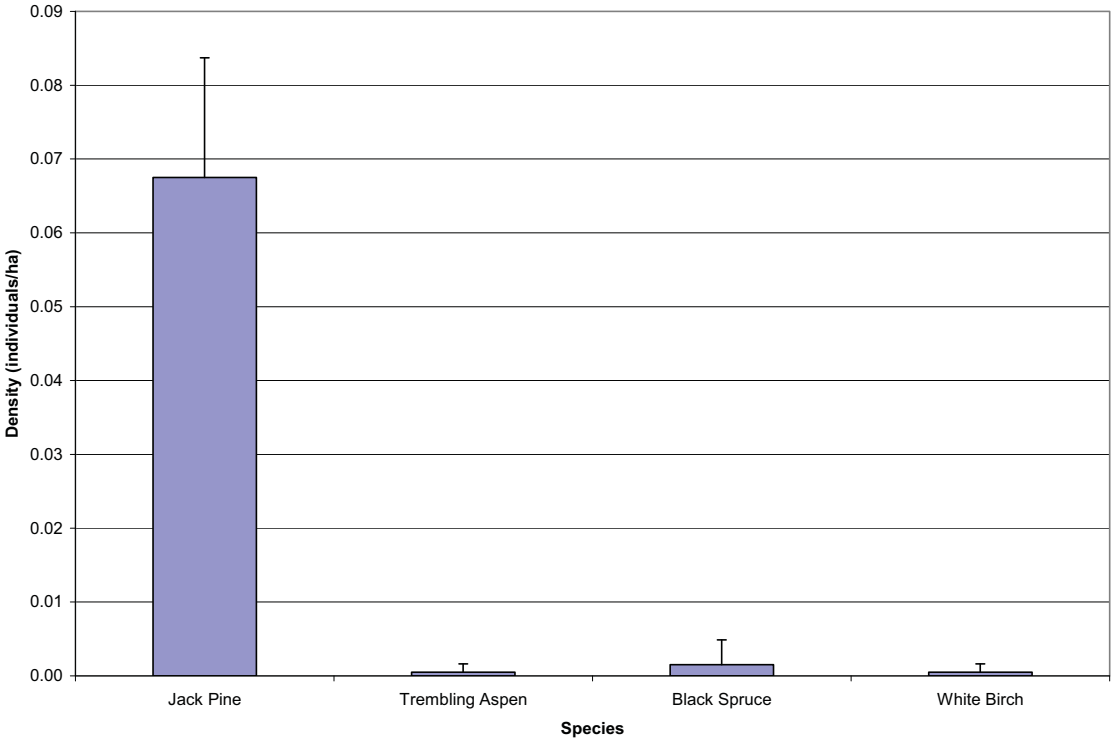


Figure 23: Density of live species in Nopiming North 1920 Jack Pine stand

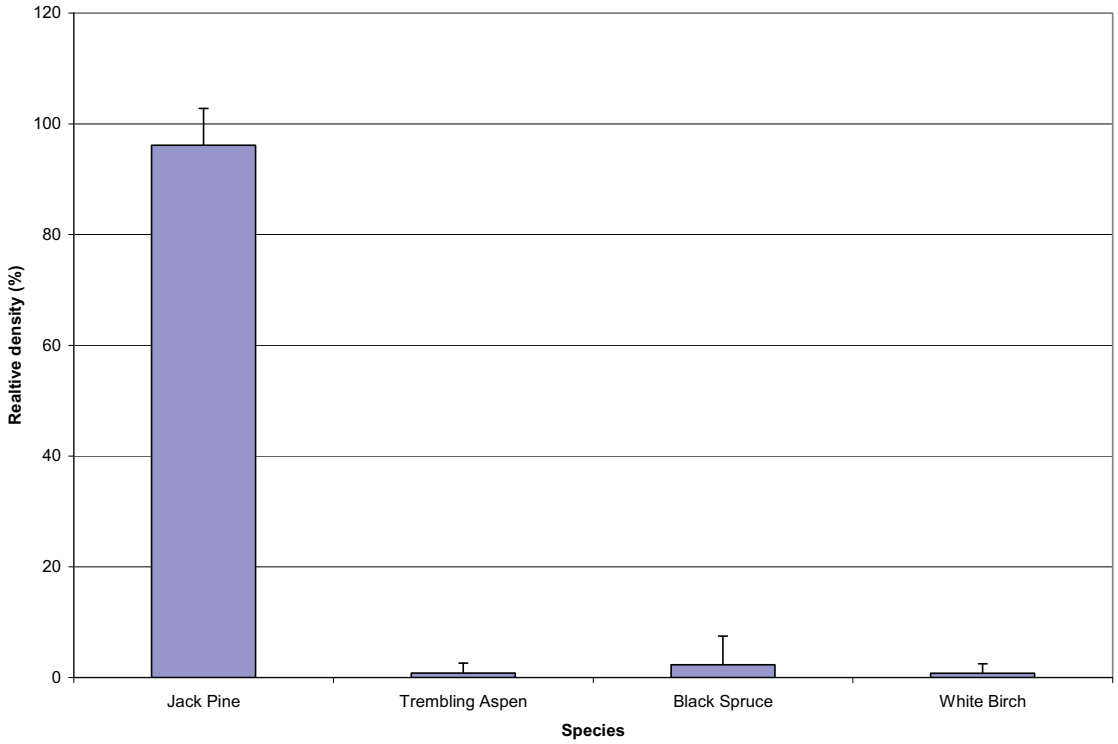


Figure 24: Relative density of live species in Nopiming North 1920 Jack Pine stand

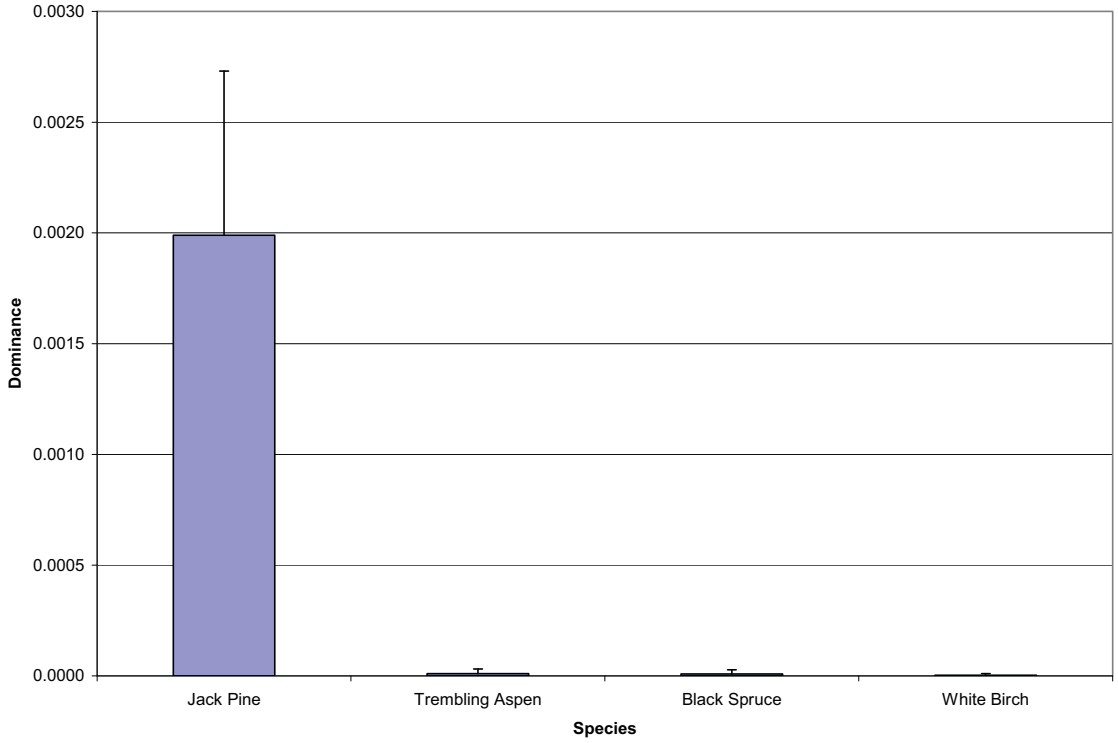


Figure 25: Dominance of live species in Nopiming North 1920 Jack Pine stand

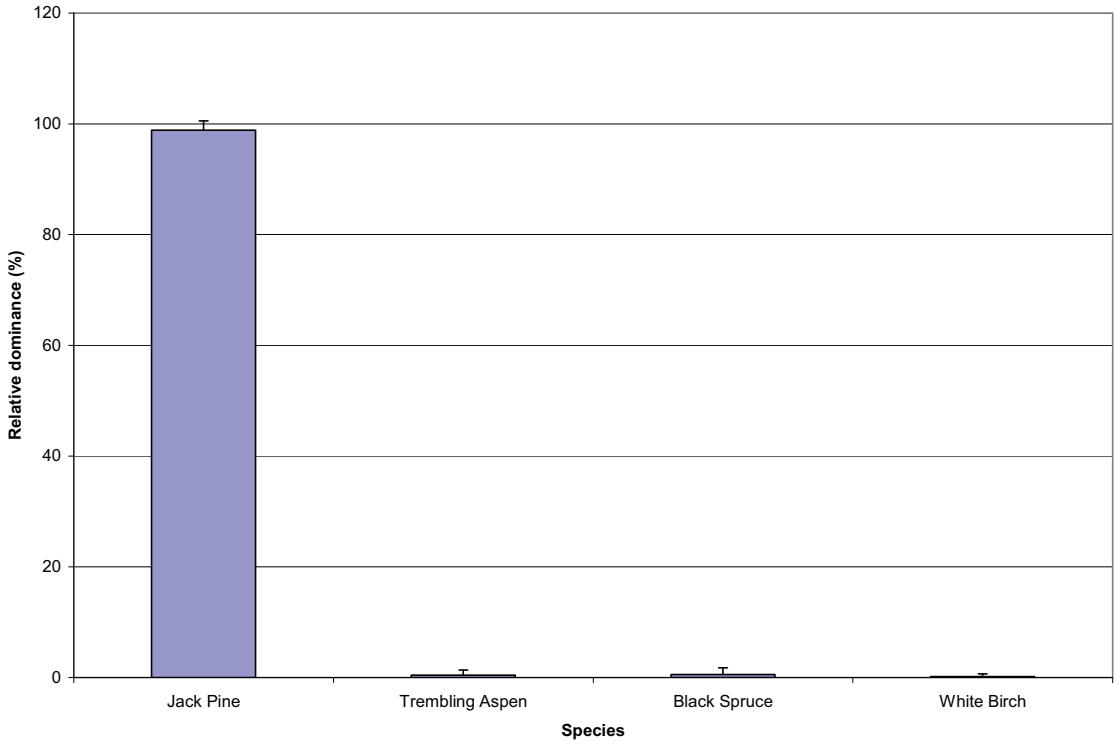


Figure 26: Relative dominance of live species in Nopiming North 1920 Jack Pine stand

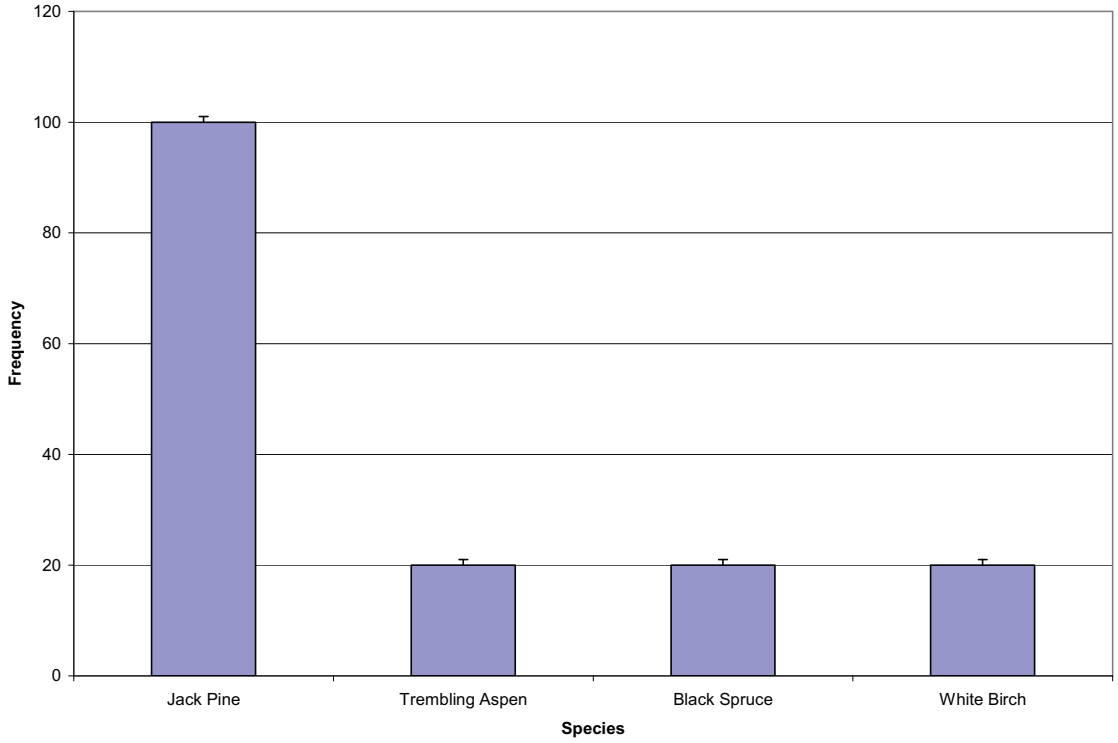


Figure 27: Frequency of live species in Nopiming North 1920 Jack Pine stand

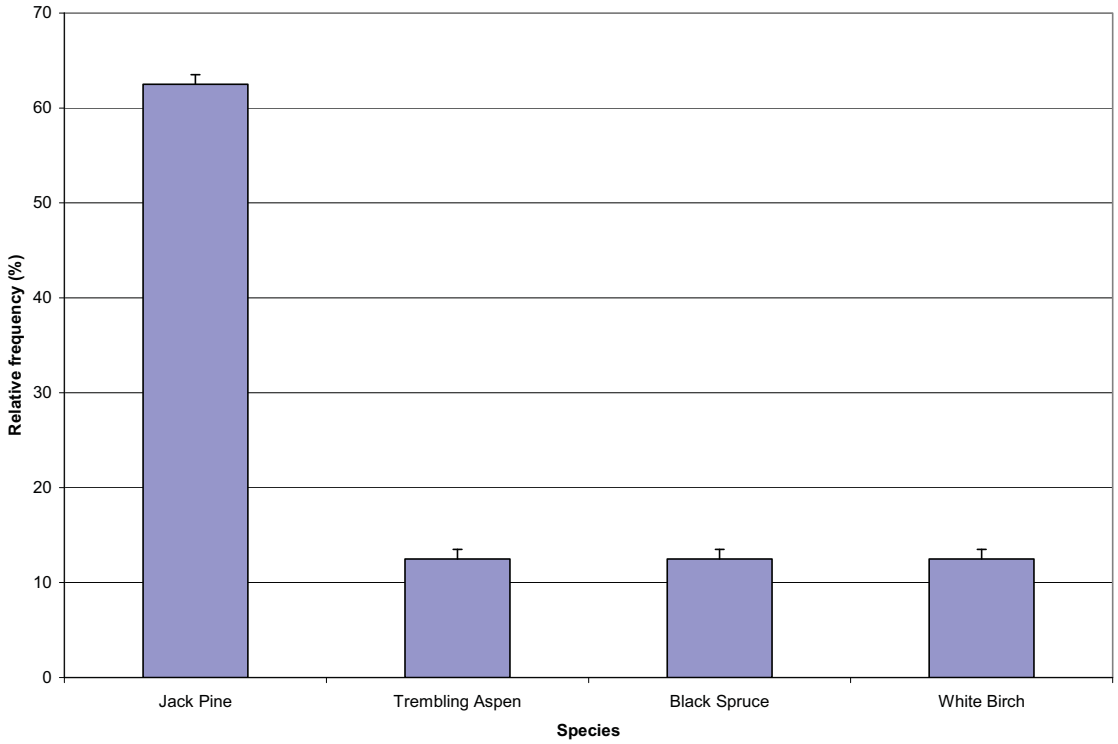


Figure 28: Relative frequency of live species in Nopiming North 1920 Jack Pine stand

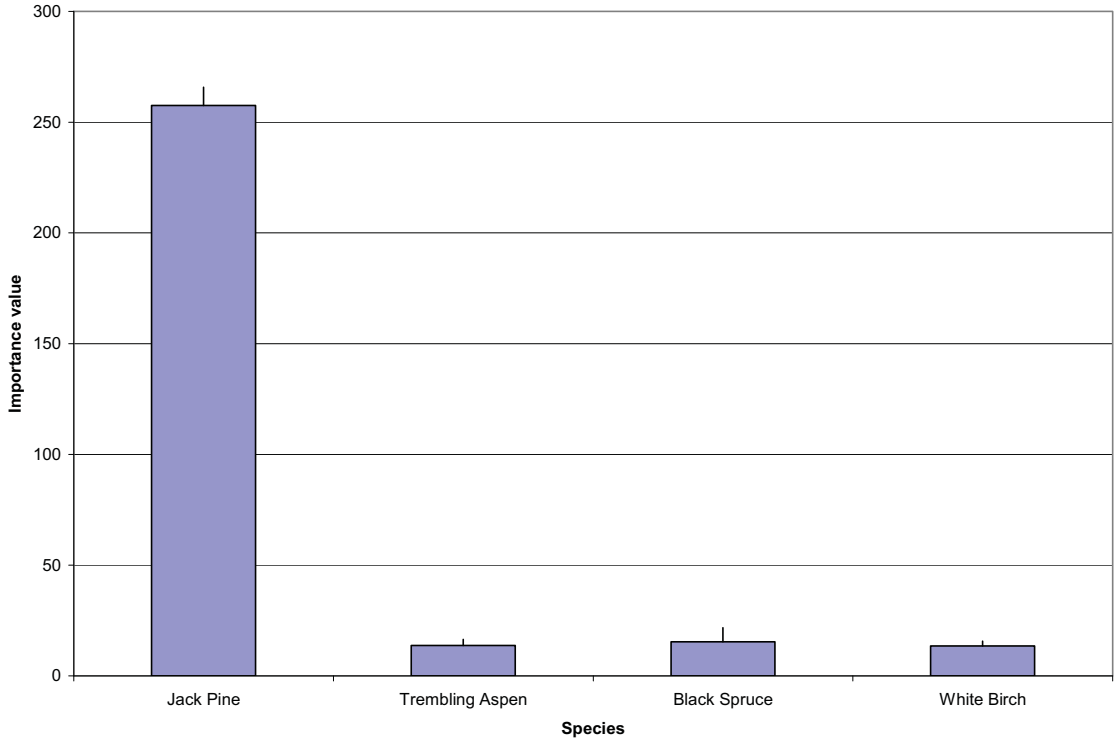


Figure 29: Importance value of live species in Nopiming North 1920 Jack Pine stand

Nopiming North & Flintstone Lake Black Spruce:

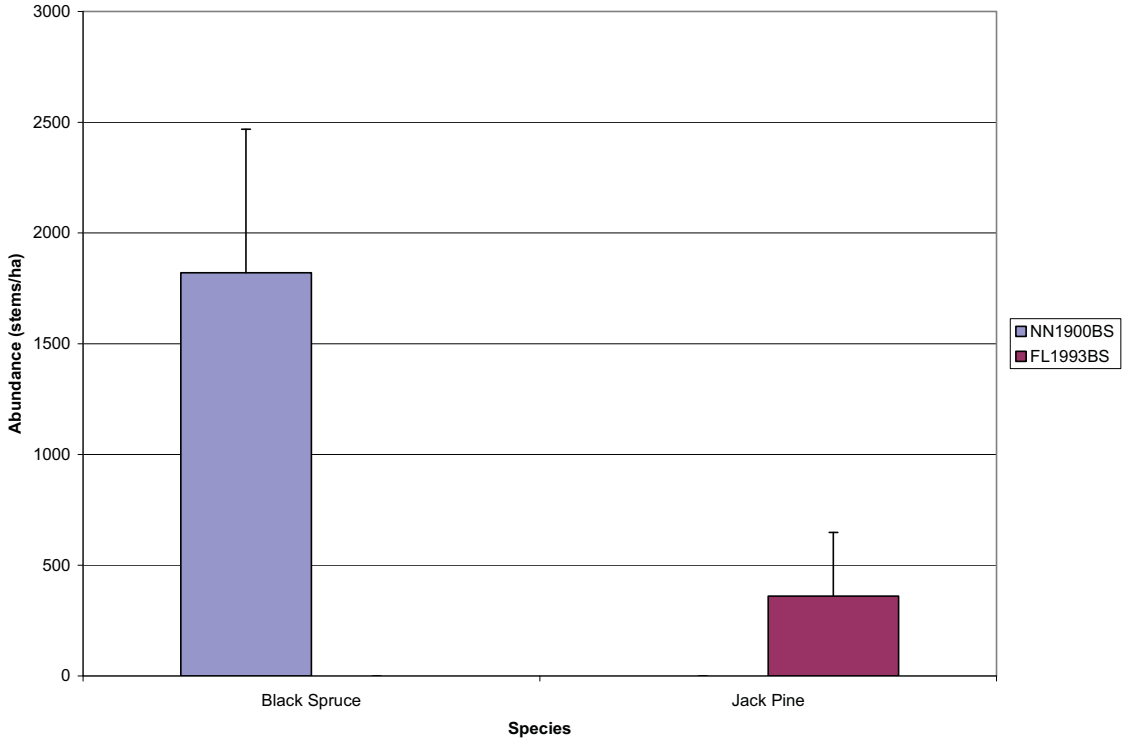


Figure 30: Abundance of live species in black spruce stands

According to the Tembec Forest Resource Inventory, the first Nopiming North 1900 Black Spruce site is composed of 90% black spruce and 10% balsam fir, while the second site is 100% black spruce, identical to the Flintstone Lake 1993 Black Spruce stand. We found that the mature black spruce site was actually entirely black spruce. The young black spruce stand did not have any black spruce "trees", but rather thousands of black spruce seedlings. The only trees found in the Flintstone Lake 1993 Black Spruce stand were jack pine. However, these trees had a relatively small dbh. It is interesting to note that the largest trees in this organic, peat area after the fire were jack pine and not black spruce. This reflects the rapid ability of jack pine to colonize areas after disturbance and their higher growth rate than black spruce. Nevertheless, the jack pine will most likely be dominated by black spruce in a few years as this wet, peatland site is more suited to black spruce.

Black spruce in the mature stand and jack pine in the young stand were the species with the greatest abundance, basal area, density, relative density, dominance, relative dominance, frequency, relative frequency and importance value in their respective stands. This is obviously the case, since both species were also the only live species found in both stands. In the instance of having a single species per stand, the relative density, relative dominance and relative frequency of this species will always be a 100% and the importance value will always be 300. This is simply explained by the fact that these calculations are based on the comparison between species in a single stand and therefore having only one species will automatically mean the full value for the lone species.

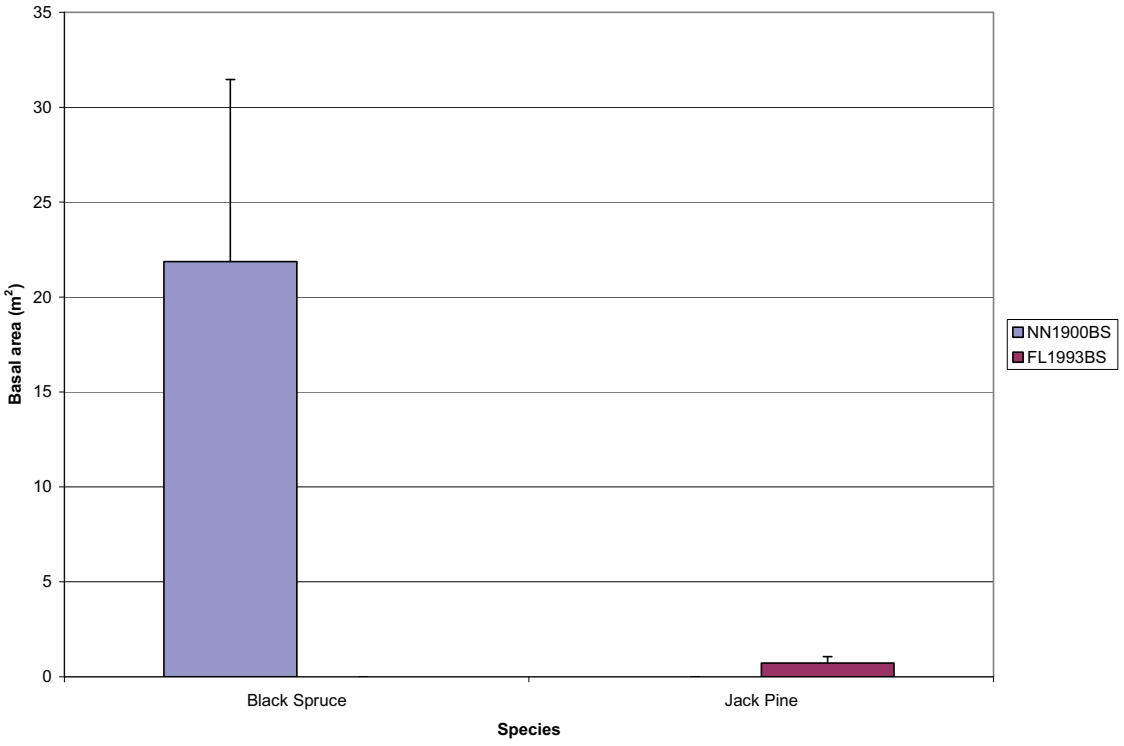


Figure 31: Basal area of live species in black spruce stands

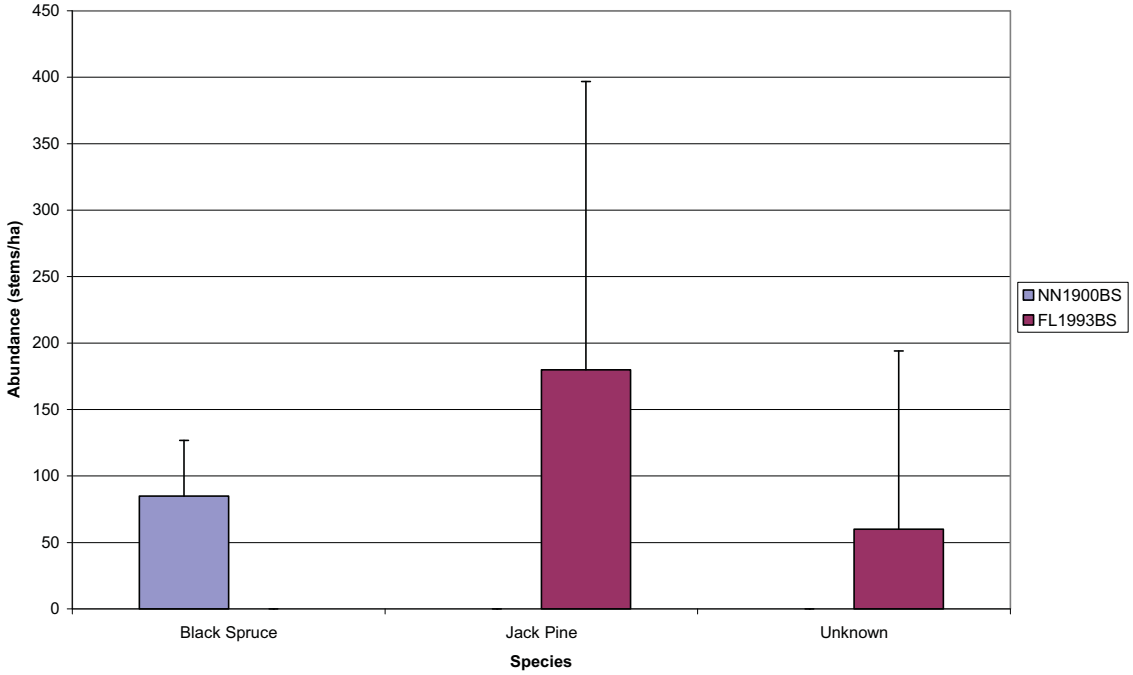


Figure 32: Abundance of dead species in black spruce stands

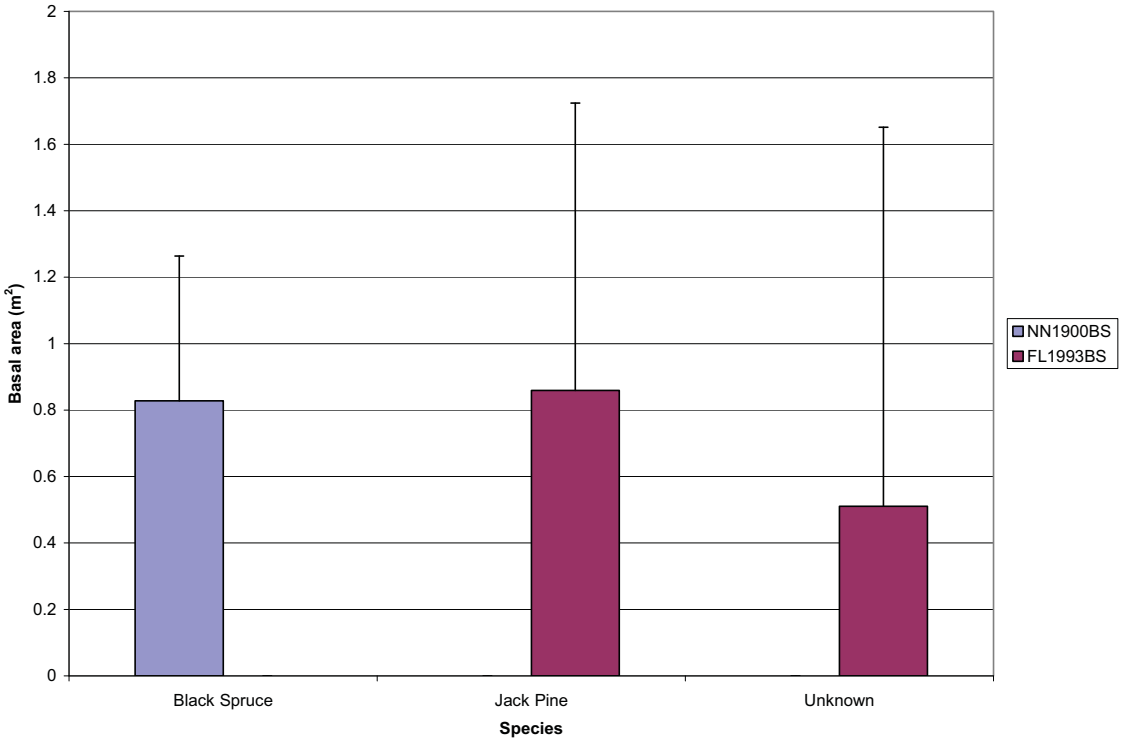


Figure 33: Basal area of dead species in black spruce stands

According to Figure 32 and 33, the number of dead species seem to be equal to the live species. In the mature site, the only dead species found was black spruce. In the young stand, jack pine was found, along with an unknown which could very well be jack pine or black spruce (unable to identify species due to fire). Both the black spruce in the mature site and the unknown in the young site had a greater basal area relative to their abundance if we compare them to the jack pine in the young stand. Since the jack pine in the young stand had a somewhat great abundance and a small basal area, this would indicate the death of immature jack pine in this stand.

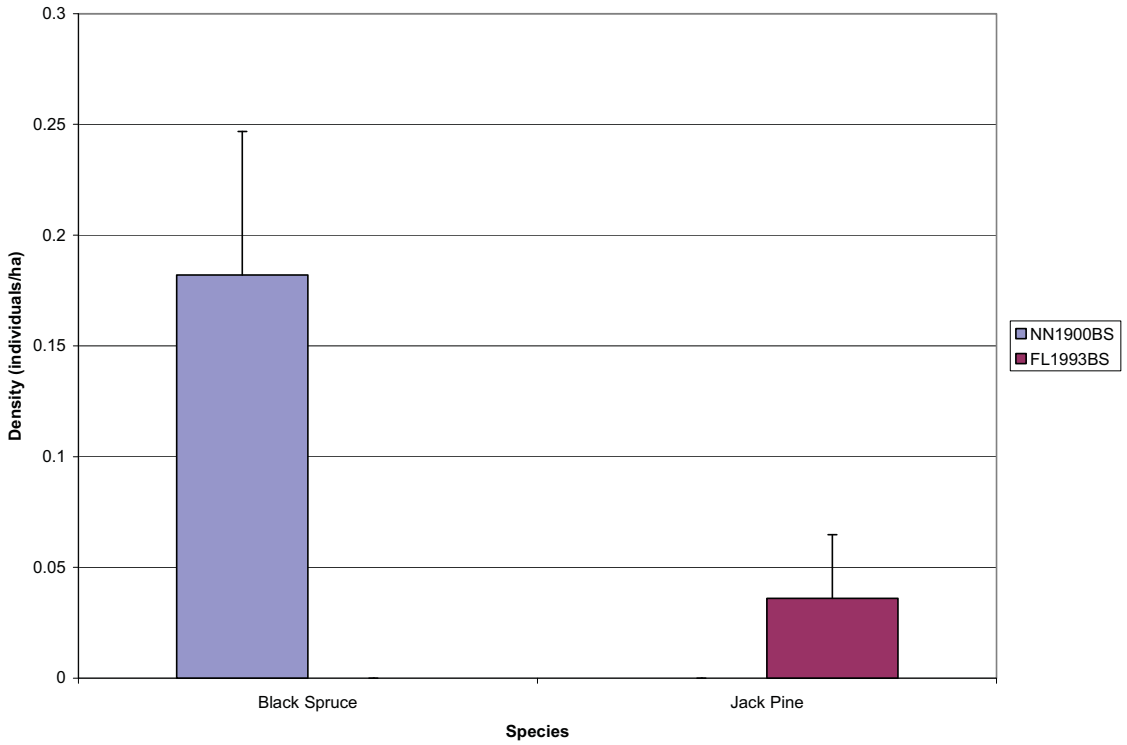


Figure 34: Density of live species in black spruce stands

As Figure 30 illustrates, the abundance of jack pine in the young stand was 5 times lower than the black spruce in the mature site. As shown in Figure 34, the ratio holds true for density since it is based on the abundance of the same species. On the other hand, Figure 31 shows that the basal area of jack pine in the young stand was 30 times less than the black spruce in the mature site. Figure 36 illustrates that the ratio holds true for dominance since it is based on the basal area of the same species.

The differences in ratios can be justified by two explanations. Firstly, black spruce in the mature stand had a large basal area compared to its abundance. Secondly, jack pine in the young stand had a small basal area compared to its abundance. The second explanation is the most probable. It appears that the jack pine in the young stand germinated quickly after the fire, but since the soil is less than ideal for jack pine, individuals are growing, but with a small dbh.

If we compare the abundance of live species to dead species in the immature stand, we can see that there was only twice the number of live jack pine compared to dead jack pine. This indicates a high mortality rate for jack pine in this stand. Based on the organic peat deposits, the extensive numbers of black spruce seedlings and the number dead of jack pine found in this stand, jack pine will most likely be out-competed by the black spruce in the years to come.

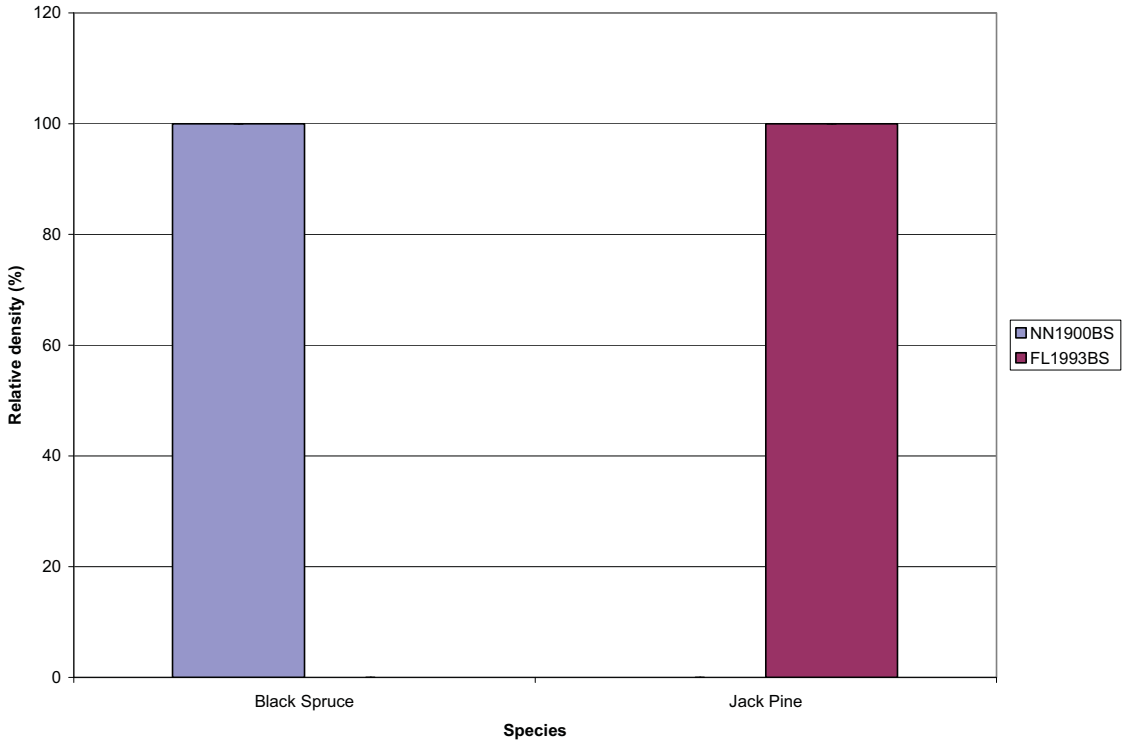


Figure 35: Relative density of live species in black spruce stands

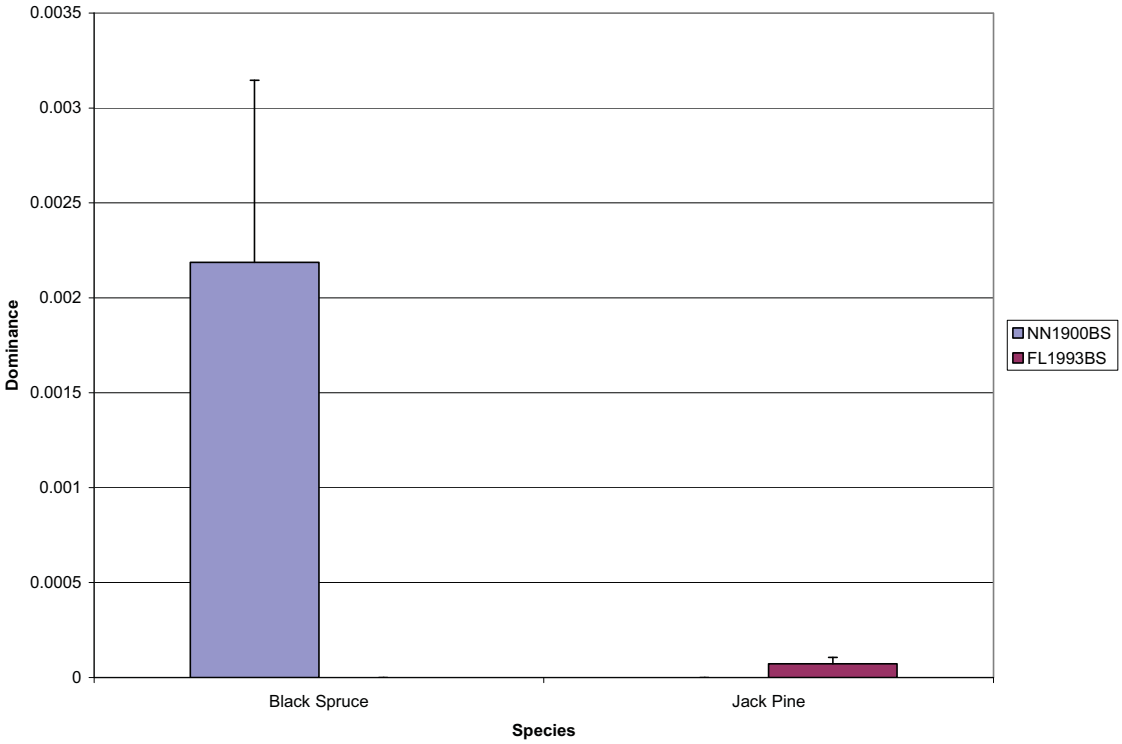


Figure 36: Dominance of live species in black spruce stands

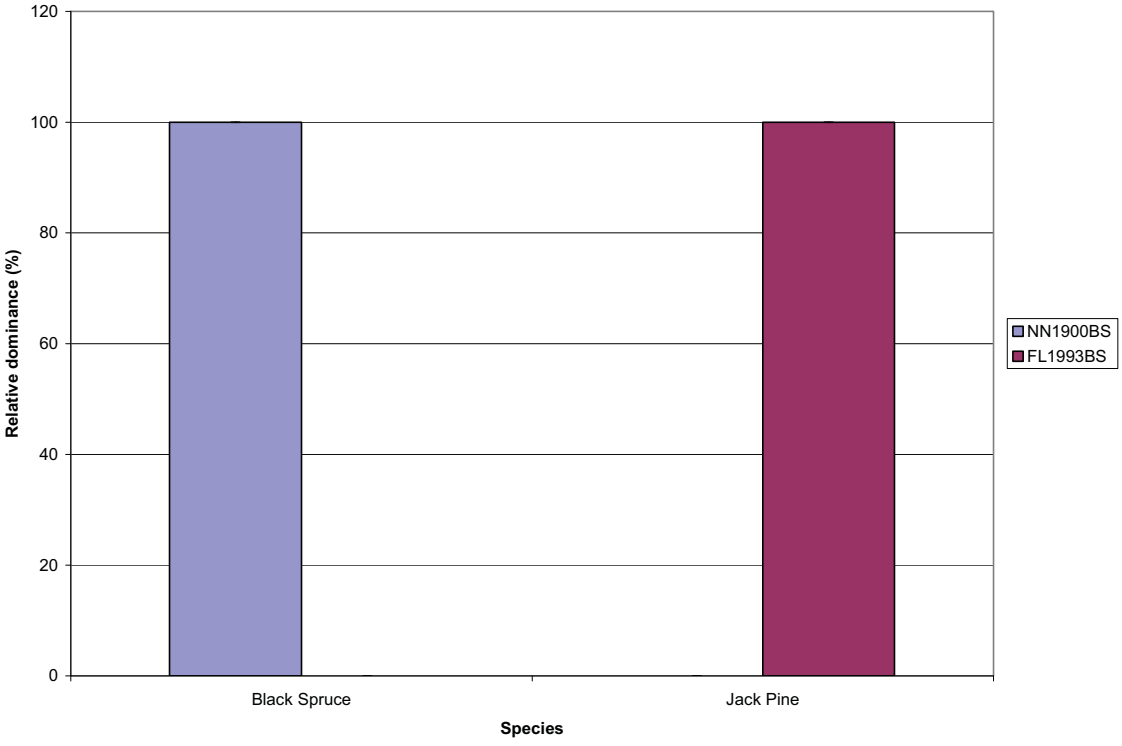


Figure 37: Relative dominance of live species in black spruce stands

Figure 38 shows that black spruce was present in every plot of the Nopiming North 1900 Black Spruce stand. The same is true for jack pine in the Flintstone Lake 1993 Black Spruce stand.

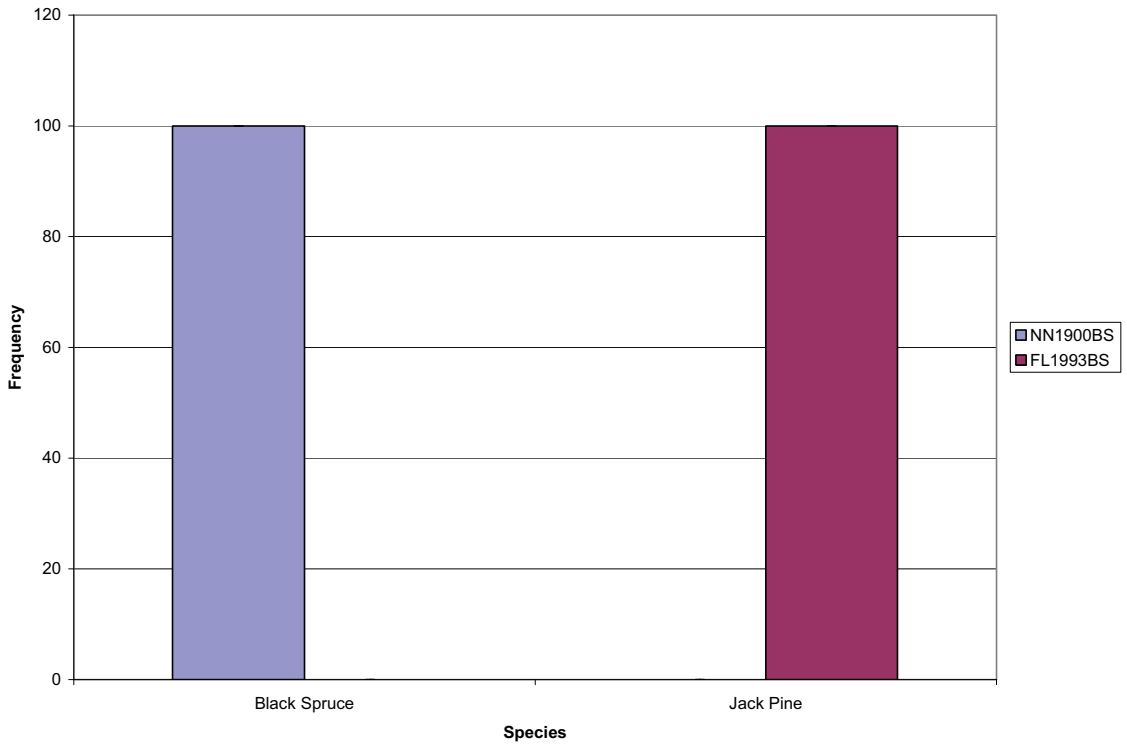


Figure 38: Frequency of live species in black spruce stands

As mentioned earlier there was only one live species in both stands. Therefore, Figure 35, 37, 39 and 40 show the full value of the calculations for black spruce in the mature stand and for jack pine in the immature stand. Needless to say, the structural role of black spruce in the mature site is vital to the stand.

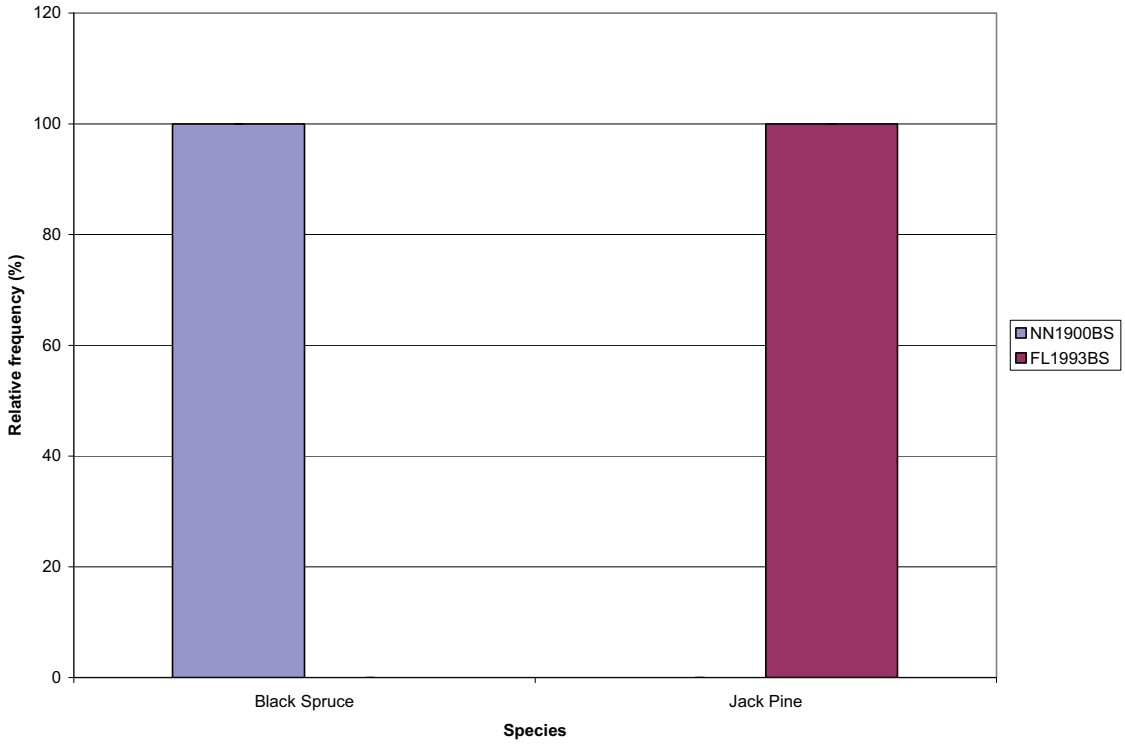


Figure 39: Relative frequency of live species in black spruce stands

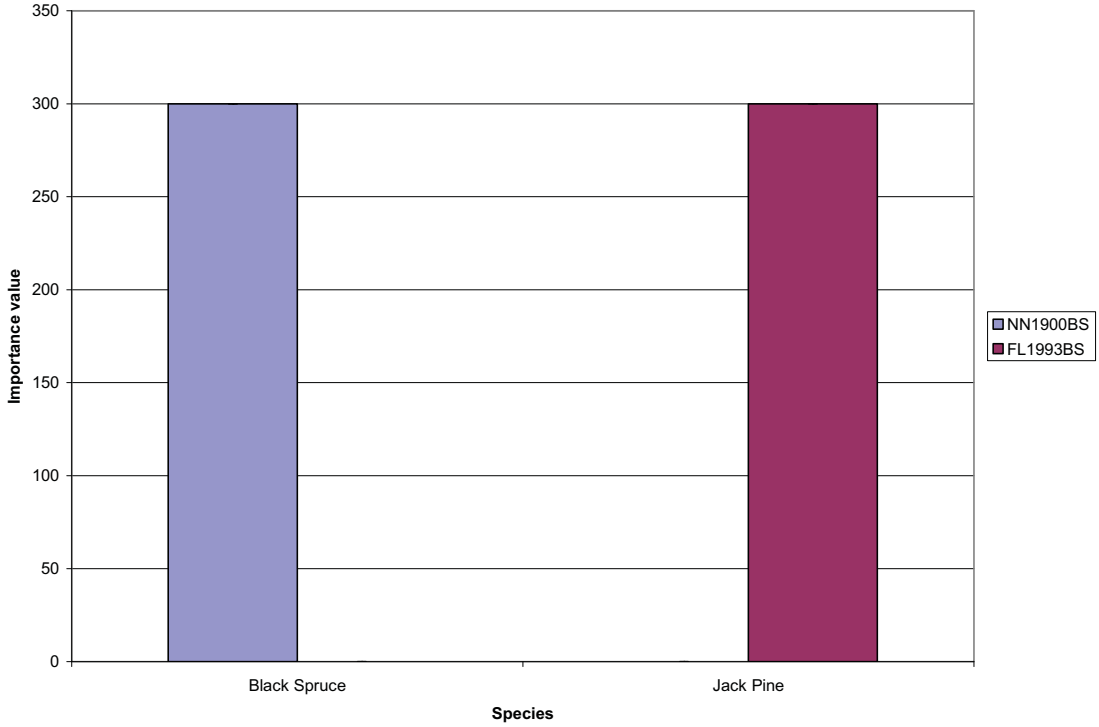


Figure 40: Importance value of live species in black spruce stands

Tree Health:

Hollow Water & Nopiming North Jack Pine:

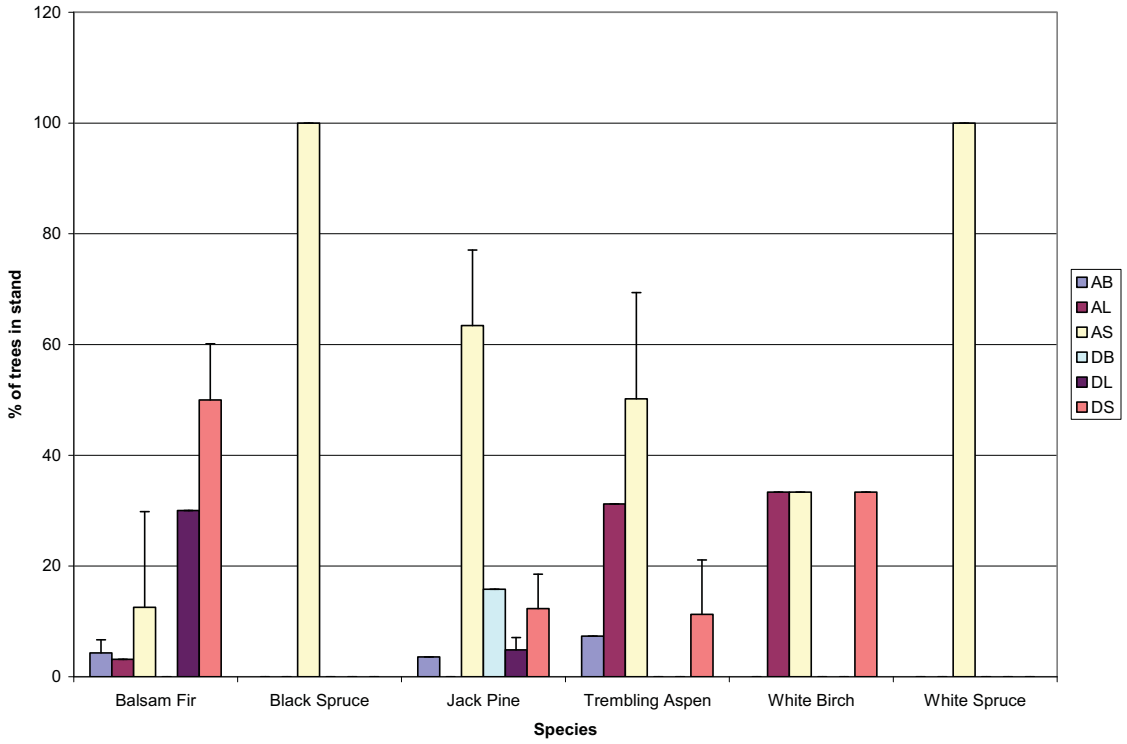


Figure 41: Tree health of each species in Hollow Water 1912 Jack Pine stand

As Figure 42, 43 and 44 illustrate, the condition of the vast majority of trees in the young jack stands was alive standing. It shows there was a very low mortality rate in these stands. According to Figure 41 and 45, the mature jack pine sites seem to differ from the younger stands. The majority of species were in the alive standing class, but there was a lot more variability in these stands compared to the young stands. Some species in the Hollow Water 1912 Jack Pine stand such as balsam fir actually had a greater percentage of individuals in the dead standing class than the alive standing class. In the Nopiming North 1920 Jack Pine stand, trembling aspen and jack pine were the only species with individuals in classes other than alive standing. It's no surprise to see the younger stands showing better tree health than the mature stands. It is a natural occurrence in a mature forest to see trees having a greater mortality rate than younger stands. Generally speaking, trees in the jack pine stands seem to be in good health.

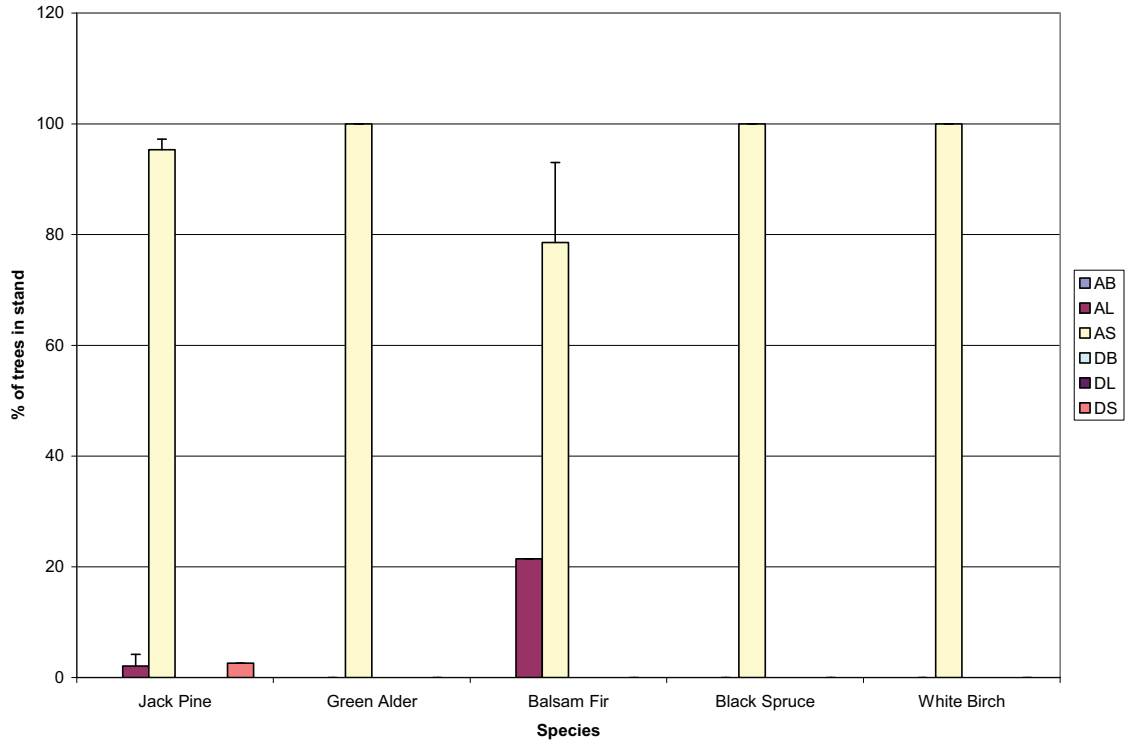


Figure 42: Tree health of each species in Hollow Water 1983 Jack Pine stand

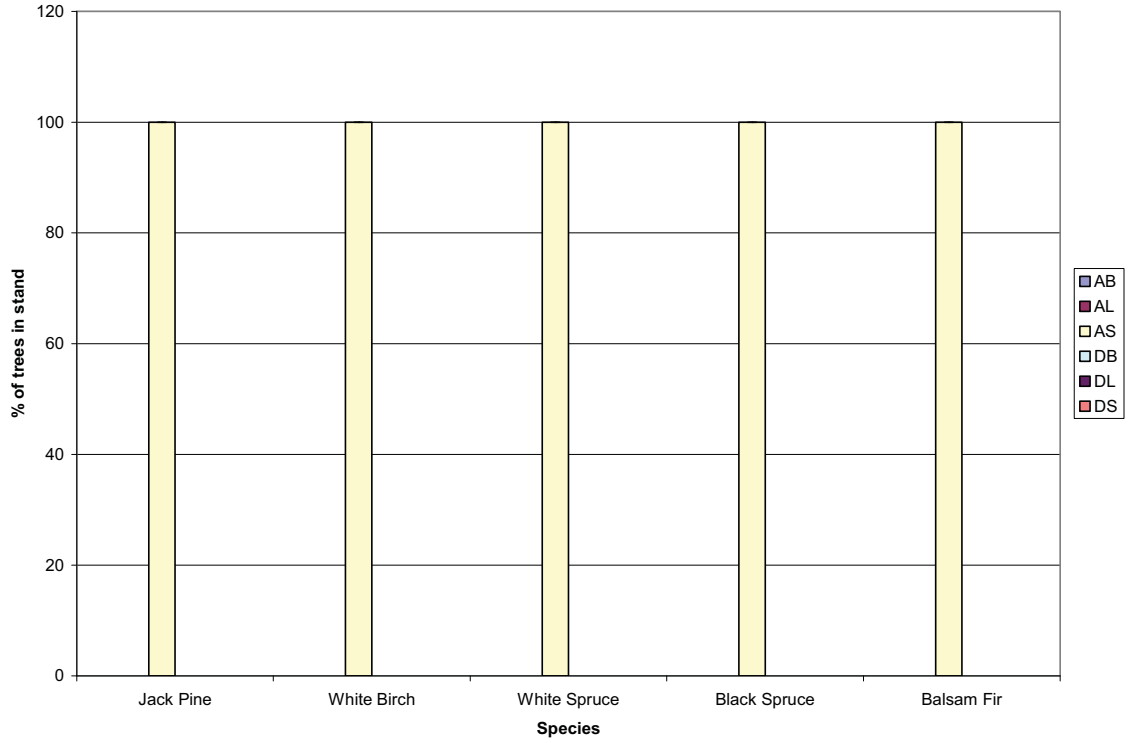


Figure 43: Tree health of each species in Hollow Water 1992 Jack Pine stand

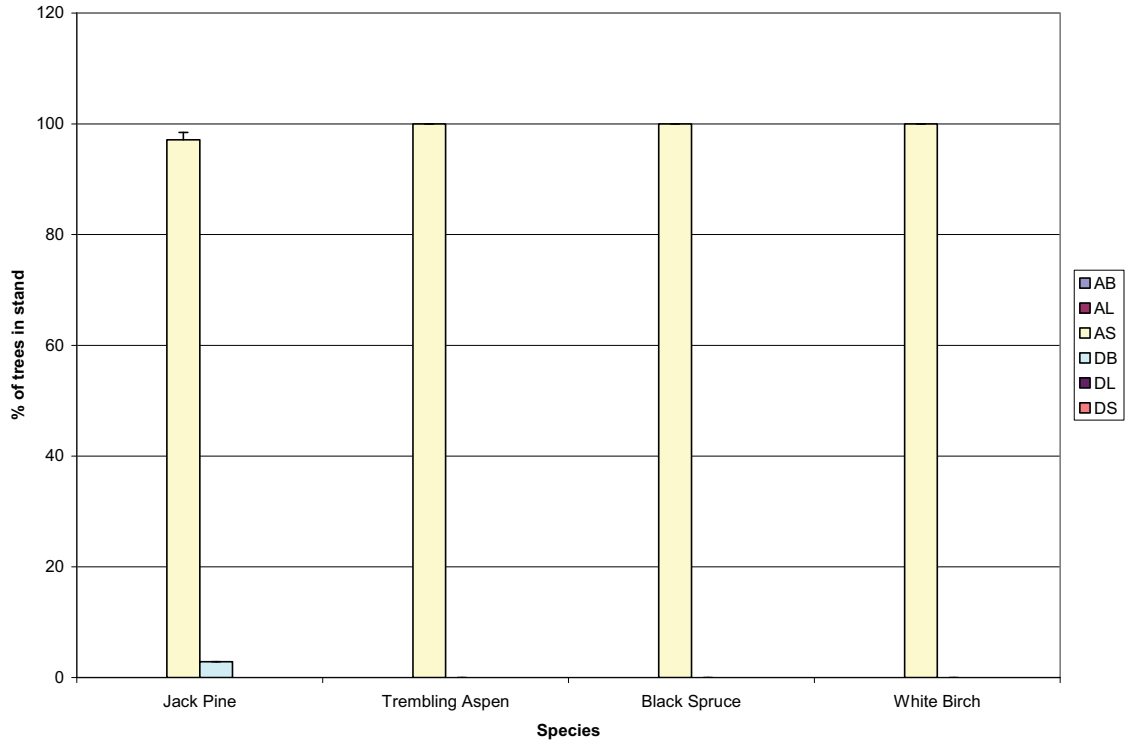


Figure 44: Tree health of each species in Hollow Water 2000 Jack Pine stand

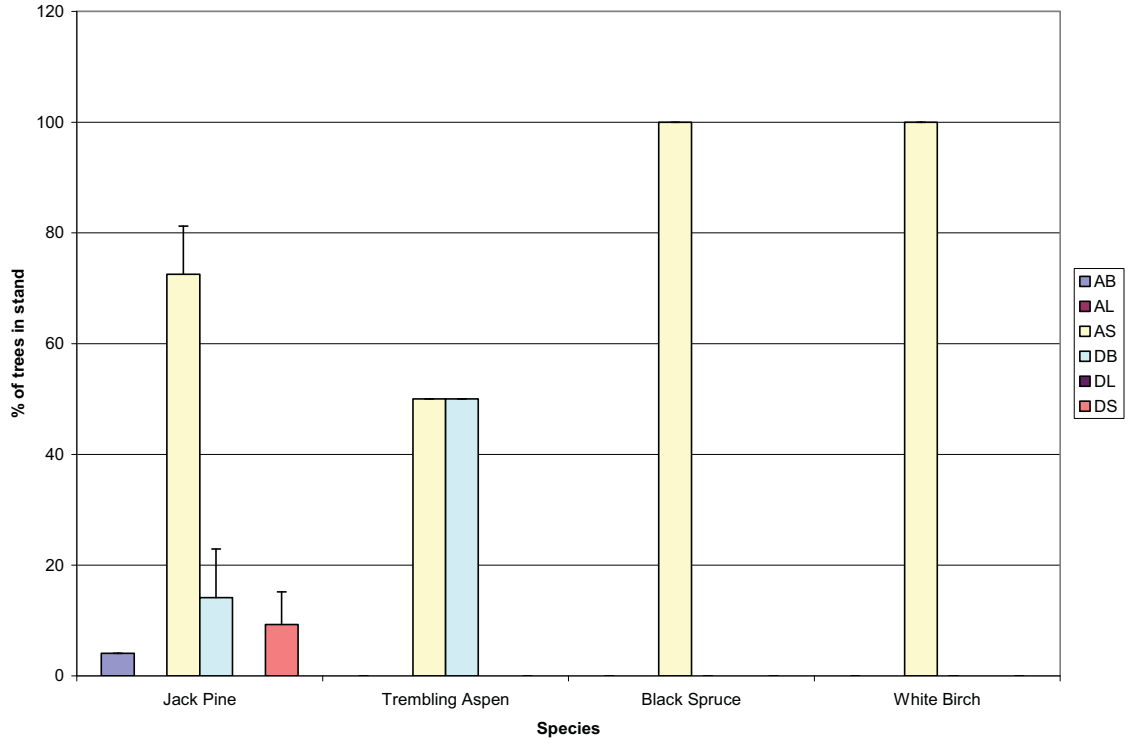


Figure 45: Tree health of each species in Nopiming North 1920 Jack Pine stand

Nopiming North & Flintstone Lake Black Spruce:

Figure 46 and 47 illustrate the conditions of the mature and immature black spruce stands. The results differ from one another. The mature black spruce stand had only one species as seen previously; black spruce. It had individuals in every tree class. The vast majority of the trees, over 90%, were in the alive standing class. This indicates the good health of this stand.

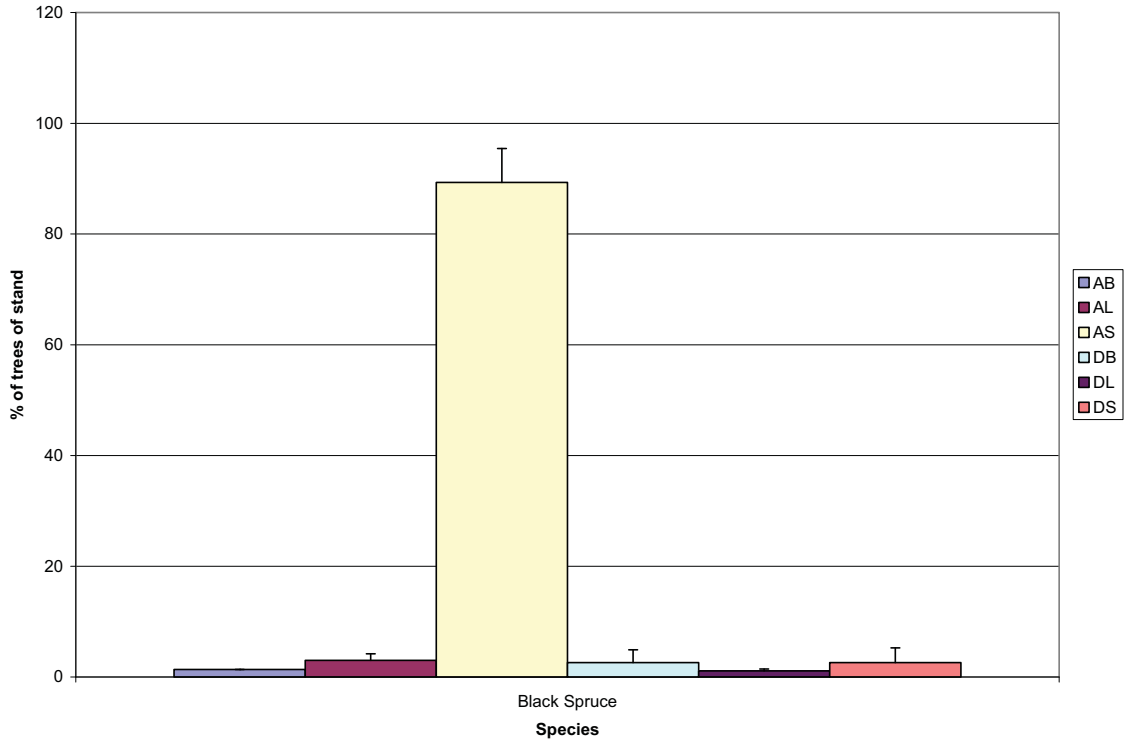


Figure 46: Tree health of each species in Nopiming North 1900 Black Spruce stand

The young black spruce stand was composed of two species; jack pine and unknown. The unknown species was unidentifiable due to the fire of 1993. All of its individuals were either dead leaning or dead standing. The jack pine found in the stand were not doing very well either. The majority of the jack pine were alive standing, but the percentage of individuals in the dead broken, dead leaning and dead standing classes was also high.

This indicates a high mortality rate for the jack pine in the immature stand. This is possibly due to the fact that the conditions are less than perfect for jack pine, but are ideal for black spruce. Delayed seedfall and delayed germination of black spruce are postfire adaptations which ensure that some seeds are always available to germinate and establish during postfire years with favorable growing conditions (http://www.rook.org/earl/bwca/nature/trees/pinusbank.html). Jack pine will always be one of the first species to germinate after a fire, but as years progress, in certain areas black spruce will become the dominant species. This may very well be the case in this stand, since the jack pine seems to be dying at a high rate.

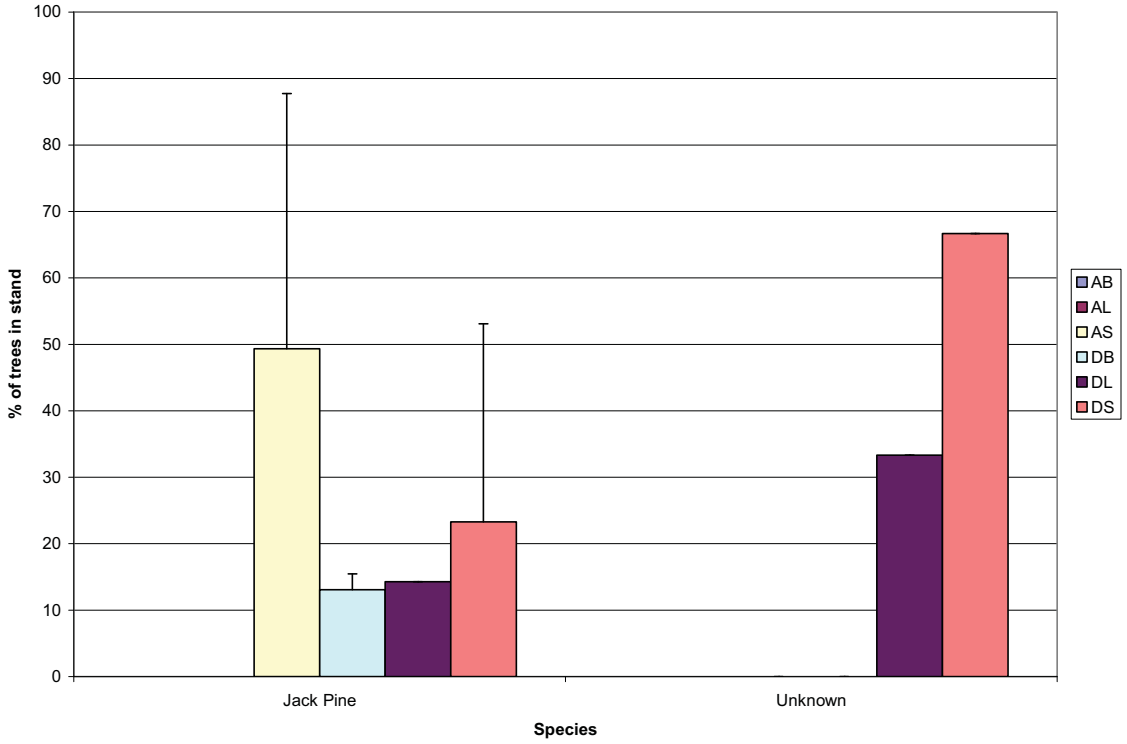


Figure 47: Tree health of each species in Flintstone Lake 1993 Black Spruce stand

Crown Class:

Hollow Water & Nopiming North Jack Pine:

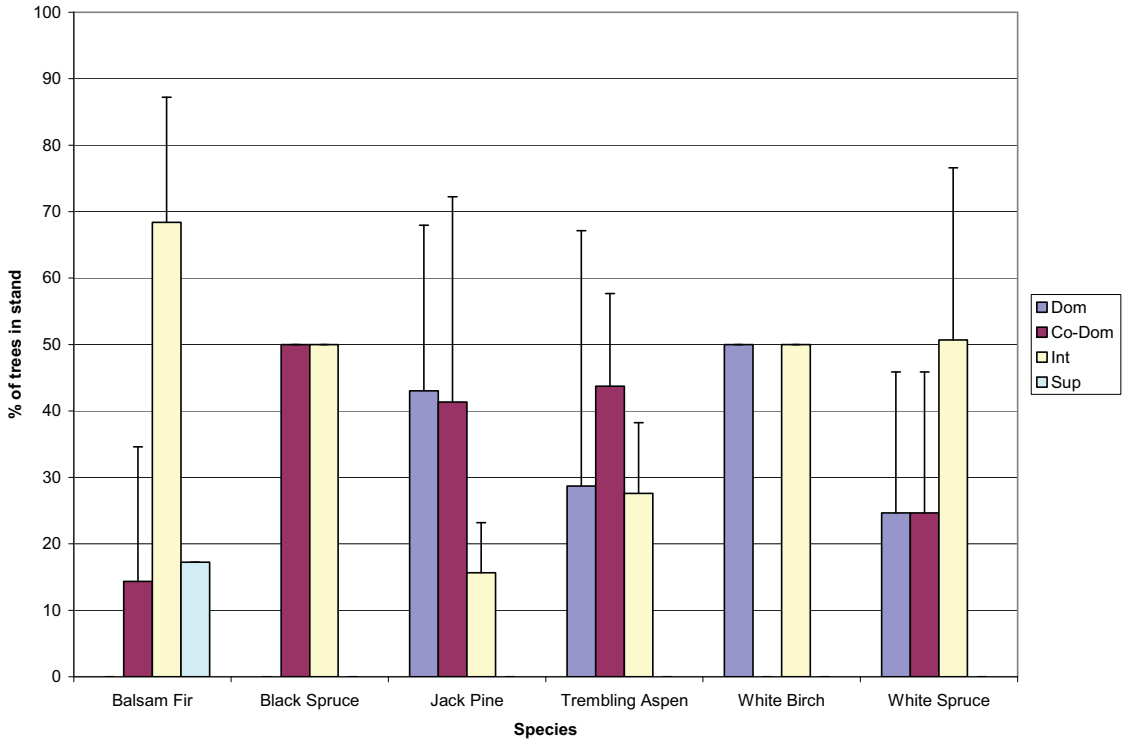


Figure 48: Crown class of each species in Hollow Water 1912 Jack Pine stand

According to Figure, 49, 50, 51 and 52, almost all jack pine in the three young Hollow Water jack pine sites and the Nopiming North 1920 Jack Pine site seem to be co-dominant. As Figure 48 illustrates, the majority of jack pine in the Hollow Water 1912 Jack Pine stand are classified as either dominant or co-dominant. It appears as though the younger the stand, the more jack pine are classified as co-dominant and the older the stand, the more jack pine are found in various classes. In the two youngest stands, Hollow Water 1992 Jack Pine and Hollow Water 2000 Jack Pine, the vast majority of all species are classed as co-dominant. Other species than jack pine in the mature stand (Fig 48) tend to be classified as intermediate or suppressed. In the Nopiming North 1920 Jack Pine site, the three species other than jack pine are intermediate or suppressed (Fig 52).

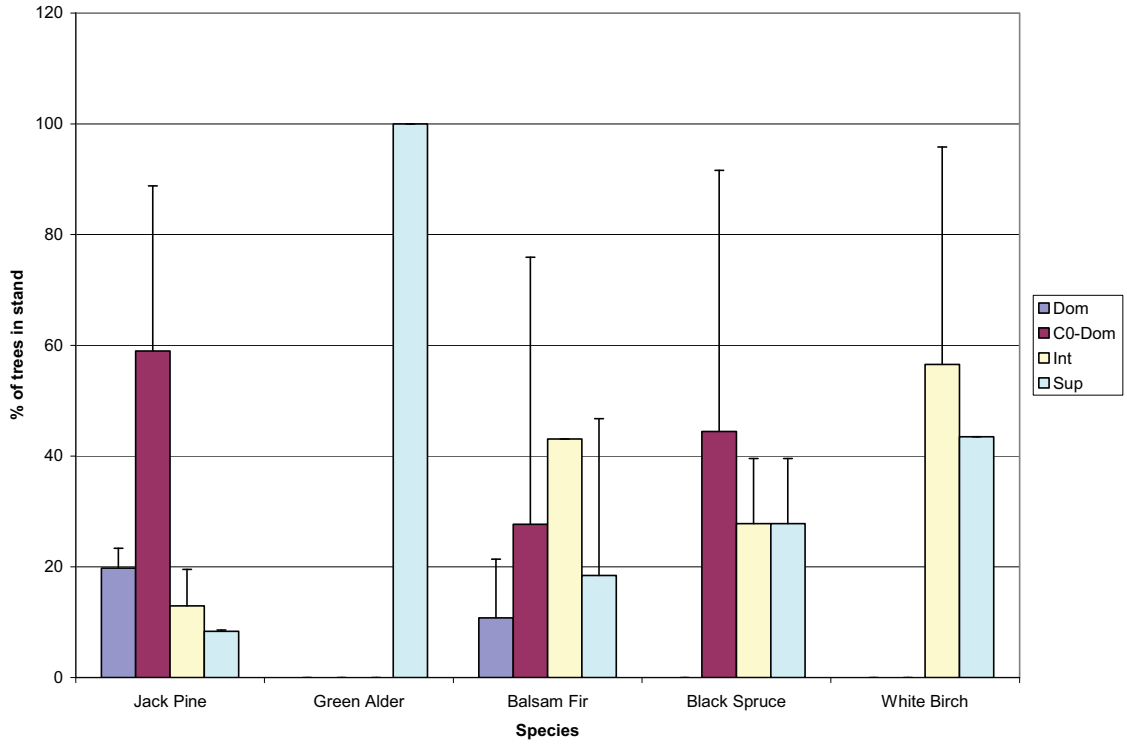


Figure 49: Crown class of each species in Hollow Water 1983 Jack Pine stand

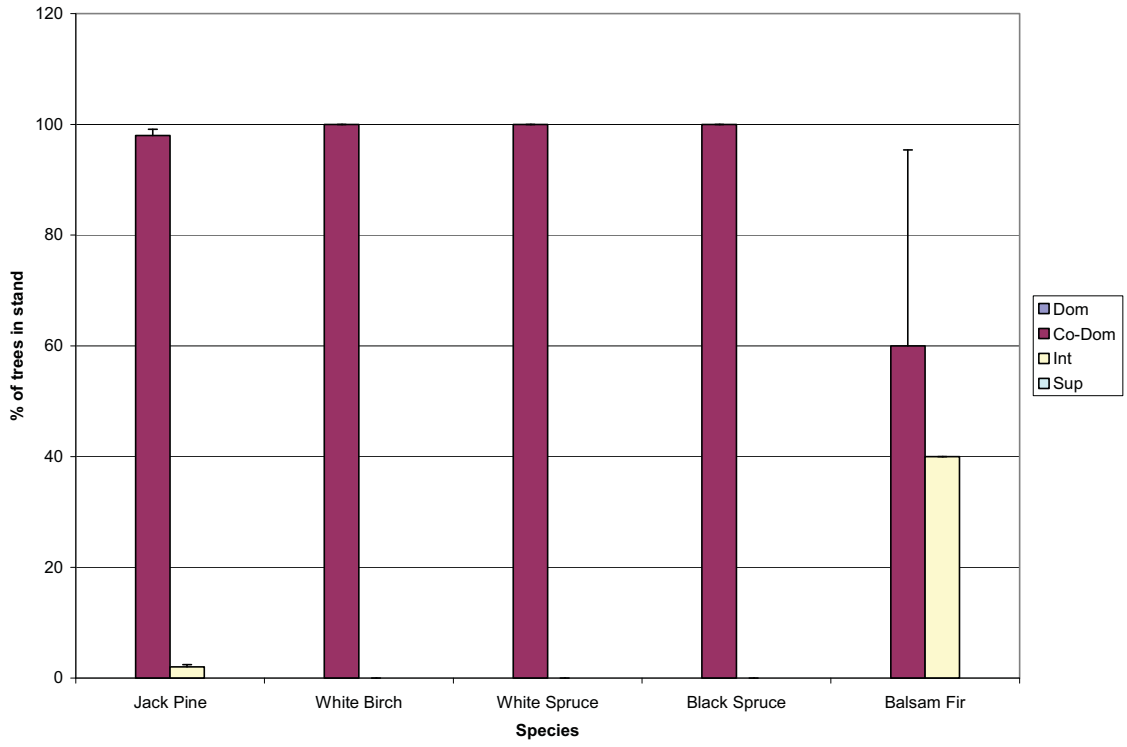


Figure 50: Crown class of each species in Hollow Water 1992 Jack Pine stand

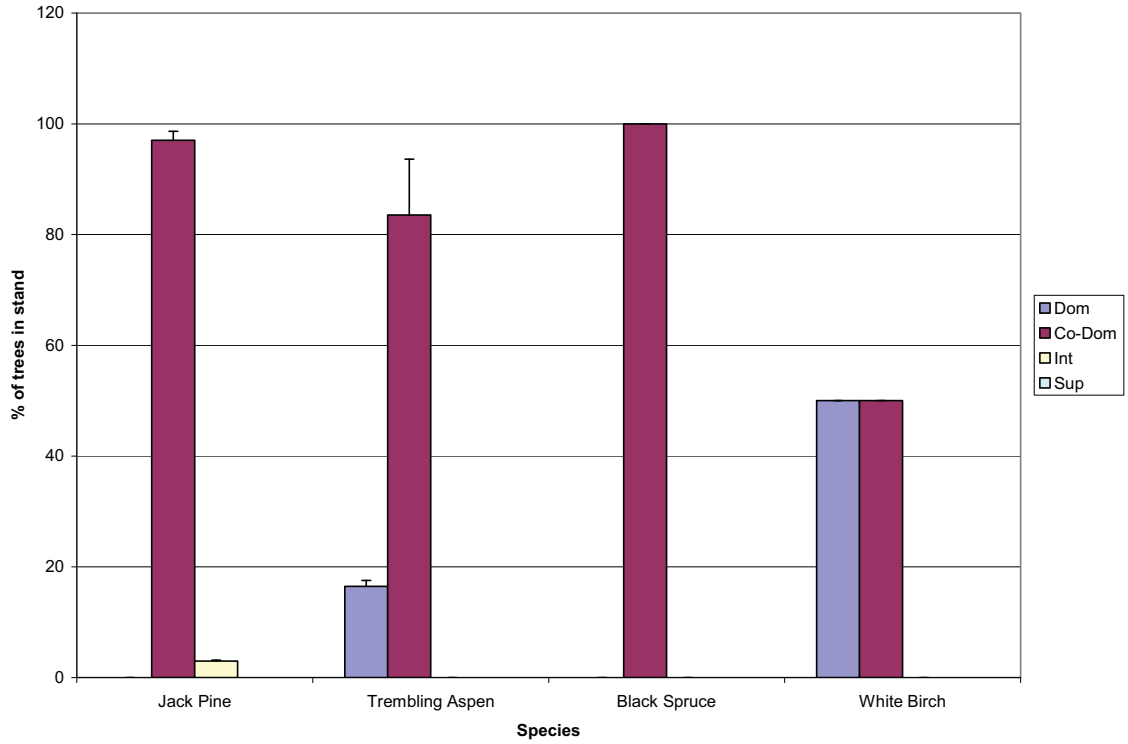


Figure 51: Crown class of each species in Hollow Water 2000 Jack Pine stand

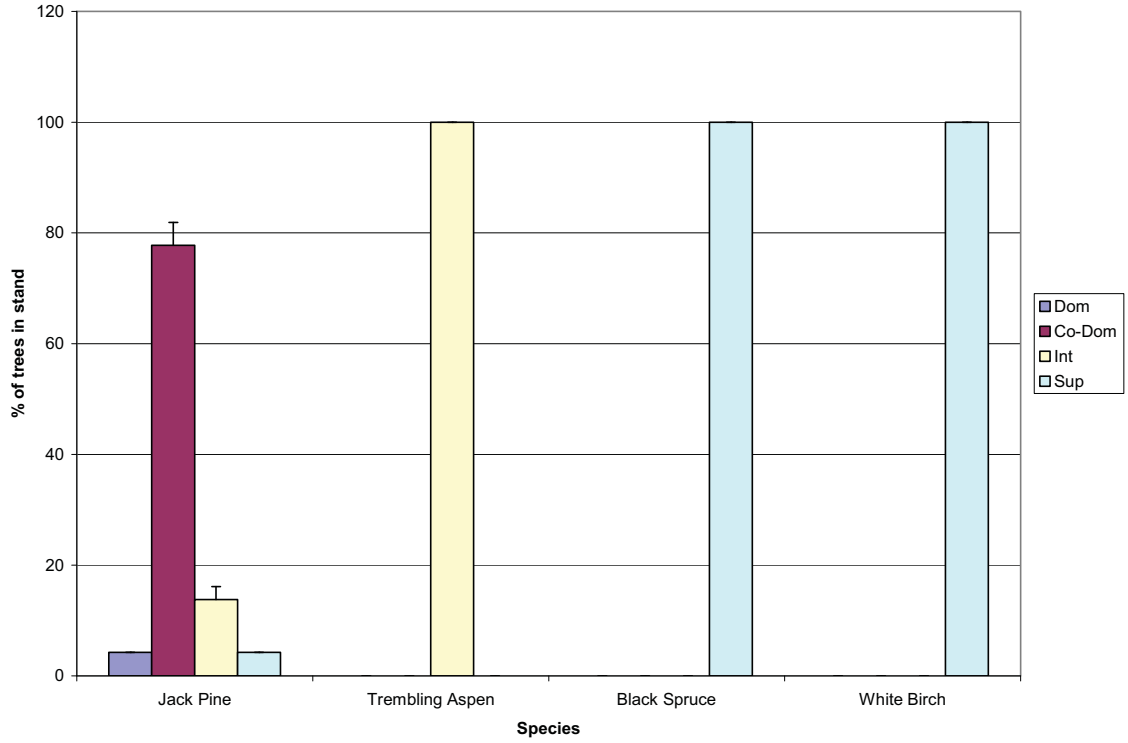


Figure 52: Crown class of each species in Nopiming North 1920 Jack Pine stand

Nopiming North & Flintstone Lake Black Spruce:

As shown in Figure 53, the majority of trees in the mature black spruce stand were classified as co-dominant. There were only a small percentage of trees in other classes. Figure 54 illustrates that jack pine were either co-dominant or dominant in the Flintstone Lake 1993 Black Spruce site, which is not surprising since jack pine regenerates so quickly compare to other species after a fire. The unknown does not have a crown class since these individuals were burnt in the fire.

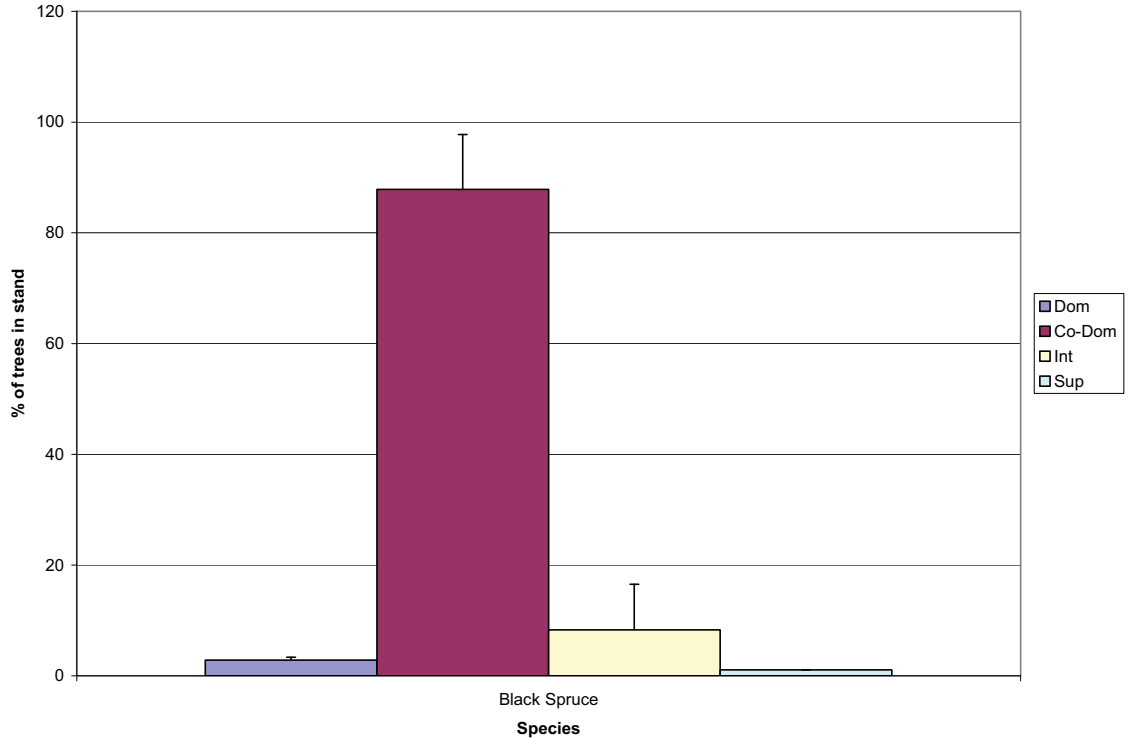


Figure 53: Crown class of each species in Nopiming North 1900 Black Spruce stand

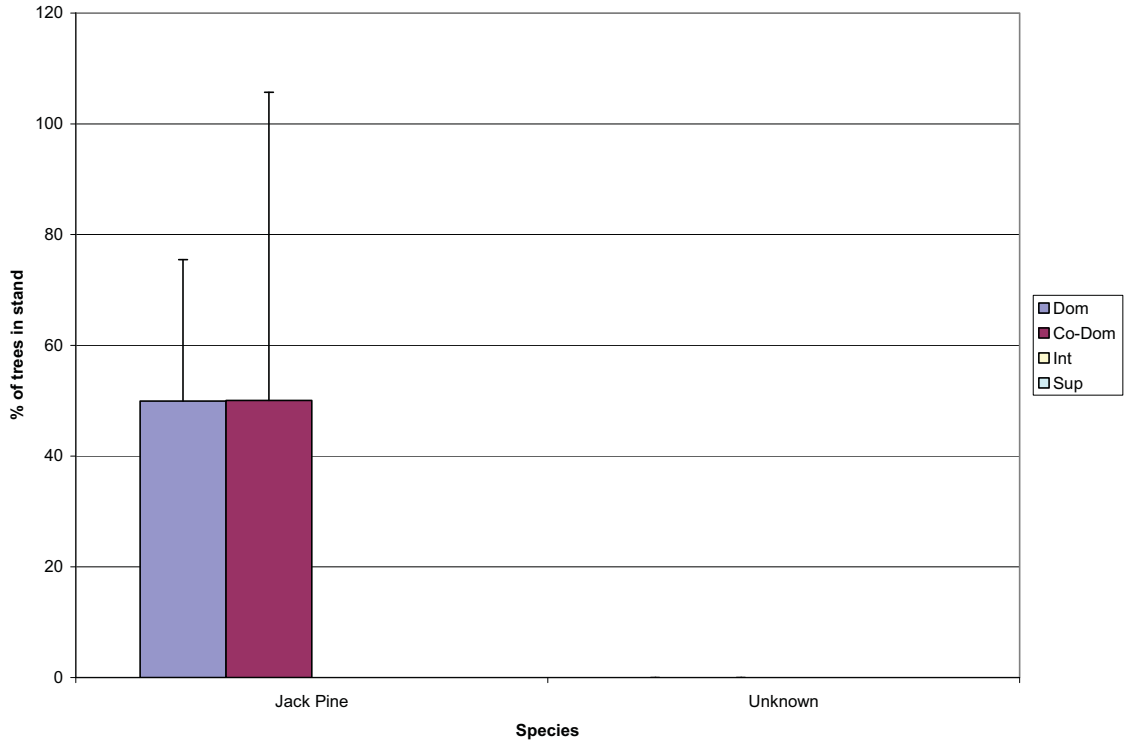


Figure 54: Crown class of each species in Flintstone Lake 1993 Black Spruce stand

Crown Rating:

Hollow Water & Nopiming North Jack Pine:

The percentage of branch mortality dictates whether trees were placed in one of five categories; 1-healthy (less than 10% branch mortality), 2-light-moderate decline (between 10-50% branch mortality), 3-severe decline (greater than 50% branch mortality), 4-dead natural and 5-dead human. According to Figure 56, 57 and 58, the bulk of trees in the young jack pine stands had a crown rating of 1 indicating that there was little crown mortality. A very small percentage of trees in these immature stands have a crown rating of 2 or even 3.

Mature jack pine stands (Fig 55 & Fig 59) tend to have trees in the first four crown ratings indicating that as the stands age, crown mortality becomes more common. Despite the greater distribution of crown ratings, Figure 55 and 59 illustrate that class 1 is still the dominant rating among trees.

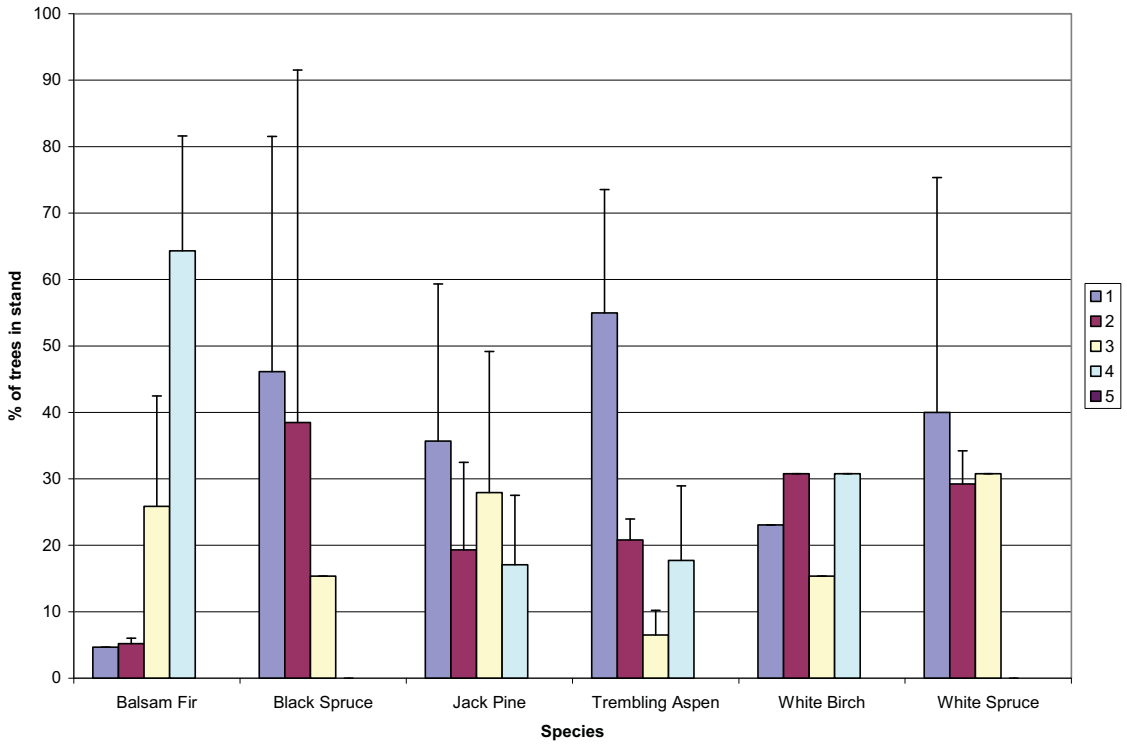


Figure 55: Crown rating of each species in Hollow Water 1912 Jack Pine stand

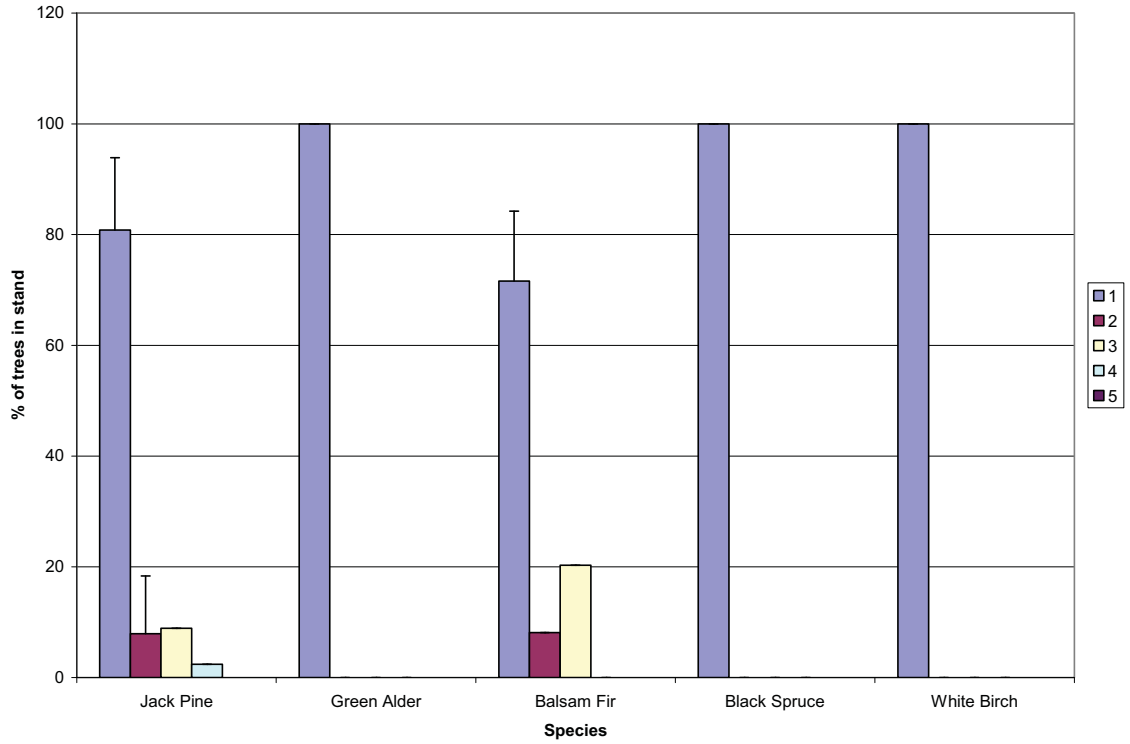


Figure 56: Crown rating of each species in Hollow Water 1983 Jack Pine stand

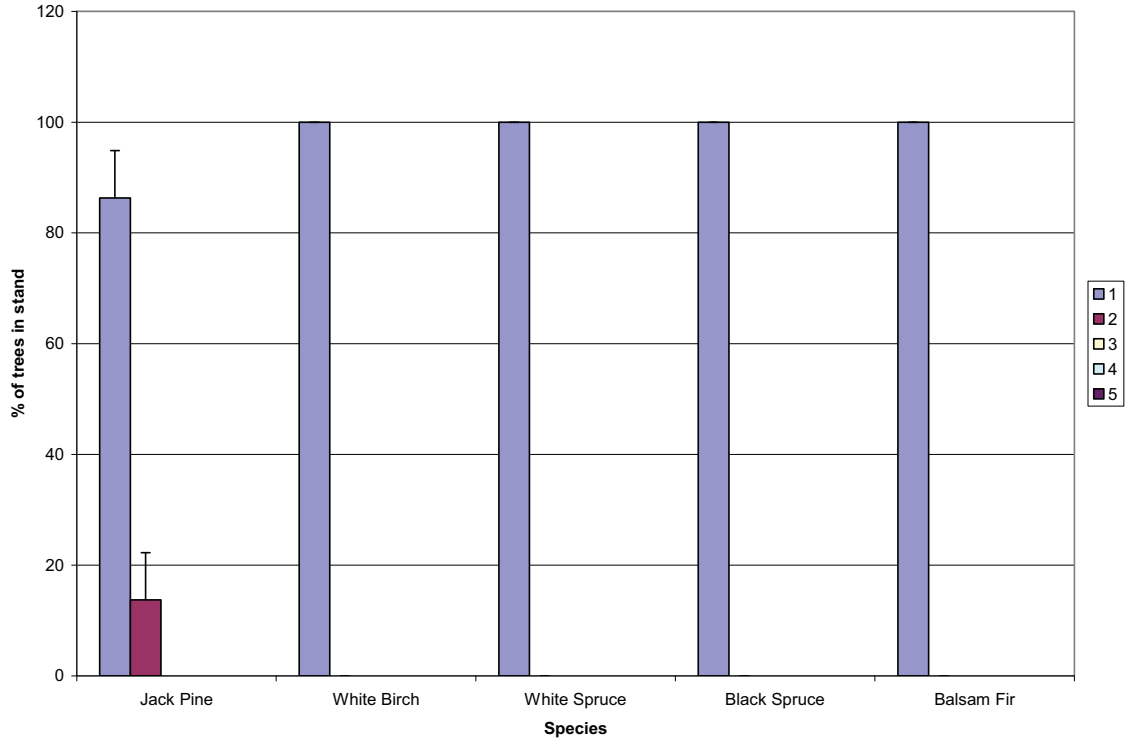


Figure 57: Crown rating of each species in Hollow Water 1992 Jack Pine stand

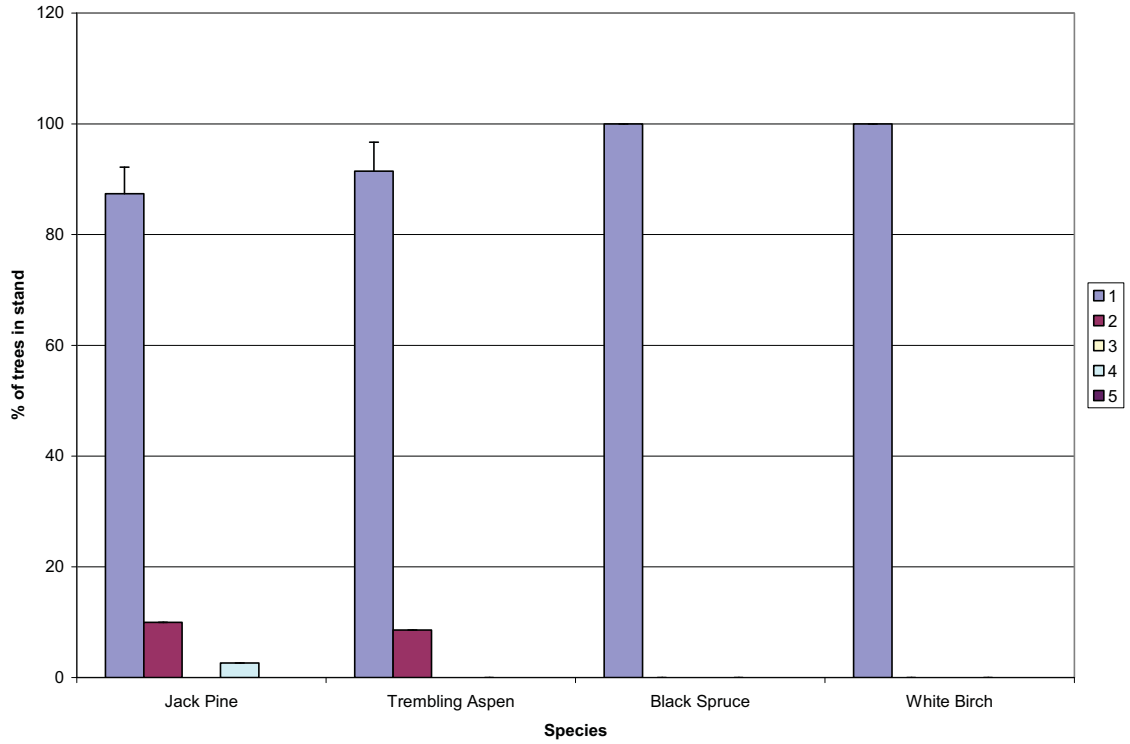


Figure 58: Crown rating of each species in Hollow Water 2000 Jack Pine stand

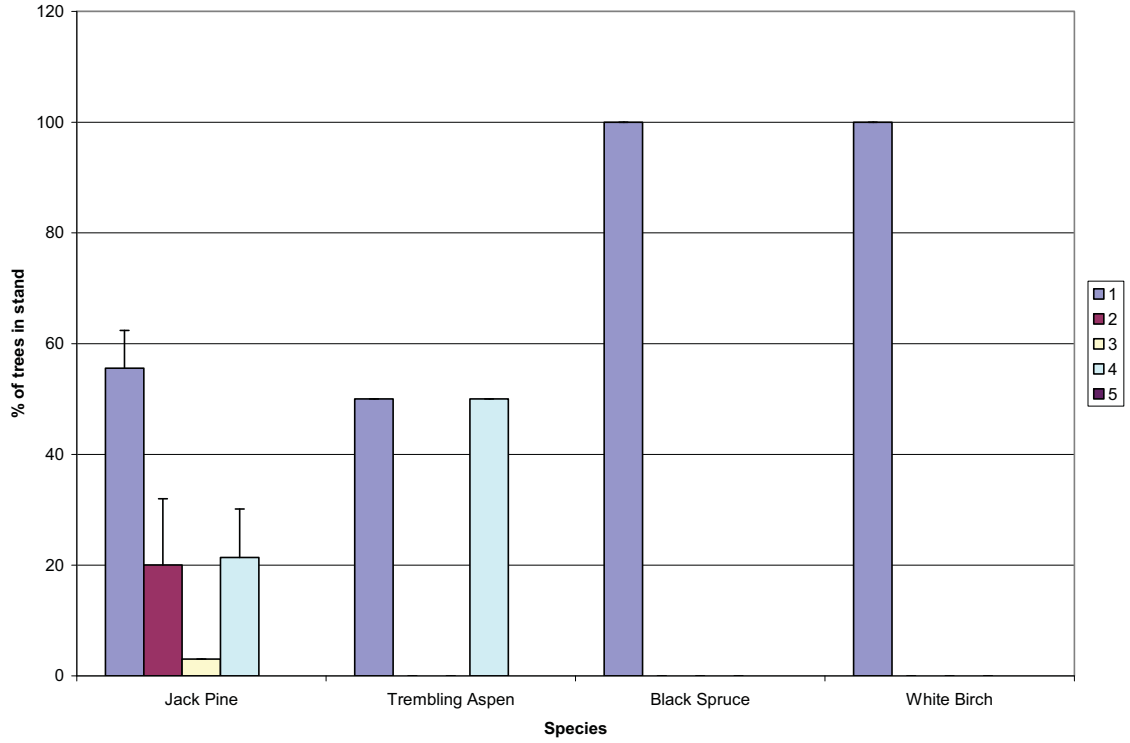


Figure 59: Crown rating of each species in Nopiming North 1920 Jack Pine stand

Nopiming North & Flintstone Lake Black Spruce:

Figure 60 illustrates that the vast majority of black spruce in the mature stand were classified as having a crown rating of 1. Only a small percentage of trees are in class 2 and 4. Therefore, most of the trees in this stand were very healthy.

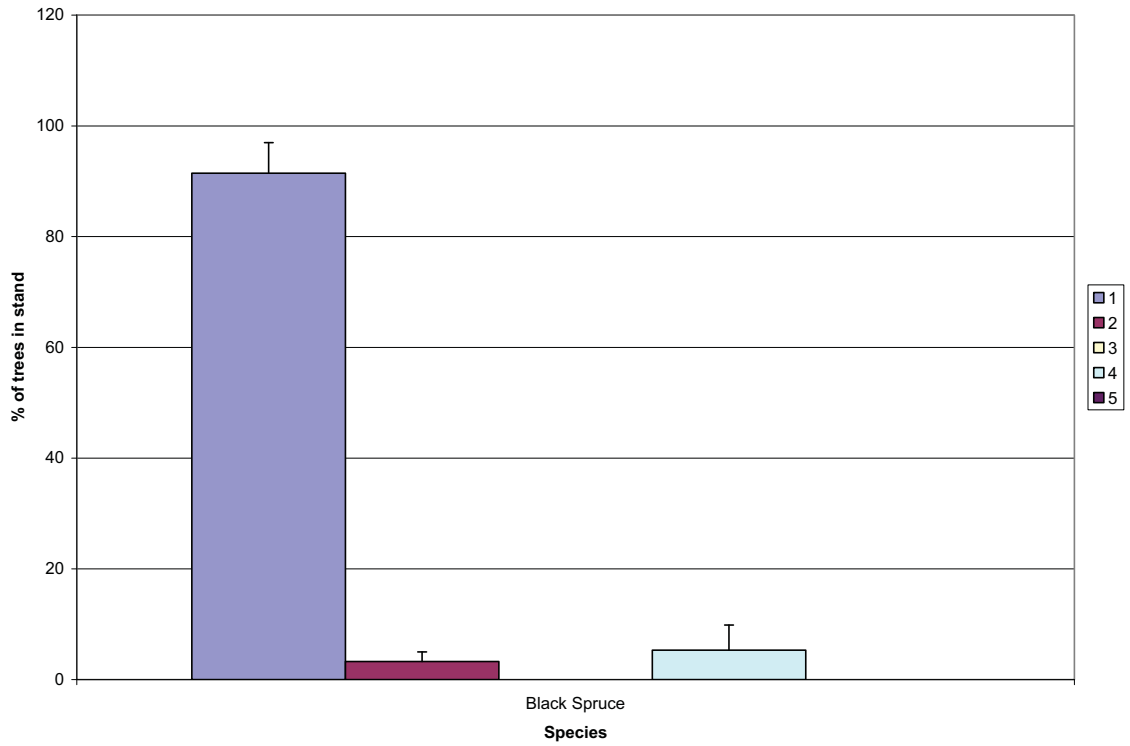


Figure 60: Crown rating of each species in Nopiming North 1900 Black Spruce stand

As figure 61 shows, trees in the immature black spruce stand were either in class 1 or 4 and a few in class 2. The unknown species are all dead; therefore they have a crown rating of 4. The majority of the jack pine in the stand were classified as having a crown rating of either 1 or 4. The relatively equal value of crown rating 1 and 4 for the jack pine may be due to its struggle with survival in a sphagnum dominated area.

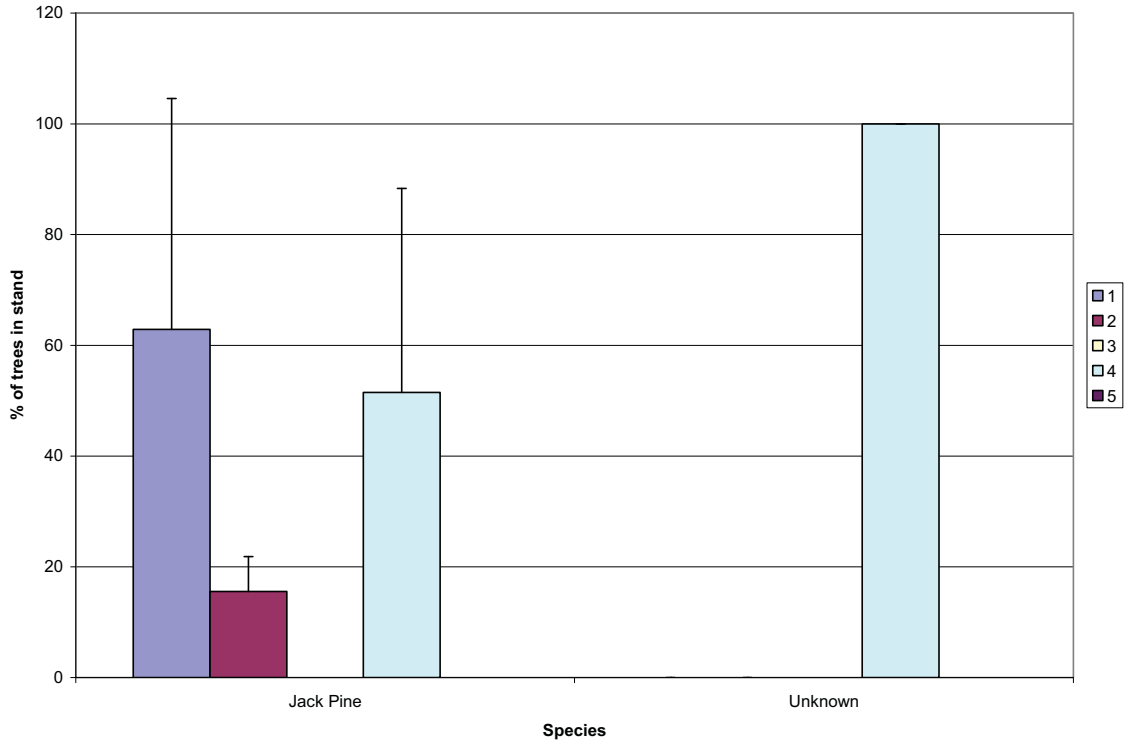


Figure 61: Crown rating of each species in Flintstone Lake 1993 Black Spruce stand

Appendix III provides a complete list of tree species found in every stand.

Figure 62: Hollow Water 1912 Jack Pine (left) and Hollow Water 1983 Jack Pine stands (1983)

Figure 63: Hollow Water 1992 Jack Pine stand

Figure 64: Hollow Water 2000 Jack Pine stand

Figure 65: Nopiming North 1920 Jack Pine stand

Figure 66: Nopiming North 1900 Black Spruce stand

Figure 67: Flintstone Lake 1993 Black Spruce stand

Shrub and Small-Tree Stratum:

Hollow Water & Nopiming North Jack Pine:

Figure 68 illustrates that balsam fir was the most abundant species in the Hollow Water 1912 Jack Pine site, followed by trembling aspen, beaked hazelnut and Manitoba maple.

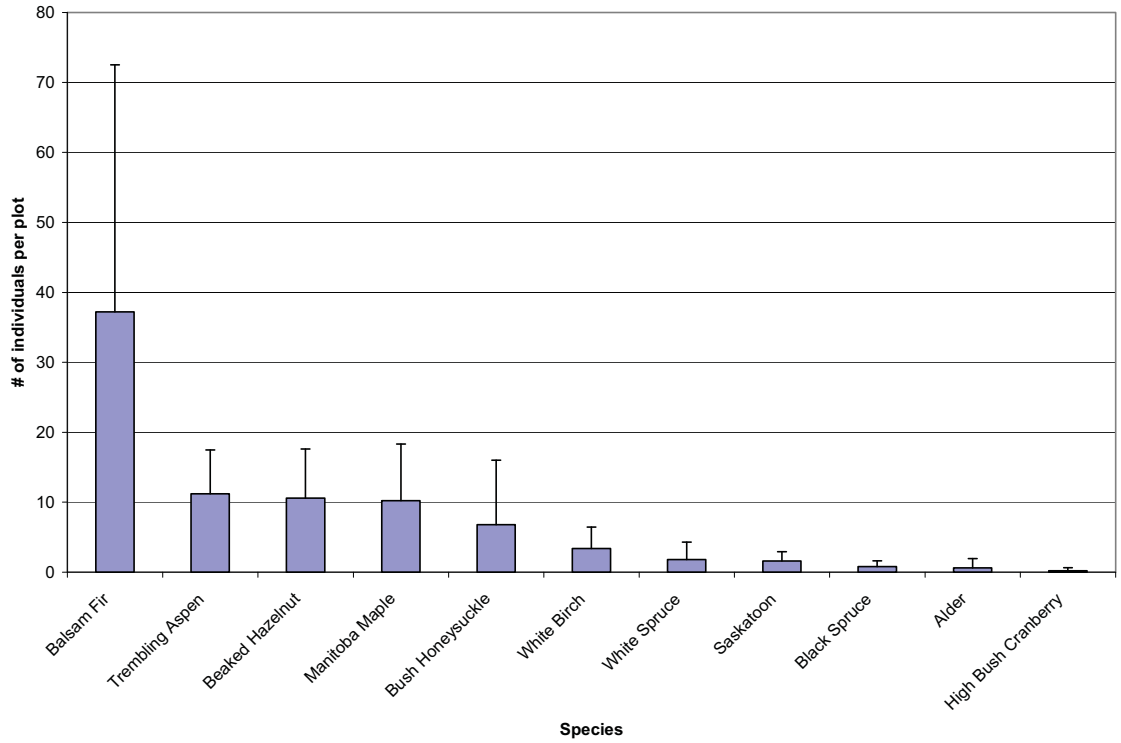


Figure 68: Number of individuals per plot in the Hollow Water 1912 Jack Pine site

The Hollow Water 1912 Jack Pine site is a mature site. Therefore, any shrubs or small trees would not receive much sunlight. It is not surprising to see balsam fir emerging as the most plentiful species in the shrub layer considering it is very shade tolerant. It readily establishes under a canopy of conifers and may assume dominance as the canopy of the pioneering trees begins to die off (http://www.rook.org/earl/bwca/nature/trees.html).

In contrast, Figure 69 to 71 demonstrates that jack pine is undeniably the species with the most individuals per plot, followed in each stand by white birch.

Based on the data from the Hollow water 1983, 1992 and 2000 Jack Pine sites, we can conclude that jack pine has by far the most individuals per plot, followed by white birch. There could be two explanations for this:

Jack pine is one of the fastest growing conifers in its range during the first 20 years. Seeds are dispersed from cones after a fire or during high temperatures at ground level (once the cones have fallen). They will germinate rapidly after release when exposed to moderate to high temperature for several days. Jack pine is also one of the least shade-tolerant trees (http://www.rook.org/earl/bwca/nature/trees.html).

If we take into account the logging origin of these three young stands, the conditions are ideal for jack pine to thrive in the wide open areas. Therefore, the mixture of sandy soils, wide open areas and jack pine's tremendous capacity of regeneration in these areas could explain its high number of individuals.

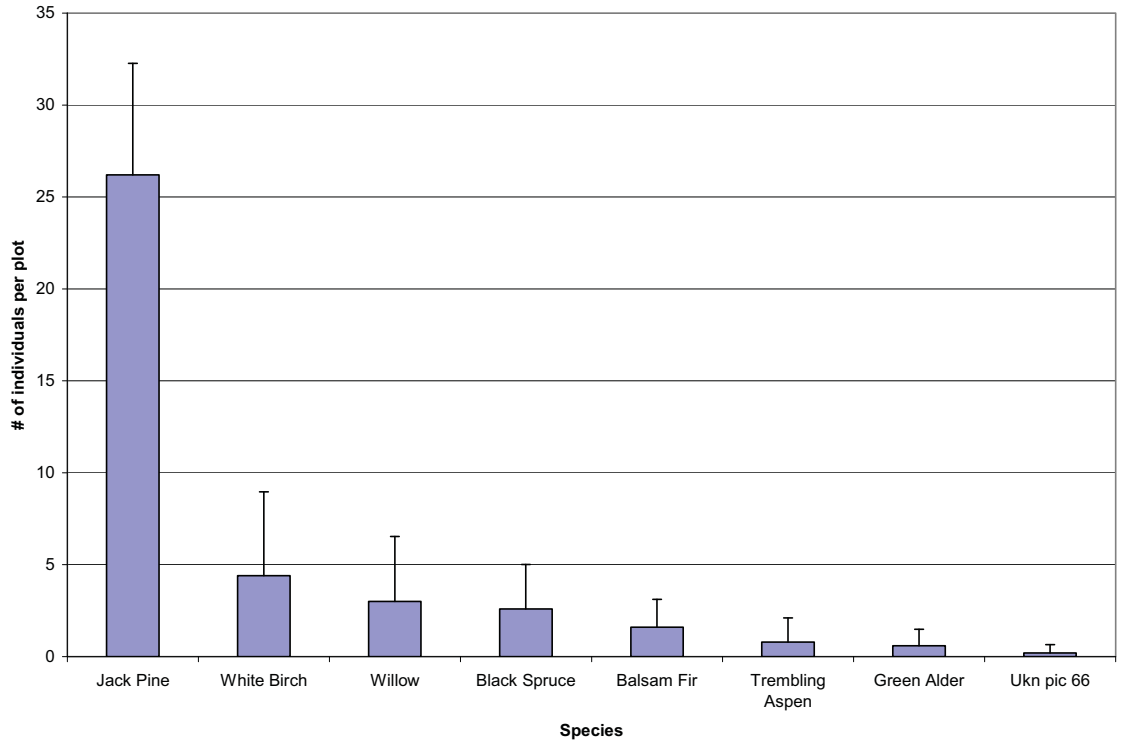


Figure 69: Number of individuals per plot in the Hollow Water 1983 Jack Pine site

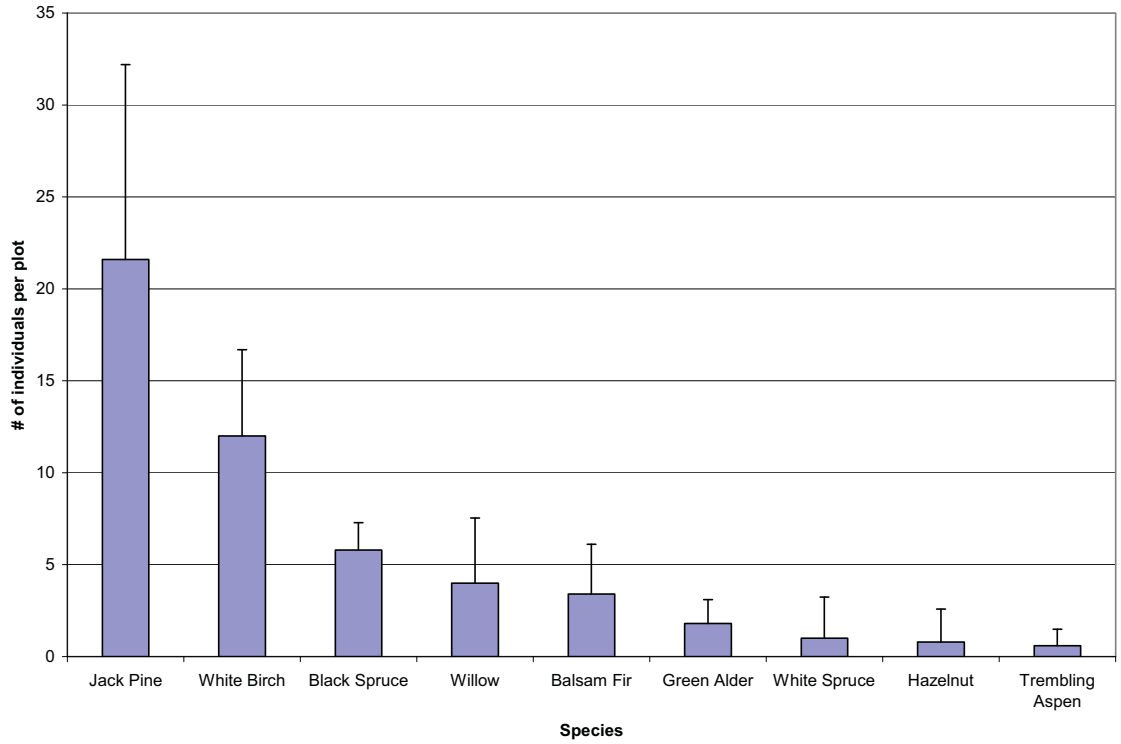


Figure 70: Number of individuals per plot in the Hollow Water 1992 Jack Pine site

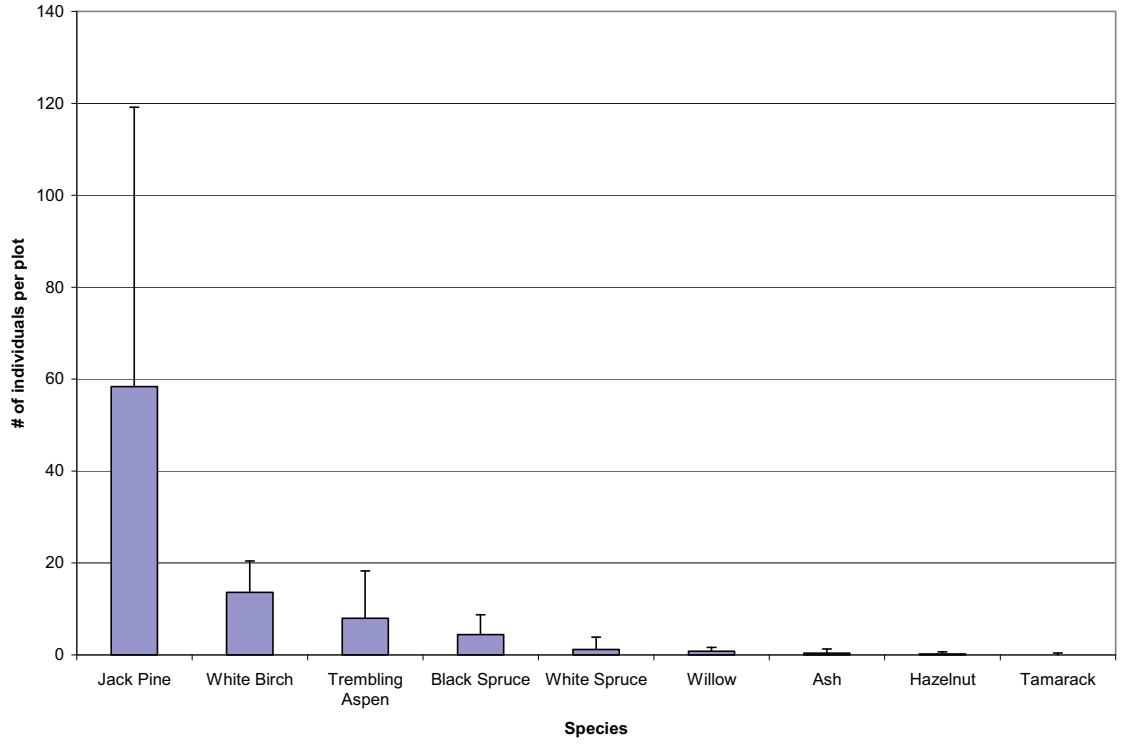


Figure 71: Number of individuals per plot in the Hollow Water 2000 Jack Pine site

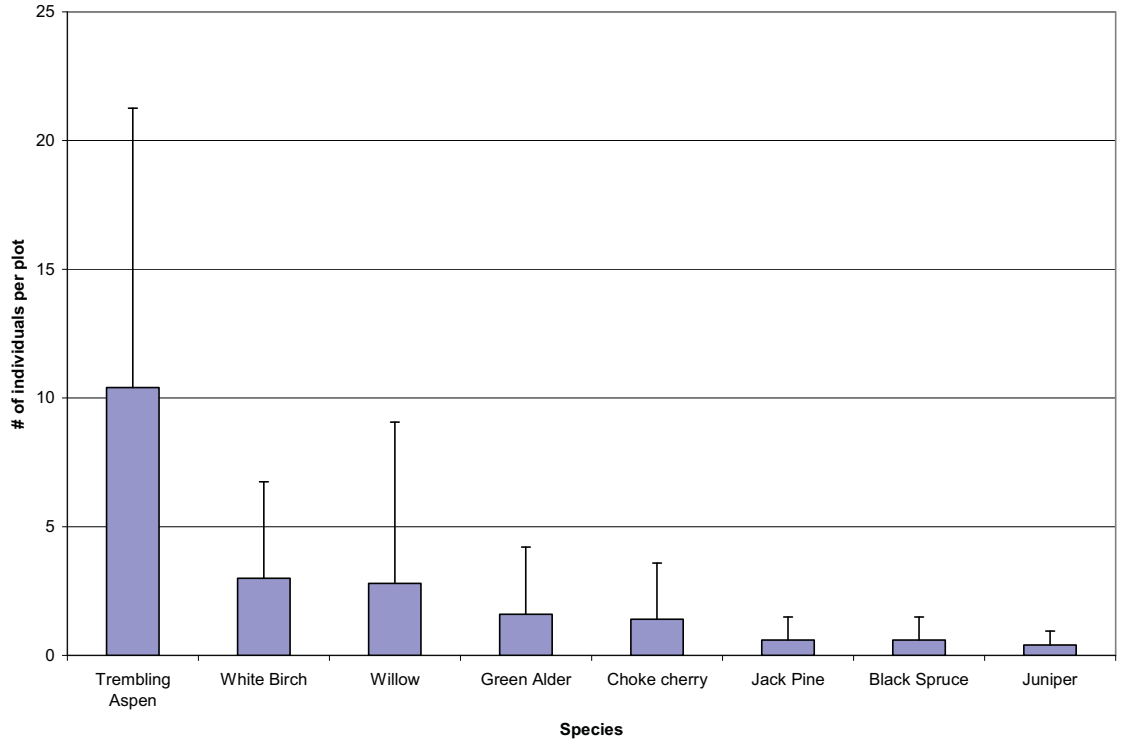


Figure 72: Number of individuals per plot in the Nopiming North 1920 Jack Pine site

As shown in Figure 72, trembling aspen was the species with the most individuals per plots, followed by white birch and willow. The canopy of this stand is formed by mature jack pine. As the stand ages, the canopy thins and more light shines through to the shrub layer. The aging stand allows more light to reach the shrub layer, favoring trembling aspen despite its shade intolerance.

Nopiming North & Flintstone Lake Black Spruce:

As illustrated in Figure 73, black spruce composed the vast majority of the shrub layer. The next species was green alder, though its number of individuals per plot was less than a tenth of the number of black spruce.

Black spruce can produce numerous seeds at the relatively young age of about 30 years. Its ability to produce massive amounts of seeds regularly and quickly and growing in

poorly drained peat bogs may account for its high numbers in the shrub layer (http://www.rook.org/earl/bwca/nature/trees.html).

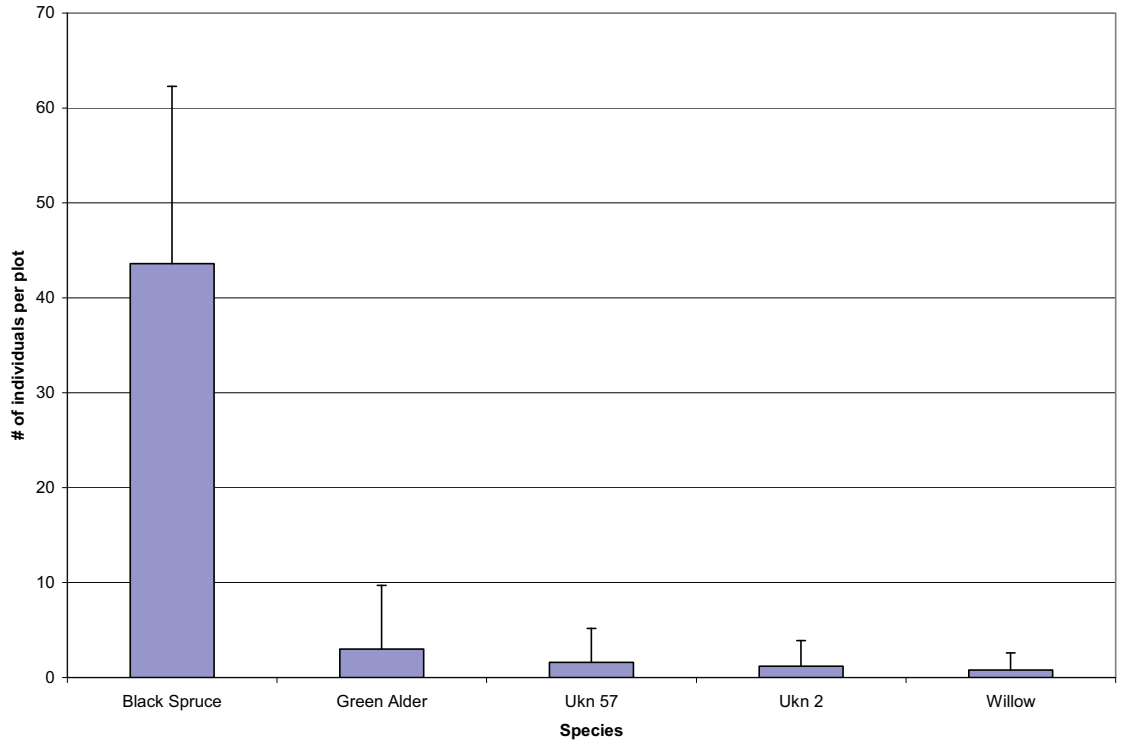


Figure 73: Number of individuals per plot in the Nopiming North 1900 Black Spruce site

As Figure 74 illustrates, black spruce was the most numerous small tree species in the Flintstone Lake 1993 Black Spruce stand, followed by jack pine. Figure 74 also demonstrates that most black spruce in this fire-origin stand are present as small trees, whereas jack pine are present mainly as trees (Fig 30).

The Flintstone Lake 1993 Jack Pine site is a young fire-origin stand located in a bog. Since the stand is situated in a bog, it is not surprising to see black spruce emerging as the most plentiful species. There is still a fair amount of jack pine in the stand which is to be expected. Of all conifers, jack pine is the best adapted to fire. A fire burnt the area just over ten years ago. Jack pine is usually one of the first species to develop in post fire areas. Black spruce is better adapted to poorly drained peat bog, and therefore will eventually outcompete the jack pine.

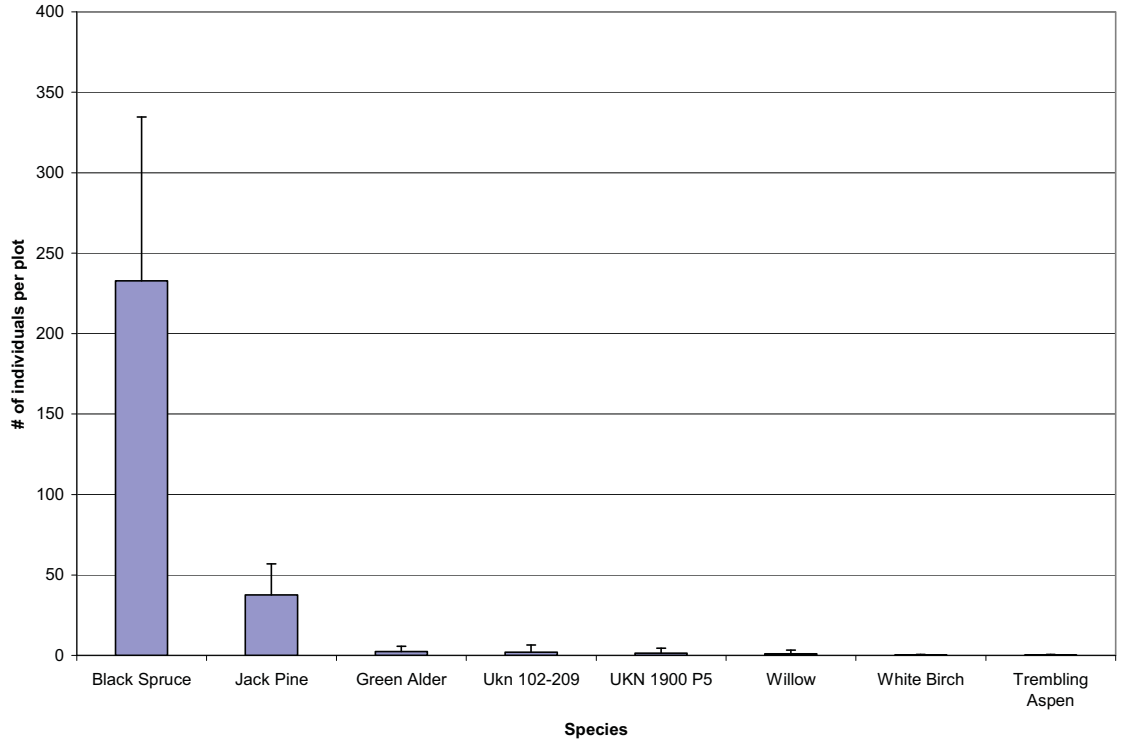


Figure 74: Number of individuals per plot in the Flintstone Lake 1993 Black Spruce site

Similarities among relatively young jack pine stands, seems to include a large amount of jack pine seedlings and saplings, followed by a considerable number of birch. The presence of both species is possibly due to the great quantity of light in these sites. Mature jack pine shrub layers appear to consist of more trembling aspen and balsam fir. The thinning of the canopy of aging stands may permit more light to reach the ground, enabling trembling aspen to flourish, while the presence of balsam fir is probably due to its ease of growth under a canopy of conifers combined with the fact it's a late successional species. Both young and mature black spruce shrub layers consist almost entirely of black spruce seedlings and saplings. The poorly drained peat bog and black spruce's capacity of producing a massive amount of seeds may account for the large number of individuals in the theses stands.

A complete list of shrub species found in every stand is found in Appendix III.

Ground Vegetation Stratum:

Hollow Water & Nopiming North Jack Pine:

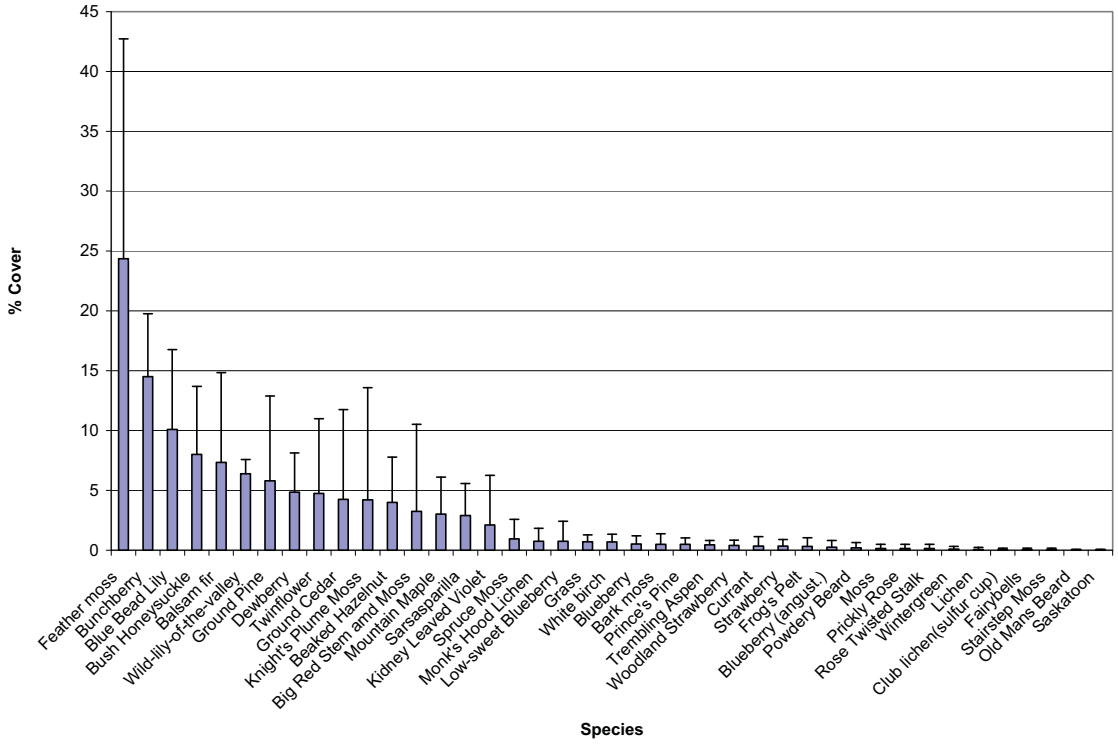


Figure 75: % Cover of ground vegetation in the Hollow Water 1912 Jack Pine site

As illustrated in Figure 75 to 79 there were a few common species which seem to cover the greatest percentage of the ground layer in these jack pine stands. These species include: moss, bunchberry, blueberry, labrador tea and wild-lily-of-the-valley. In every stand, moss covered the greatest percentage of the ground layer. Species such as bearberry, beaked hazelnut, bunchberry, labrador tea, twinflower, prickly rose, velvetleaf blueberry, wild sarsaparilla, large leaf aster, moccasin flower, dwarf rattlesnake plantain, Canada mayflower, wintergreen, reindeer lichens and feathermosses are associated with jack pine (http://www.rook.org/earl/bwca/nature/trees.html). All of the following species, with the exception of large leaf aster and Canada mayflower, were present in these stands, along with several other various species. Figure 75 to 79 also illustrate that there was a large amount of variation in % of cover of each species between plots.

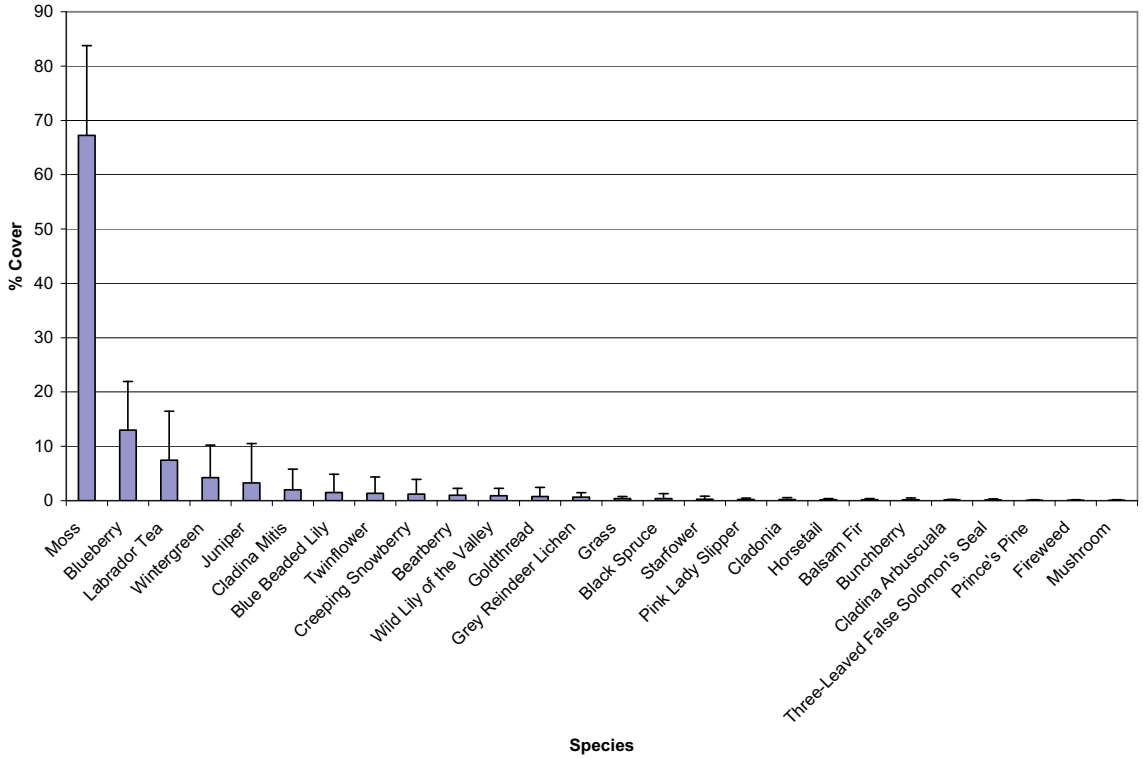


Figure 76: % Cover of ground vegetation in the Hollow Water 1983 Jack Pine site

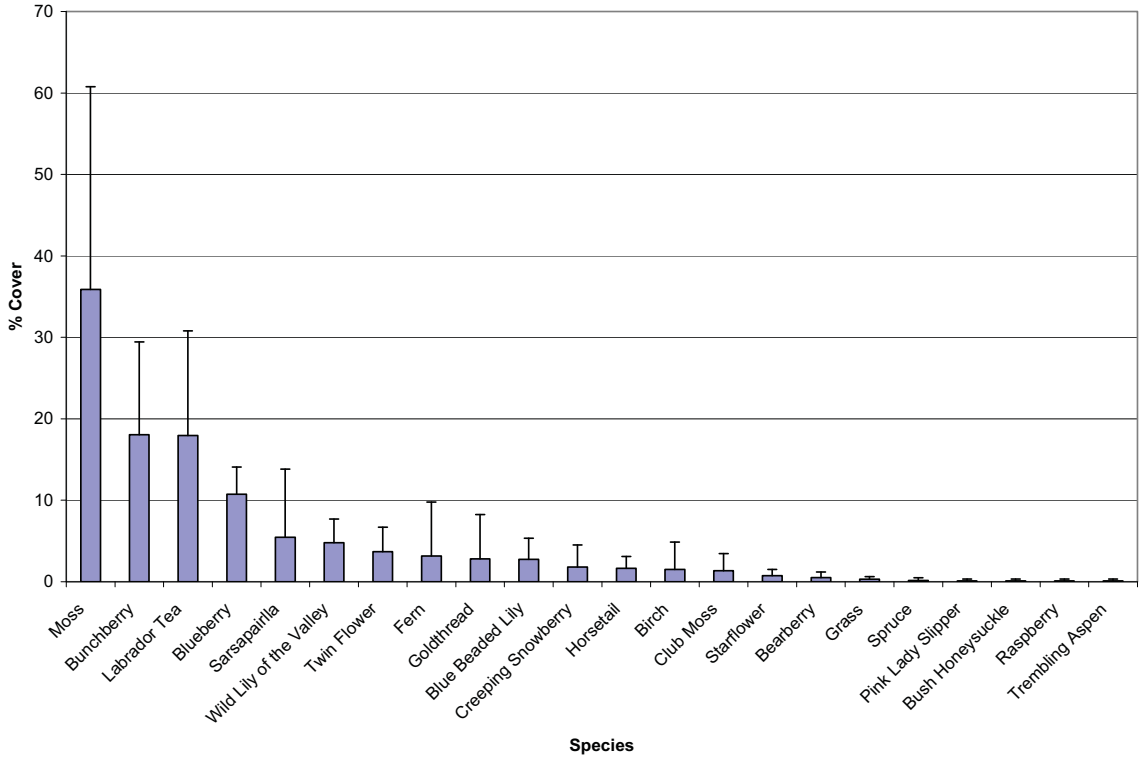


Figure 77: % Cover of ground vegetation in the Hollow Water 1992 Jack Pine site

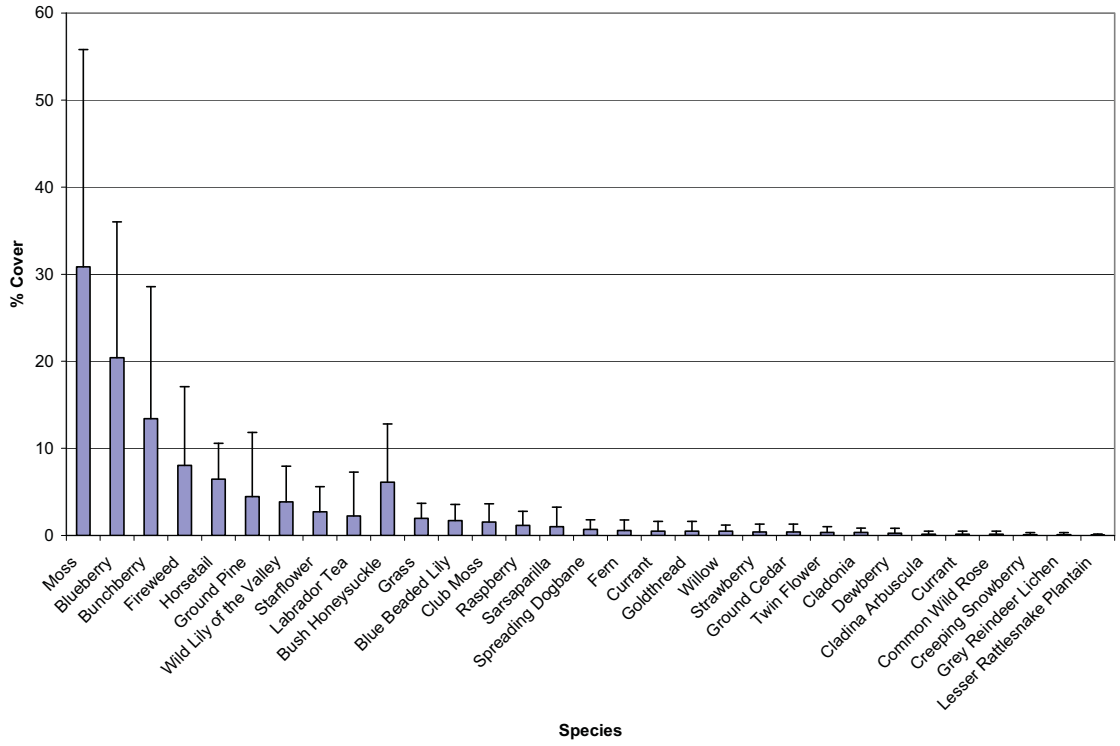


Figure 78: % Cover of ground vegetation in the Hollow Water 2000 Jack Pine site

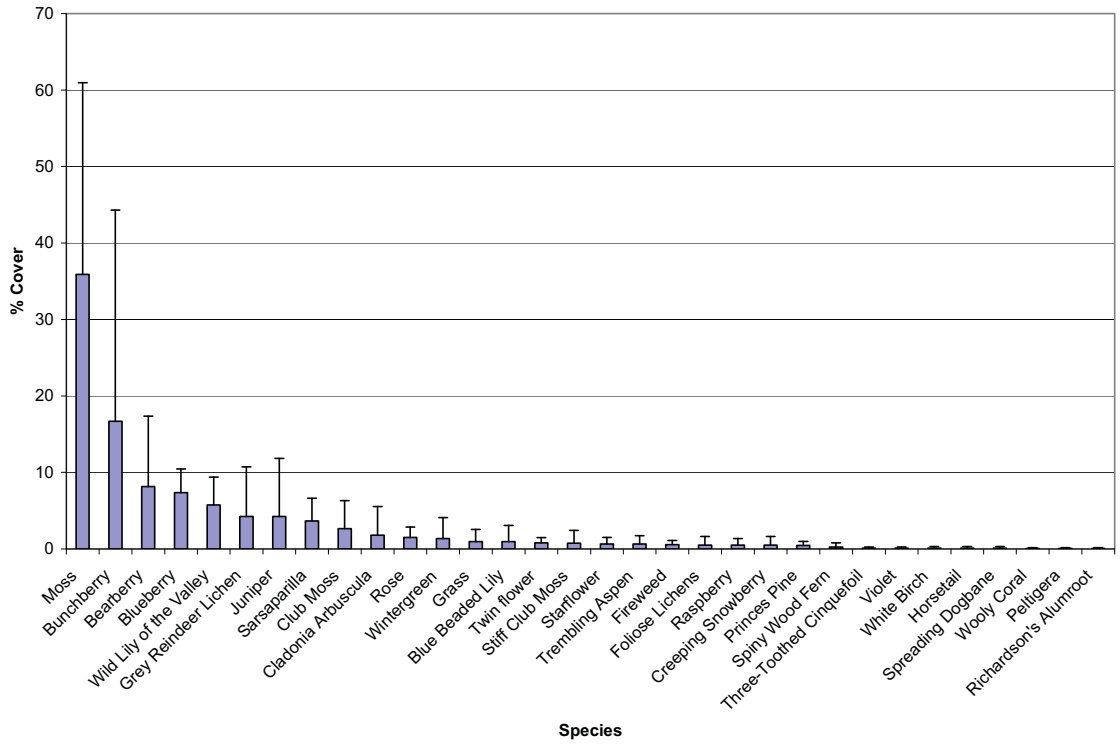


Figure 79: % Cover of ground vegetation in the Nopiming North 1920 Jack Pine site

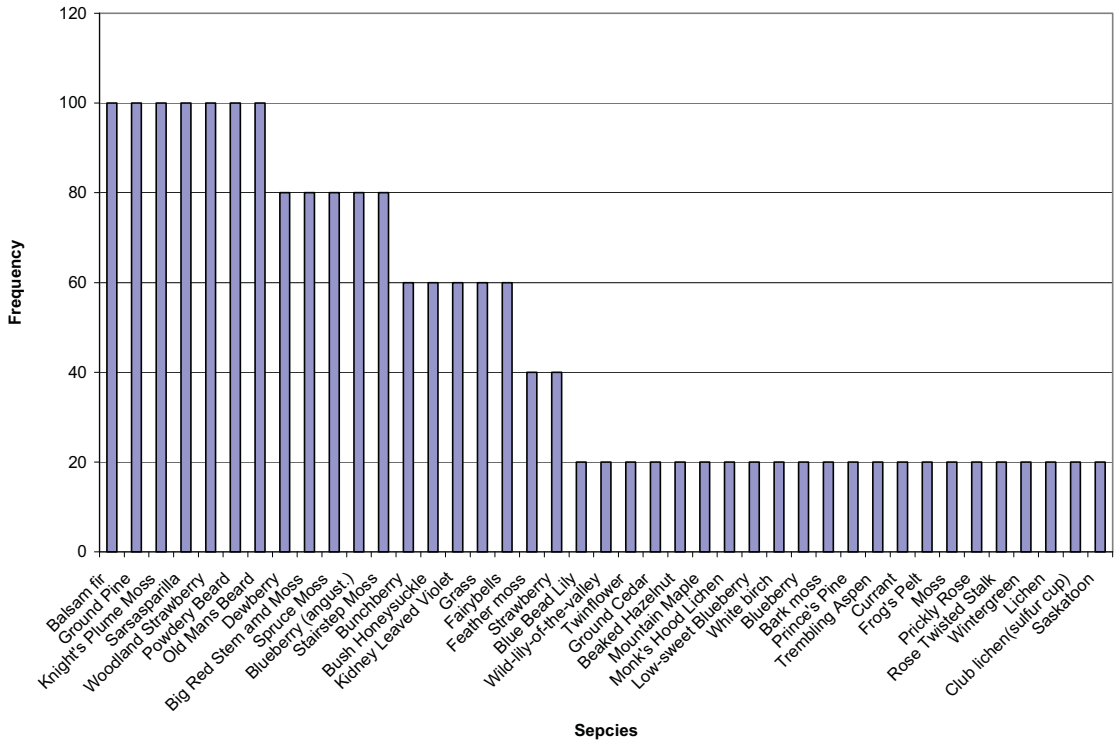


Figure 80: Frequency of ground vegetation in the Hollow Water 1912 Jack Pine site

The species with the greatest frequency are similar to those with the greatest percentage of cover of the ground layer (Fig 80, 81, 82, 83 and 84). Species that have the greatest frequency are moss, blueberry, labrador tea, grass, sarsaparilla, bunchberry and wild-lily-of-the-valley. The only difference between the percentage of cover and frequency was that sarsaparilla and grass was among species with the greatest frequency. The ground vegetation between stands was fairly similar, although frequency and percentage of cover did vary from stand to stand.

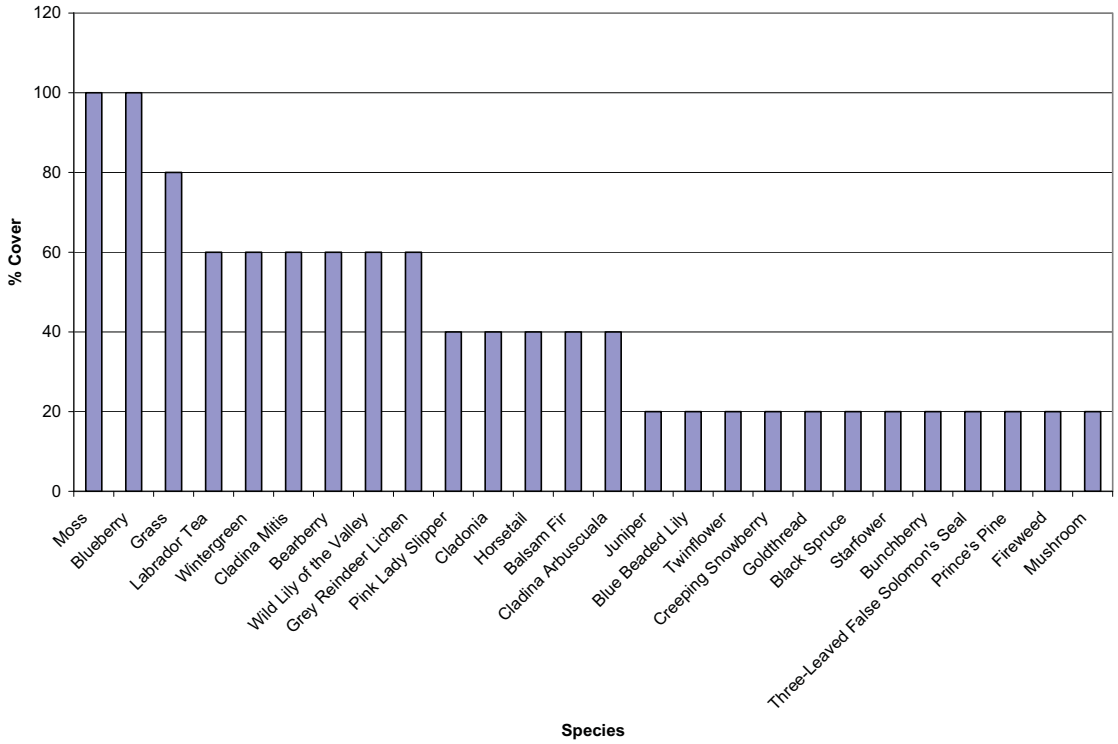


Figure 81: Frequency of ground vegetation in the Hollow Water 1983 Jack Pine site

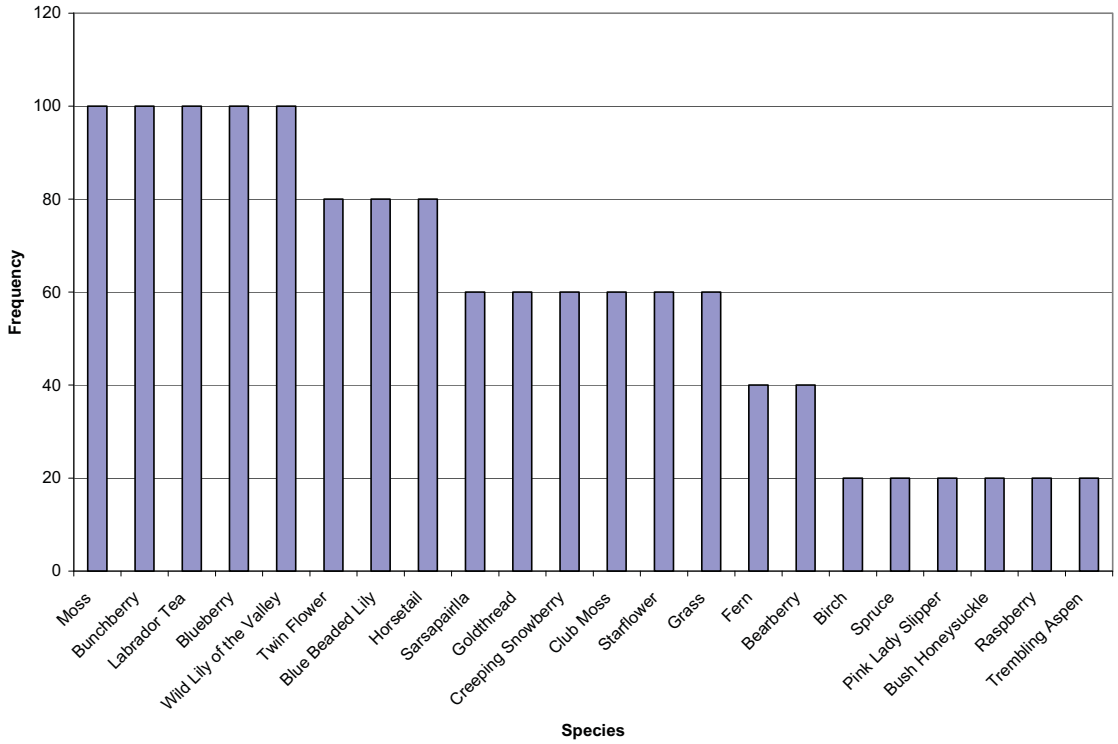


Figure 82: Frequency of ground vegetation in the Hollow Water 1992 Jack Pine site

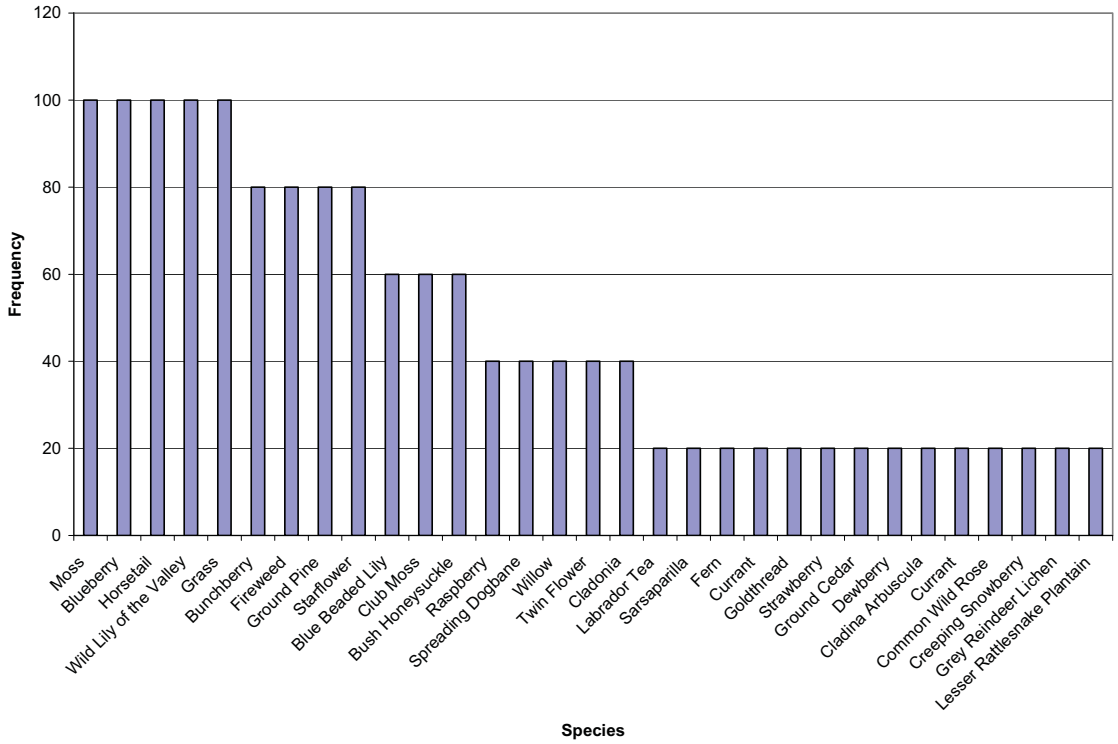


Figure 83: Frequency of ground vegetation in the Hollow Water 2000 Jack Pine site

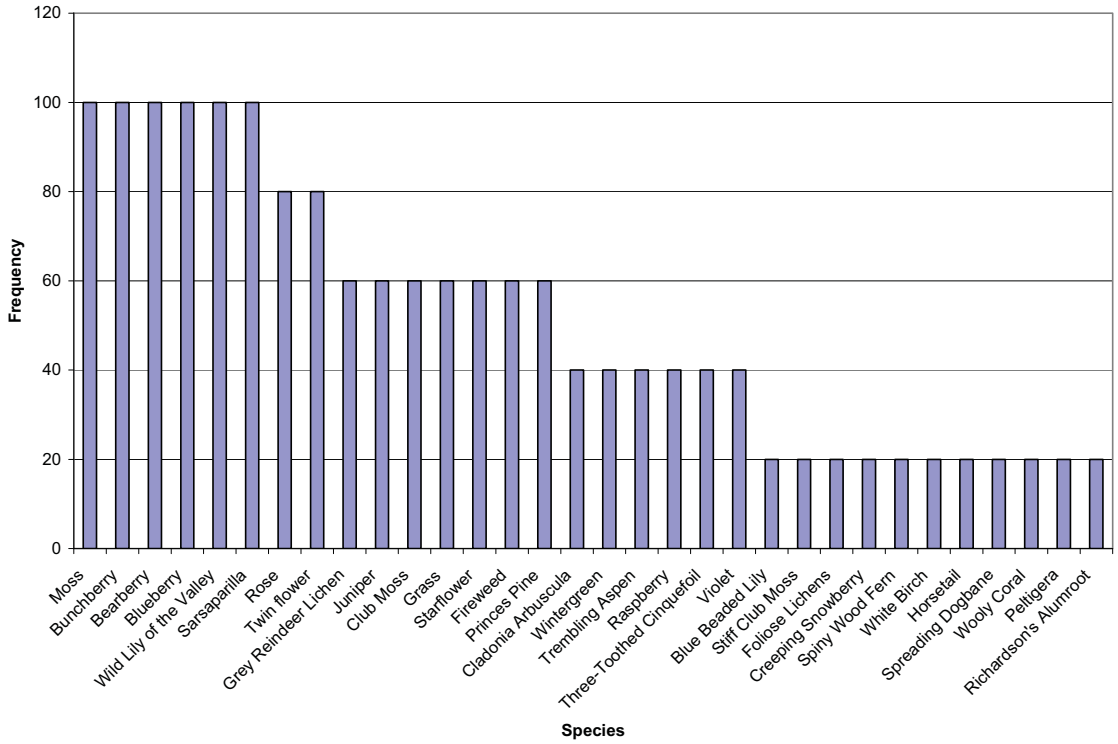


Figure 84: Frequency of ground vegetation in the Nopiming North 1920 Jack Pine site

Nopiming North & Flintstone Lake Black Spruce:

Figure 85 and 86 illustrate the presence a few common species between the Nopiming North 1900 Black Spruce and Flintstone Lake 1993 Black Spruce stands, along with a relatively high percentage of cover; moss, labrador tea, leatherleaf, three-leaved-false solomon's seal, grass and small bog cranberry. Species in both the Nopiming North 1900 Black Spruce and Flintstone Lake 1993 Black Spruce stands had very similar ground vegetation.

Species such as mountain maple, speckled alder, bog rosemary, bog birch, leatherleaf, bunchberry, red osier dogwood, beaked hazel, creeping snowberry, bog laurel, labrador tea, twinflower, red raspberry, mountain cranberry, wild sarsaparilla, bluejoint reedgrass, sedges, blue bead lily, stemless ladyslipper, fireweed, sheathed cottonsedge, dwarf rattlesnake plantain, tall northern bog orchid, blunt leaf orchid, canada mayflower, panicle bluebells, indian pipe, cinnamon fern, one-sided pyrola, purple pitcher plant, bog false solomon's seal, starflower, reindeer mosses, dicranum moss, bristly clubmoss, schreber's feather moss, hair cap mosses and sphagnum mosses are associated with black spruce. A conspicuous characteristic of black spruce stands is a nearly continuous ground cover of feather mosses, sphagnum mosses, and/or reindeer lichens are associated with black spruce. (http://www.rook.org/earl/bwca/nature/trees.html).

The vast majority of ground species were found in both the mature and immature black spruce stands.

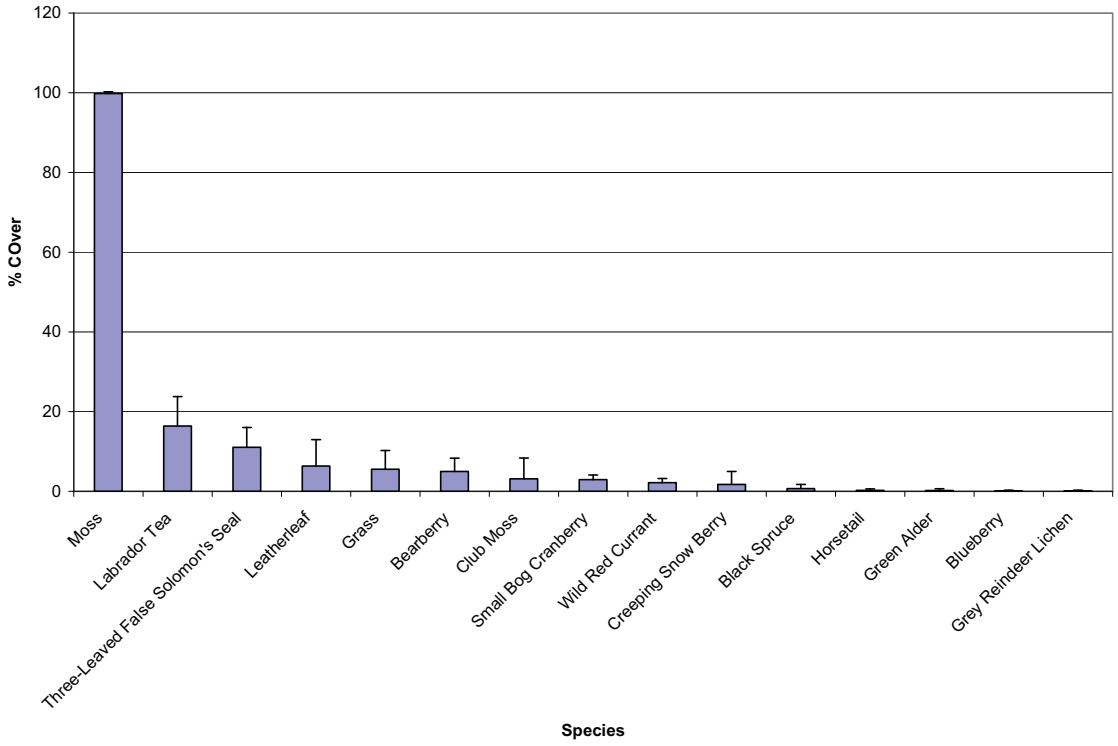


Figure 85: % Cover of ground vegetation in the Nopiming North 1900 Black Spruce site

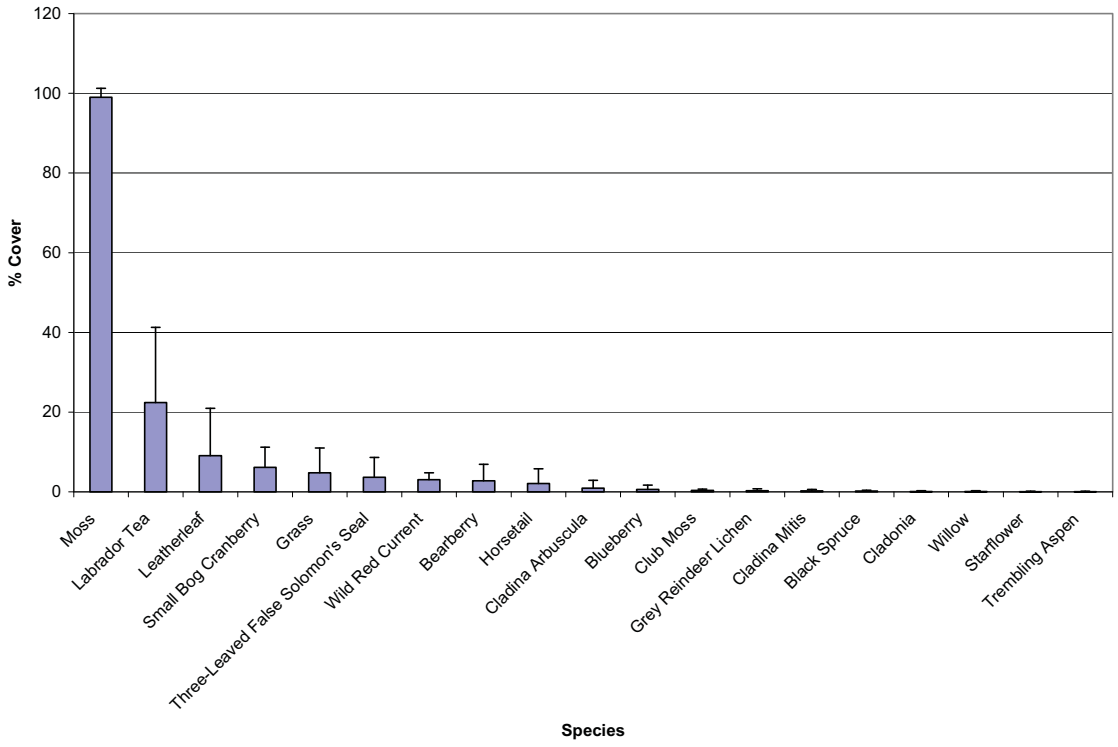


Figure 86: % Cover of ground vegetation in the Flintstone Lake 1993 Black Spruce site

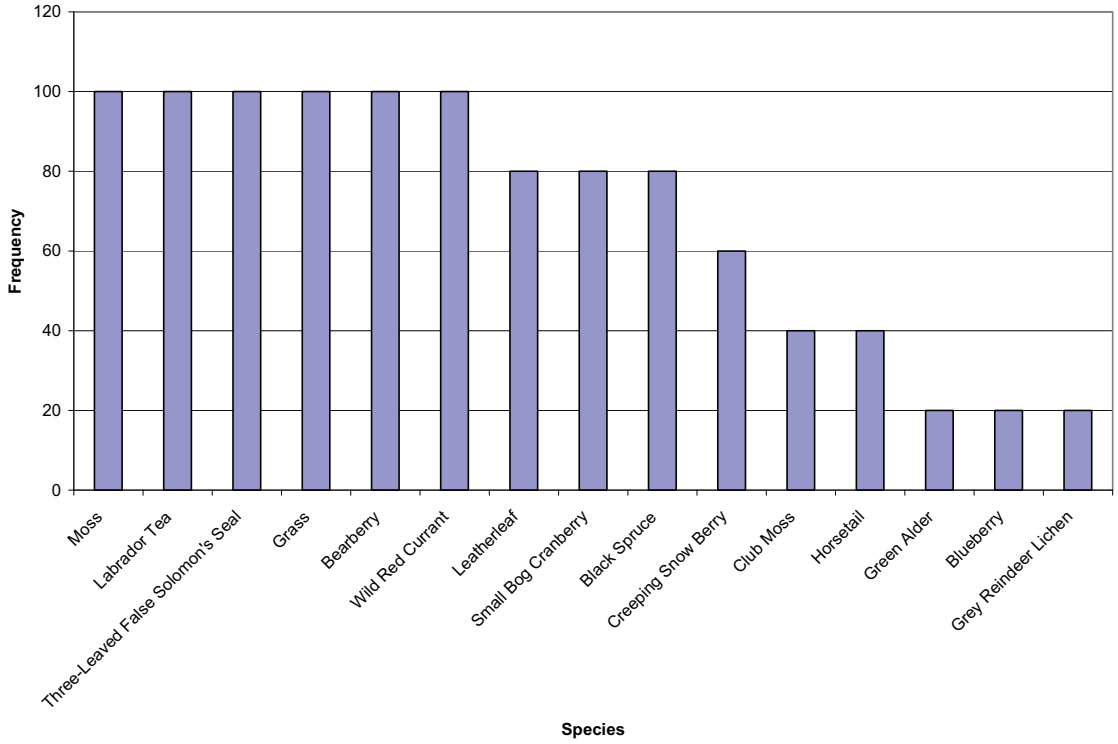


Figure 87 Frequency of ground vegetation in the Nopiming North 1900 Black Spruce site

As shown in Figure 87 and 88, the frequency at which species were found in the mature and young black spruce stands is relatively similar to that of the percentage of cover. Species with the greatest frequency were for the most part, the ones with the greatest percentage of cover. Species with the greatest frequency included: Moss, labrador tea, three-leaved false solomon's seal, grass, wild red currant and bearberry. The only differences between the highest species value for percentage of cover and frequency was the addition of wild red currant and bearberry and the loss of leatherleaf and small bog cranberry among the top frequencies. Although leatherleaf and small bog cranberry were not among the top frequency values, they were very close behind.

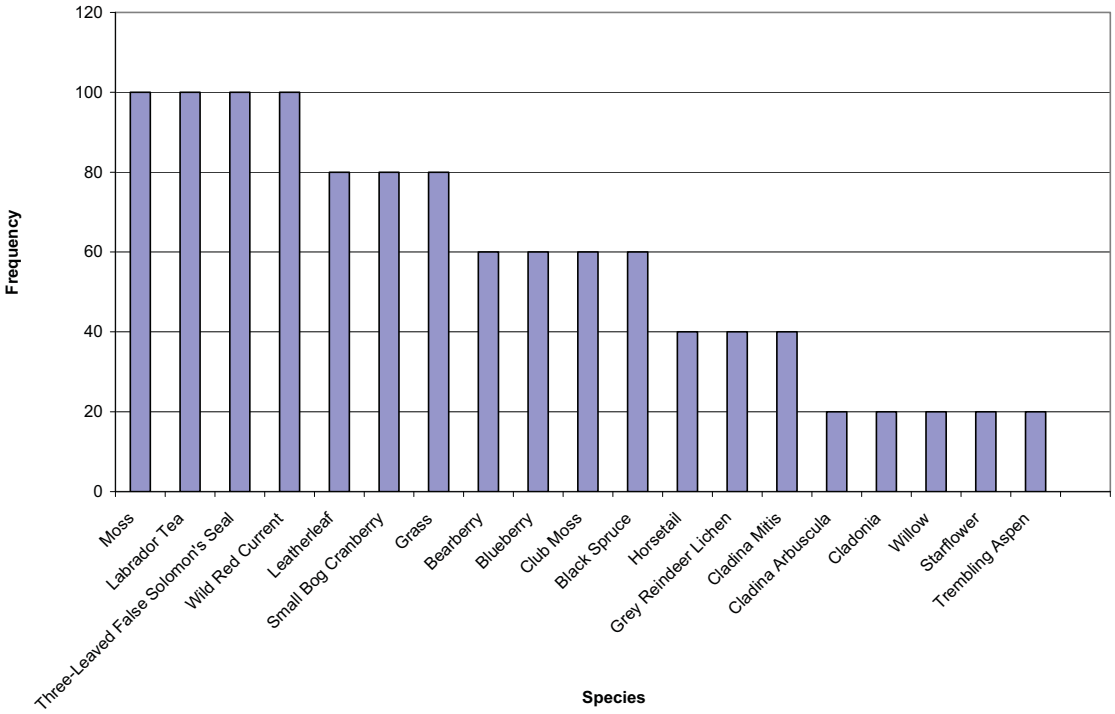


Figure 88: Frequency of ground vegetation in the Flintstone Lake 1993 Black Spruce site

A complete list of ground vegetation species found in every stand is found in Appendix III.

Figure 89: Typical Ground Vegetation found in a Jack Pine stand (left) and in a Black Spruce stand (right)

Downed Woody Debris:

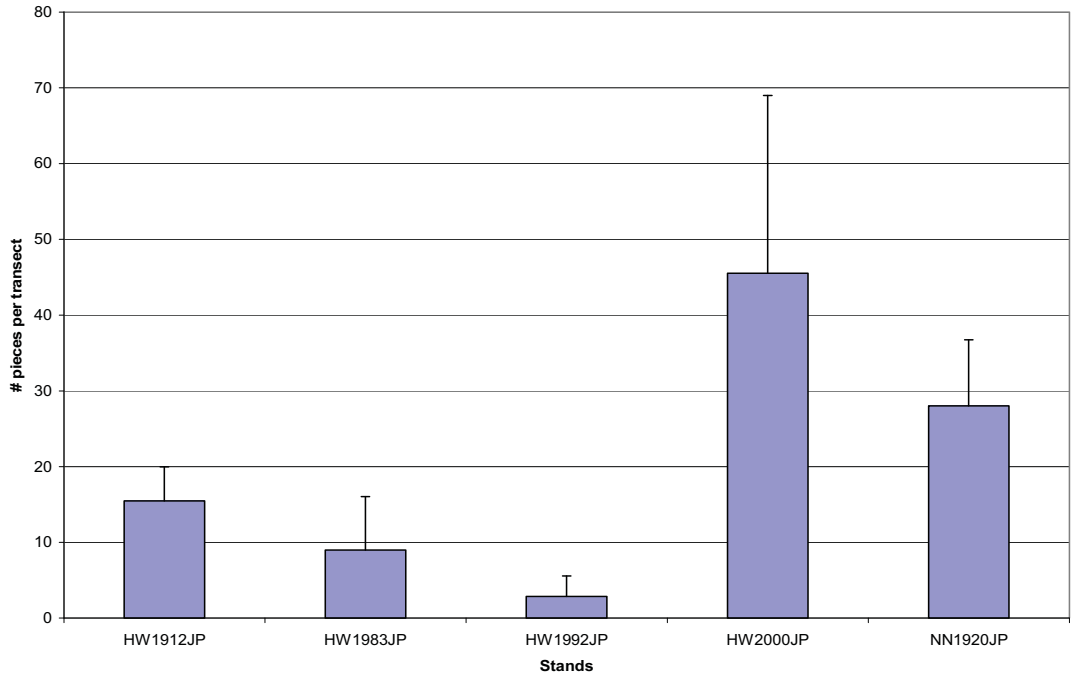


Figure 90: # of pieces per transect for each jack pine stand

Figure 90 illustrates that the Hollow Water 1992 Jack Pine stand had the lease amount of pieces per transect, with less than 3, and that the Hollow Water 2000 Jack Pine stand had the most pieces per transect with almost 46. The high number of pieces per transect for the Hollow Water 2000 Jack Pine stand is probably due to the numerous logs left in the area after it was logged. The increase in the number of piece as the forest ages (eg. From Hollow water 1992 to 1983 to 1912) reflects the mortality of trees in the stand as self-thinning occurs and as these trees begin to fall down.

Figure 91 illustrates the volume per transect. As shown, trends in the data from the Hollow Water 1992 Jack Pine and Hollow Water 1983 Jack Pine stands were comparable to Figure 90. However, volume values increased significantly for the Hollow Water 1912 Jack Pine stand compared to the number of pieces per transect. Despite the fewer fallen pieces in the Hollow Water 1912 Jack Pine stand, the volume is considerably greater due its size of logs. Since the site is mature, trees will have a greater dbh and therefore, fallen trees will have a greater volume.

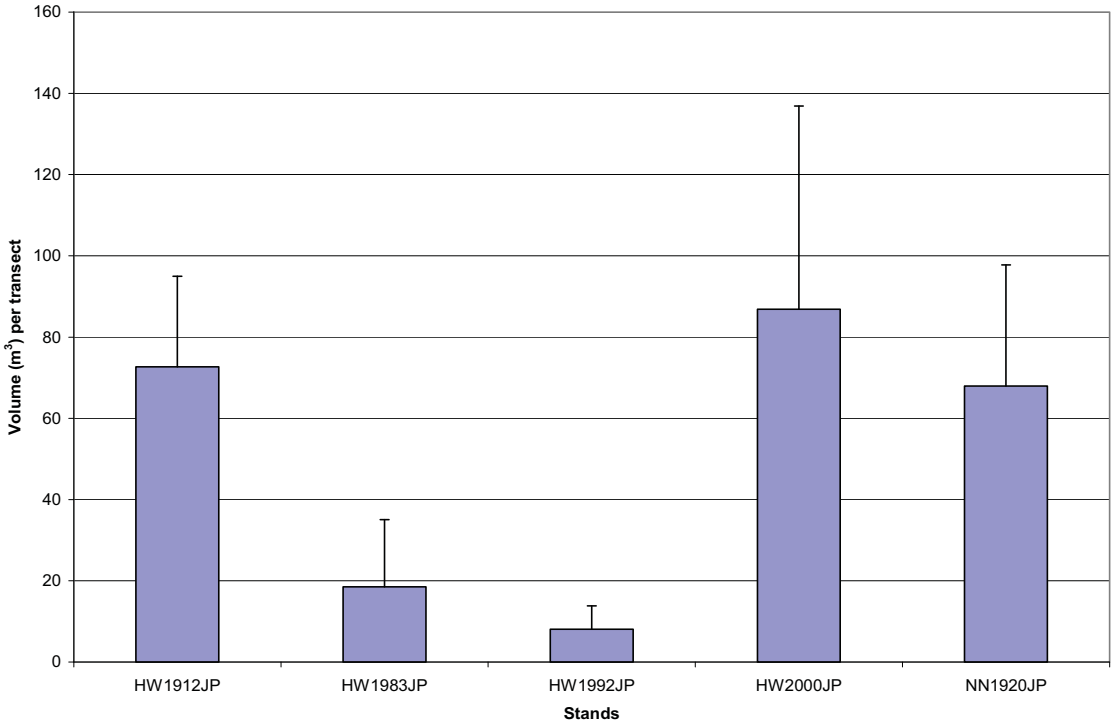


Figure 91: Volume per transect for each jack pine stand

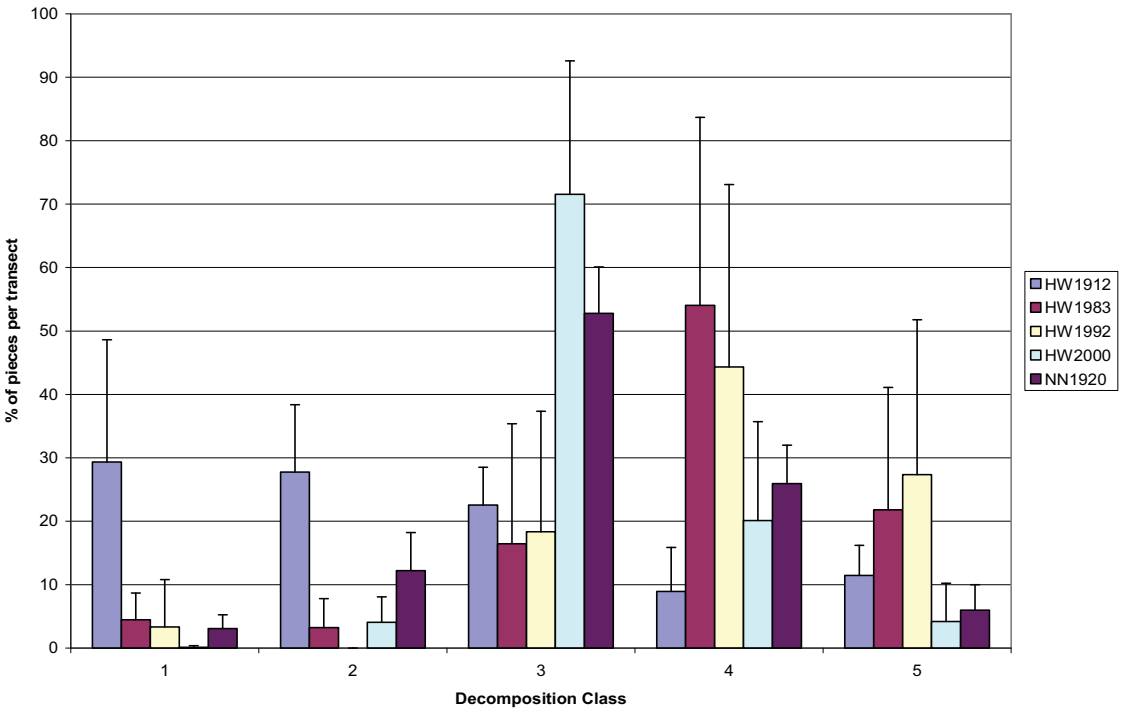


Figure 92: % of pieces per transect in each decomposition class for each jack pine stand

Figure 92 shows the percentage of pieces per transect for each decomposition class. The pieces in the oldest stand, Hollow Water 1912 Jack Pine, were congregated in class 1 and 2, which would indicate a somewhat recent fall of trees. Downed woody debris in the Hollow Water 2000 Jack Pine and Nopiming North 1920 Jack Pine stands were concentrated in the 3rd decomposition class. In the case of the Hollow Water 2000 Jack Pine stand, logs are for the most part a reminder of its logging origin. As for the Nopiming North 1920 Jack Pine stand, it simply indicates trees have fallen throughout the years. Both the Hollow Water 1983 Jack Pine and Hollow Water 1992 Jack Pine stands retain the bulk of their downed woody debris in the 4th decomposition class. This could indicate two things; the downed woody debris has been there for quite a while or the decomposition rate is rather rapid. The latter is likely the case as these pieces of downed woody debris has a small dbh and likely represented logging slash (branches) which would decompose rapidly.

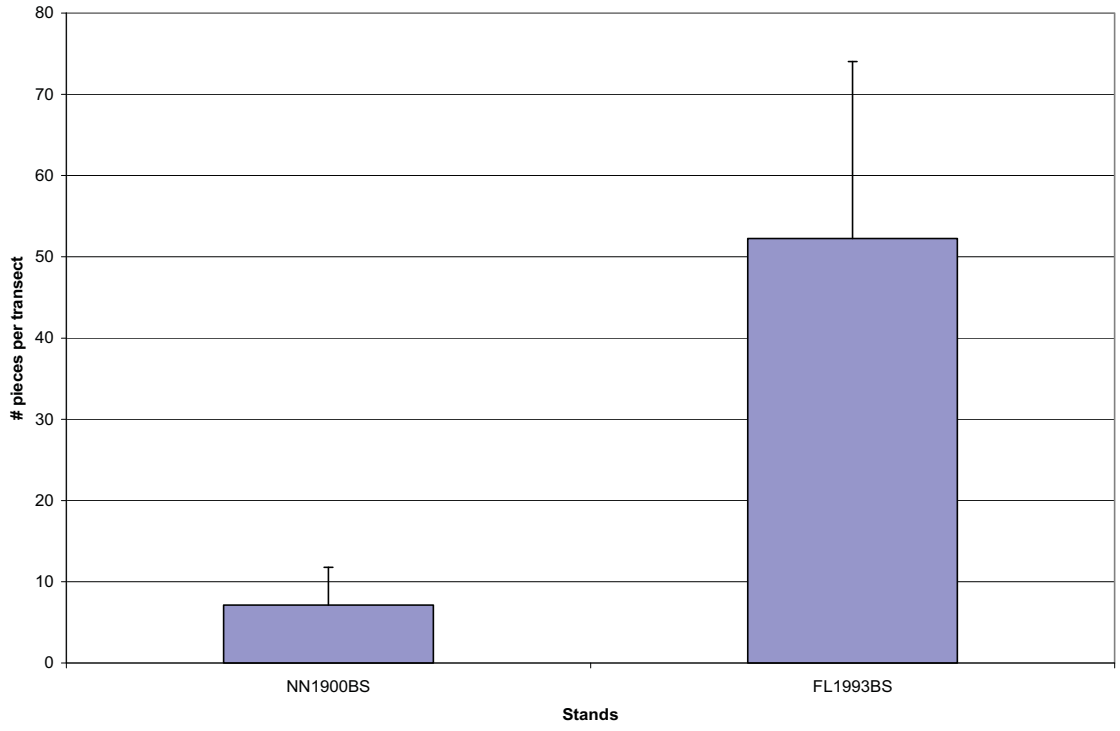


Figure 93: # of pieces per transect for each black spruce stand

As illustrated in Figure 93, there was a much greater number of pieces per transect for the Flintstone Lake 1993 Black Spruce stand compared to the Nopiming North 1900 Black Spruce stand. The Flintstone Lake 1993 Black Spruce site is of recent fire origin and therefore the downed woody debris represents the massive conversion of live, standing trees to downed woody debris.

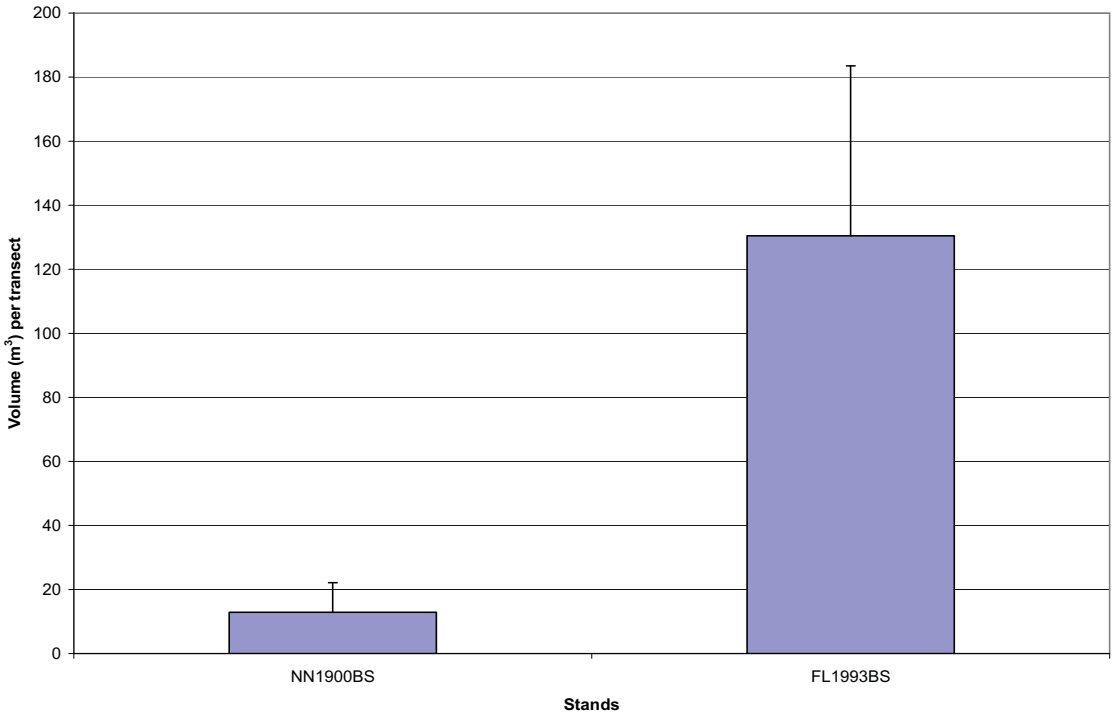


Figure 94: Volume per transect for each black spruce stand

Expectedly, Figure 94 shows that the volume per transect was ten times greater for the Flintstone Lake 1993 Black Spruce stand compared to the Nopiming North 1900 Black Spruce stand. The number of pieces per transect for the Flintstone Lake 1993 Black Spruce site was roughly seven times greater than the Nopiming North 1900 Black Spruce site and the volume was ten times greater. This could mean that the downed woody debris in the Flintstone Lake 1993 Black Spruce stand had large dbhs or simply that the falling trees in the Nopiming North 1900 Black Spruce stand had small dbhs. It could also very well be a combination of both.

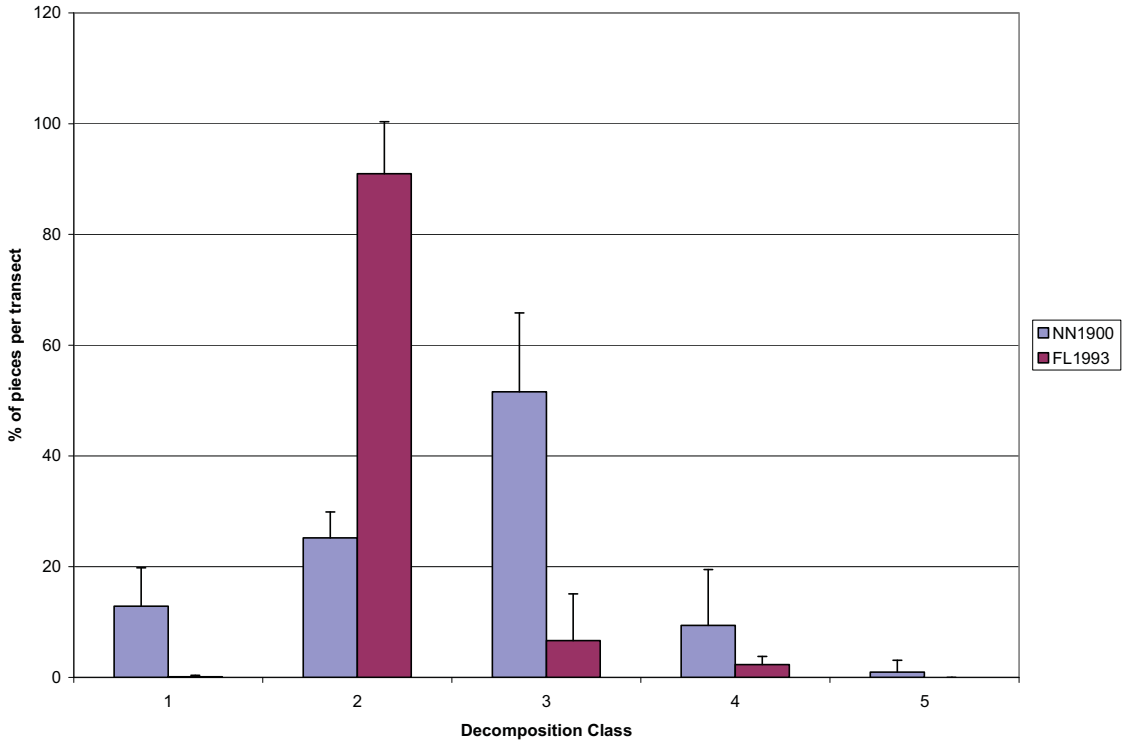


Figure 95: % of pieces per transect in each decomposition class for each black spruce stand

As illustrated in Figure 95, the majority of the Flintstone Lake 1993 Black Spruce's downed woody debris was found in the 2nd decomposition class. As mentioned previously, this young stand is of fire origin. The bulk of the logs crossing the transect are what remains from the fire, which explains the congregation of downed woody debris in one decomposition class. In addition, the fire past through this area fairly recently, which would explain the early state of decomposition.

Figure 95 also shows that the logs from the Nopiming North 1900 Black Spruce stand were predominantly found in the 3rd decomposition class. Along with the fact that there is an average amount of downed woody debris in the first two decomposition classes, this would indicate that the majority of the fallen trees are moderately advanced as far as decomposition and that there is a small amount of trees falling regularly.

Light Transmission:

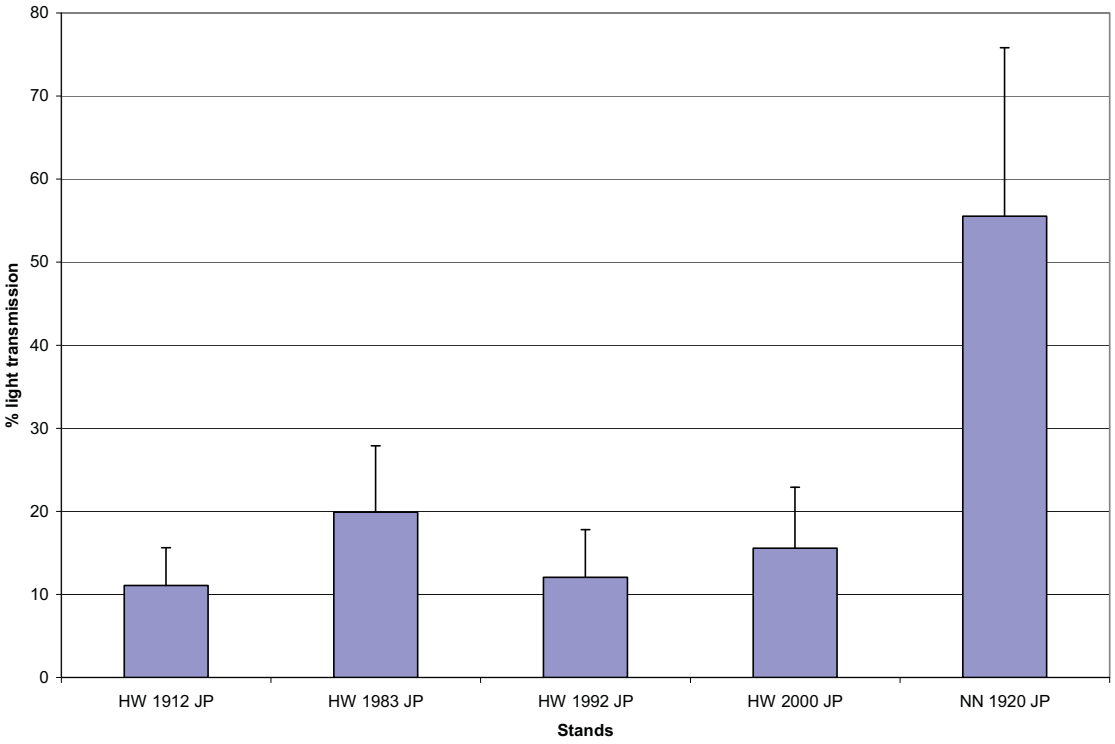


Figure 96: % of light transmission in the jack pine stands

According to Figure 96, the percentage of light transmission within the jack pine sites ranged from 11 to 55%. The Hollow Water sites did not vary much ranging from 11 to 20%, despite the considerable differences in age between stands. The lone Nopiming North jack pine site demonstrated a very high percentage of light transmission relative to the Hollow Water site. The jack pine stand in Nopiming North was not as dense as the ones in the Hollow Water. The soil in the Hollow Water area is composed for the most part of sand deposits. The Nopiming North area is characterized mostly by exposed bedrock with little surficial deposits. These differences in soils may explain the differences in density of Hollow Water and Nopiming North.

Relatively low light transmission within young stands is to be expected because of the large number of individuals in the plots. Even if the Hollow Water 1912 Jack Pine site, a mature stand is compared to the Nopiming North 1920 Jack Pine site, there is still a substantial difference in light transmissions. Another possible explanation for the

differences could be due to the higher abundance of trembling aspen within the Hollow Water 1912 Jack Pine site, which may well decrease the percentage of light transmission.

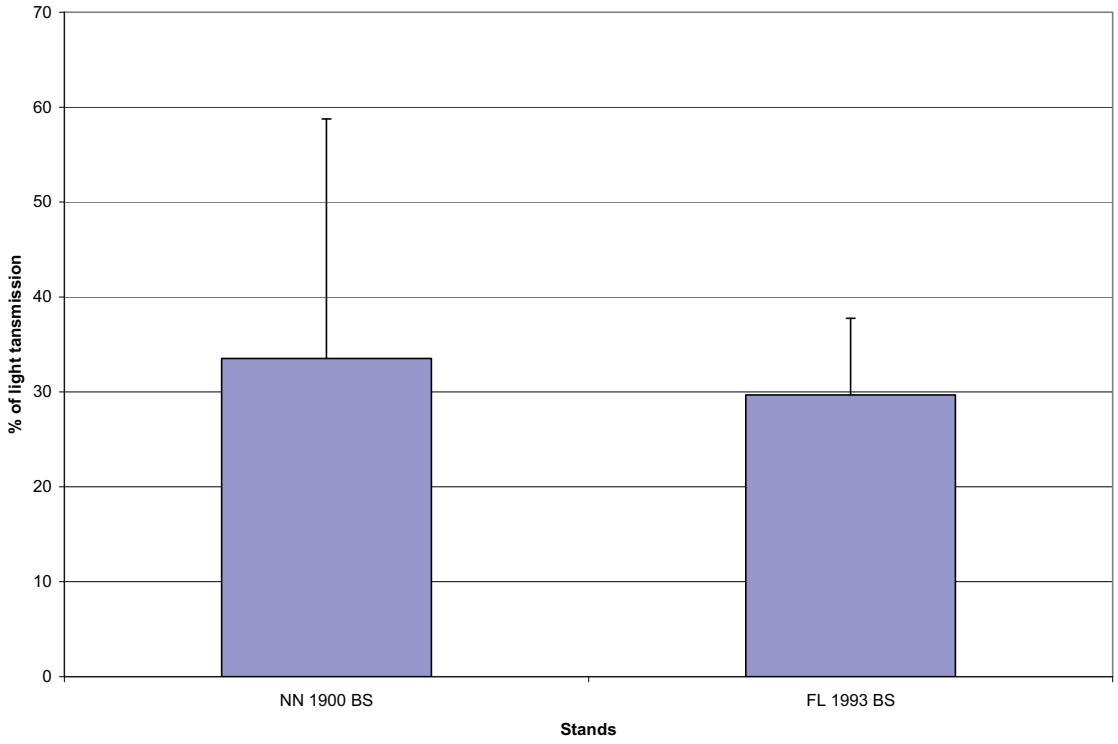


Figure 97: % of light transmission in the black spruce stands

As illustrated in Figure 97, the percentage of light transmission in both black spruce sites were very similar. The Nopiming North 1900 Black Spruce and Flintstone Lake 1993 Black Spruce stands had 33 and 30% of light transmission, respectively. Despite the difference in age, both stands are fire origin and have a similar soil type; poorly drained peat bog.

Tree height:

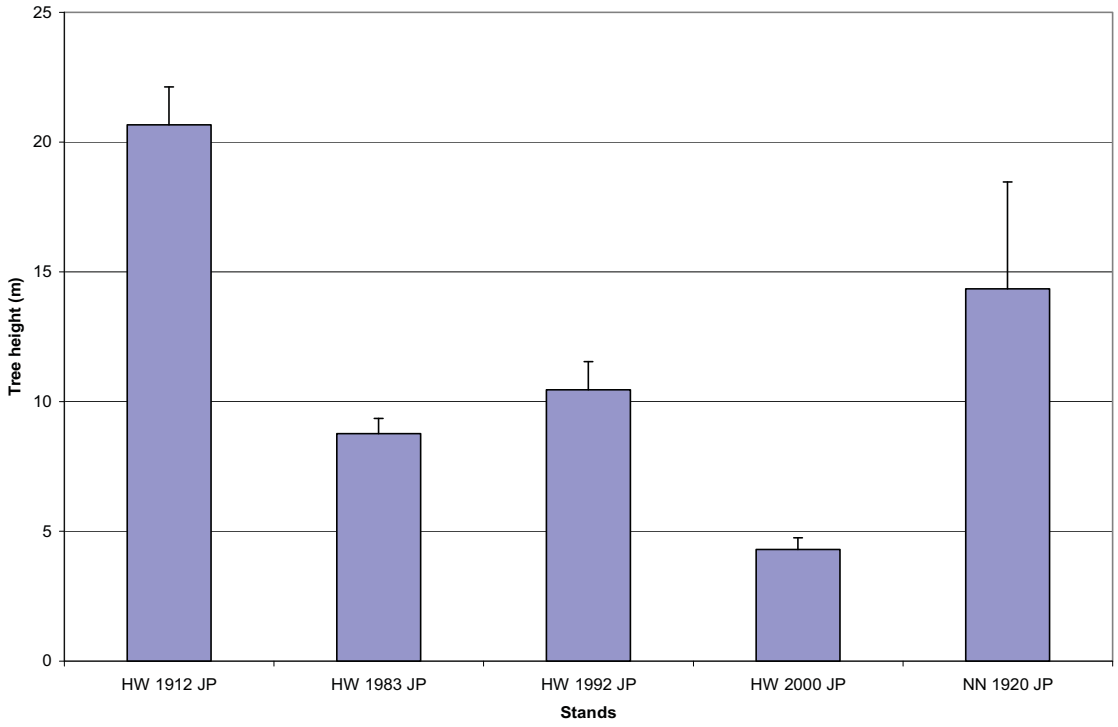


Figure 98: Tree height in each jack pine stand

According to Figure 98, the average tree heights ranged from 21 to 4.5 metres. If we compare stands of roughly similar years of origin in the Hollow Water area and the Nopiming North area, it seems trees in the Hollow Water area are 7 metres taller than the ones in Nopiming North. This may be due to the differences in soils fertility.

Unexpectedly, trees in the Hollow Water 1983 Jack Pine stand are nearly 2 metres shorter than trees in the Hollow Water 1992 Jack Pine stand. Both sites encompass similar a type of soil, that is sand deposits and both stands are of logging origin. The abundance of jack pine trees in the younger (1992) site was significantly less than in the slightly older (1983) site (Fig 8). This difference in abundance may have resulted in less competition between trees, and thus better growth (height) in the Hollow Water 1992 Jack Pine stand.

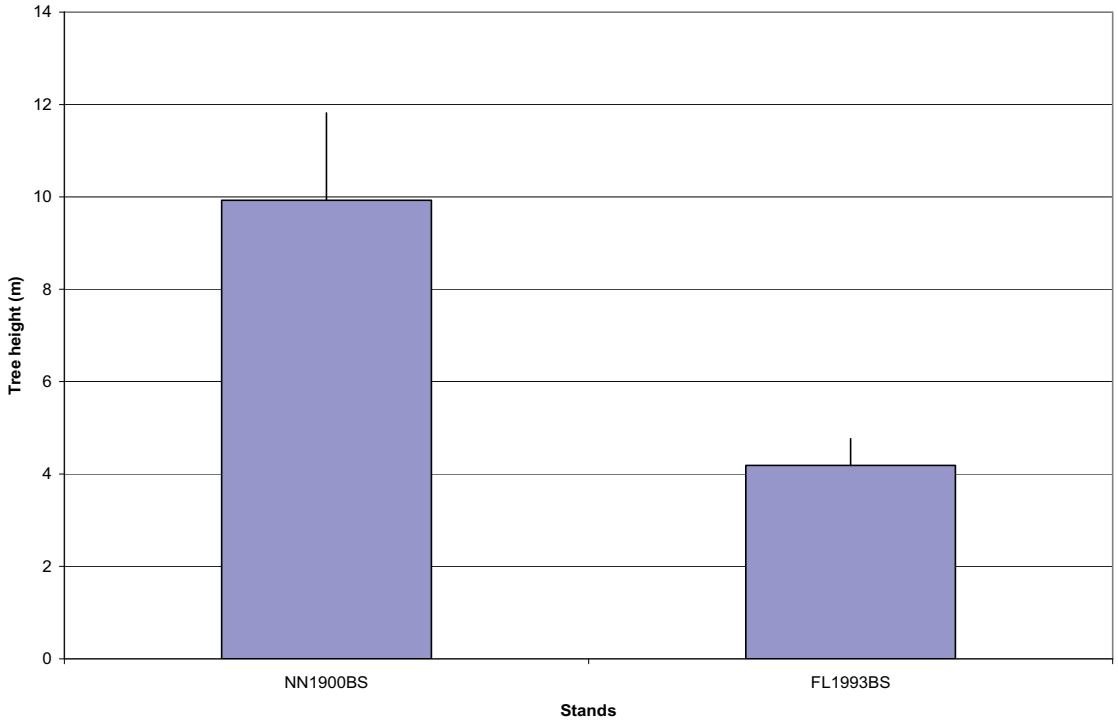


Figure 99: Tree height in each black spruce stand

As illustrated in Figure 99, tree height for the Nopiming North 1900 Black Spruce and Flintstone Lake 1993 Black Spruce stands were respectably 10 and 4 metres, respectively. The lower value for the 1993 site reflects the effects of the recent forest fire.

Tree age:

According to Figure 100, the trees ages ranged from 22 to 129 years. Most stands were within 5 to 15 years of the values found in the Tembec Forest Resource Inventory (FRI). However, Nopiming North 1900 Black Spruce stand is close to 30 years older than indicated in the FRI.

The Hollow Water 1992 Jack Pine stand was about 8 years older than marked. This may also explain its average tree height being greater than the Hollow Water 1983 Jack Pine stand.

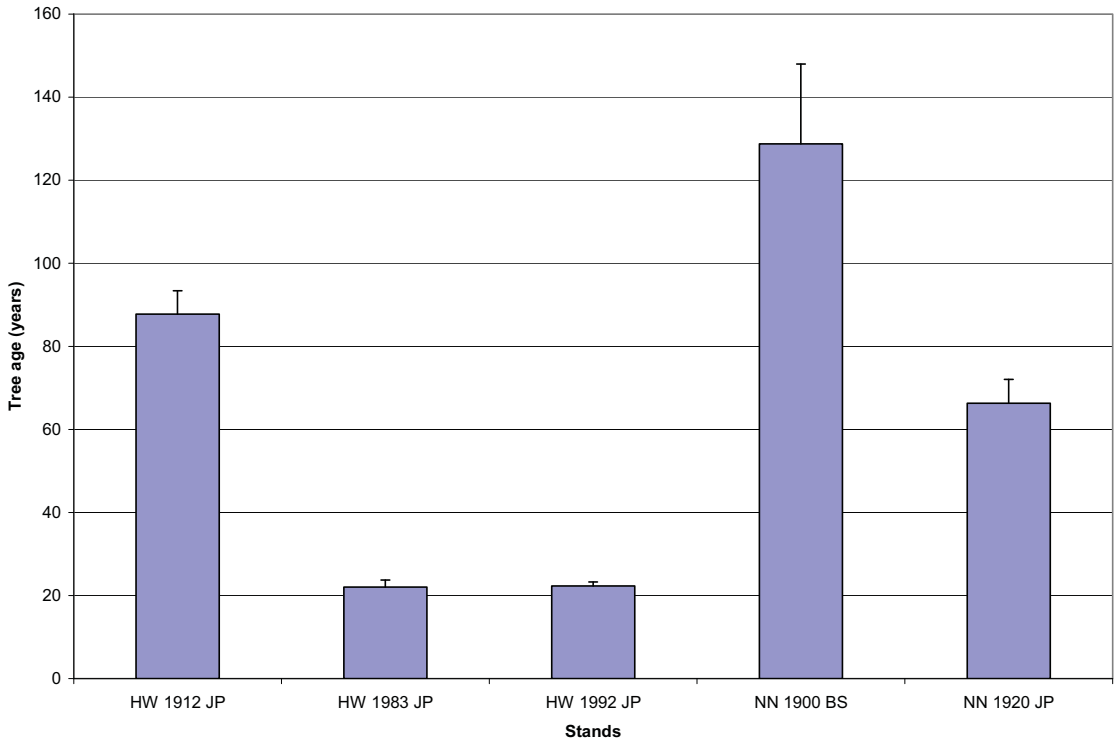


Figure 100: Tree age of each stand (with the exception of HW2000JP and FL1993BS)

Air and Soil temperature:

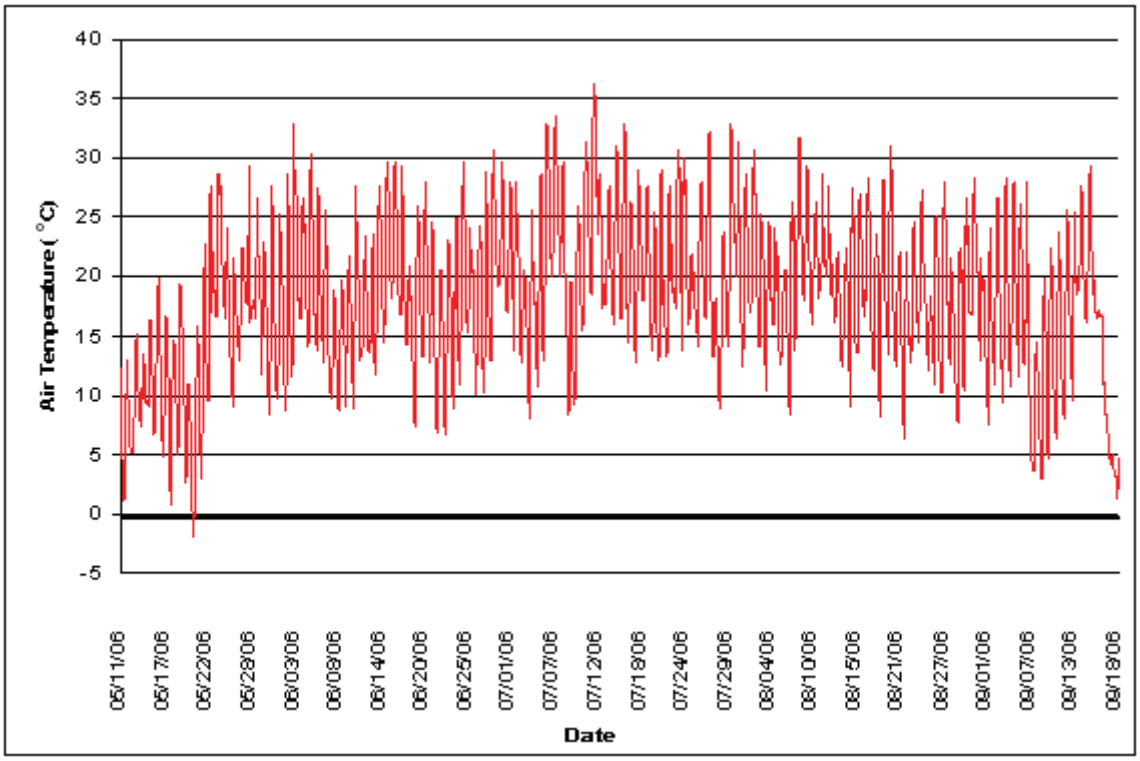


Figure 101: Air temperature in the Nopiming North 1920 Jack Pine stand

Figure 101 shows the hourly air temperature and Figure 102 shows the hourly soil temperature in the Nopiming North 1920 Jack Pine stand from May 11, 2006 to September 19, 2006.

As illustrated in Figure 101, the air temperature ranged from -5 to 37°C. The coldest month recorded was May, whereas July was the warmest month. Several days in July exceeded the 30°C mark. As can be seen in the graph, there was much a great deal of daily variation in the air temperature. The average air temperature from May to September was 18.1°C.

As shown in Figure 102, the soil temperature ranged from 6 to 20°C. The coldest month recorded was once again May, whereas July was the warmest month. In contrast to air temperature, soil temperature showed little daily variation. The moisture in the soil

served as a temperature buffer, preventing any drastic changes in soil temperature. The average soil temperature from May to September was 15.0°C.

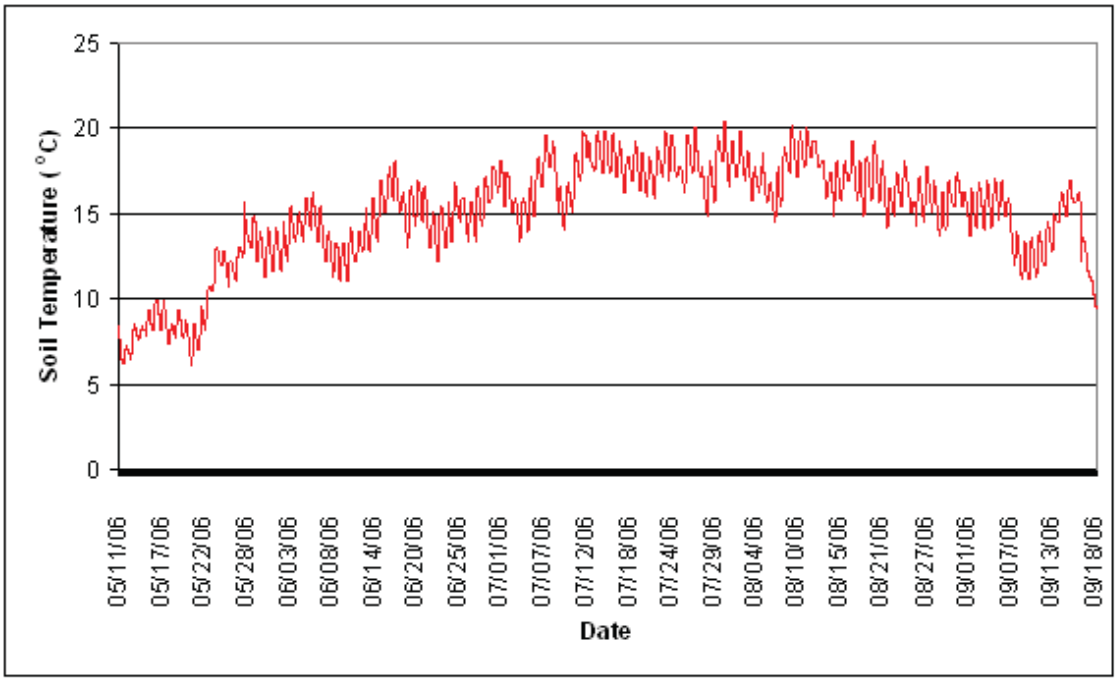
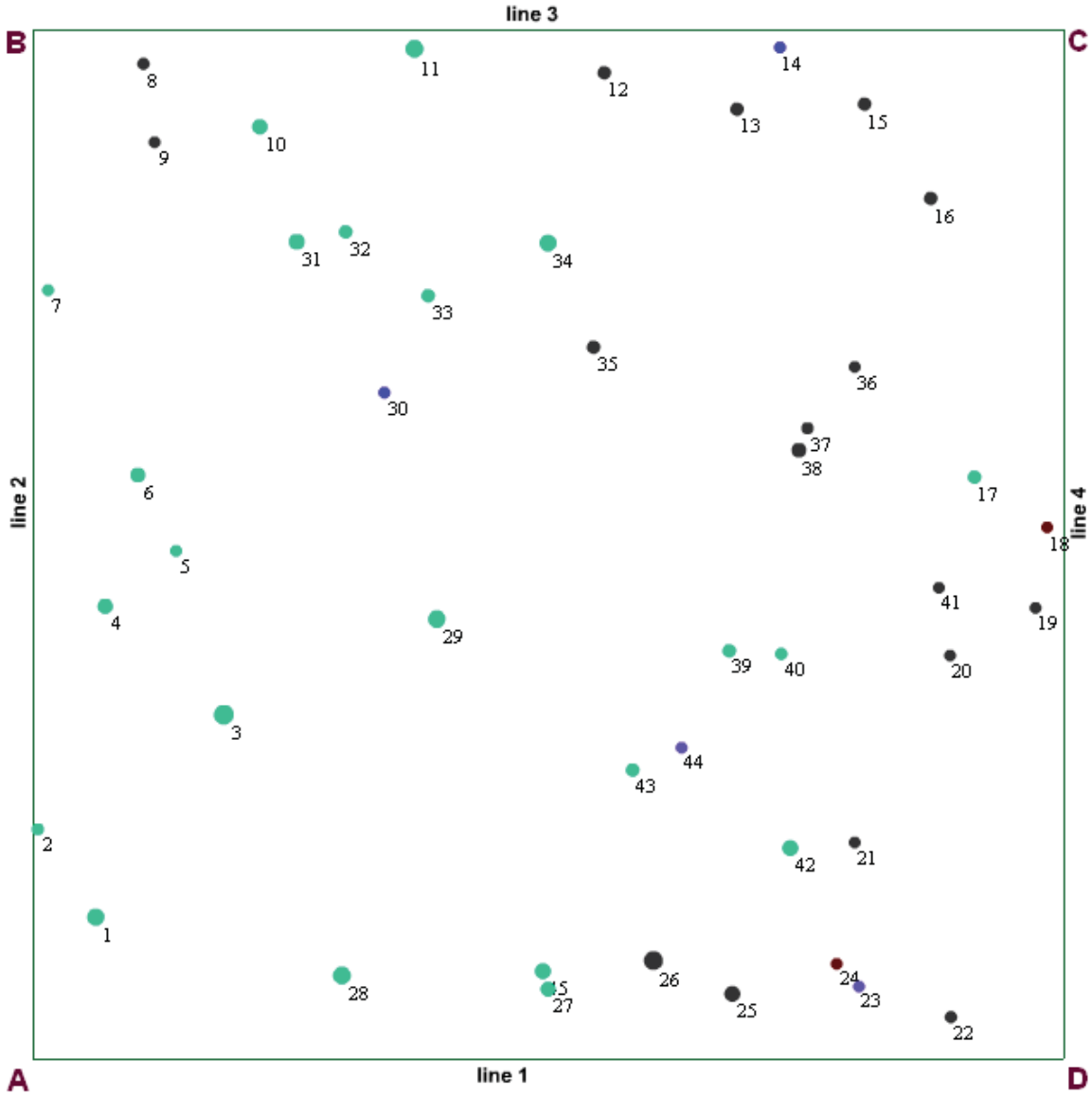


Figure 102: Soil temperature in the Nopiming North 1920 Jack Pine stand

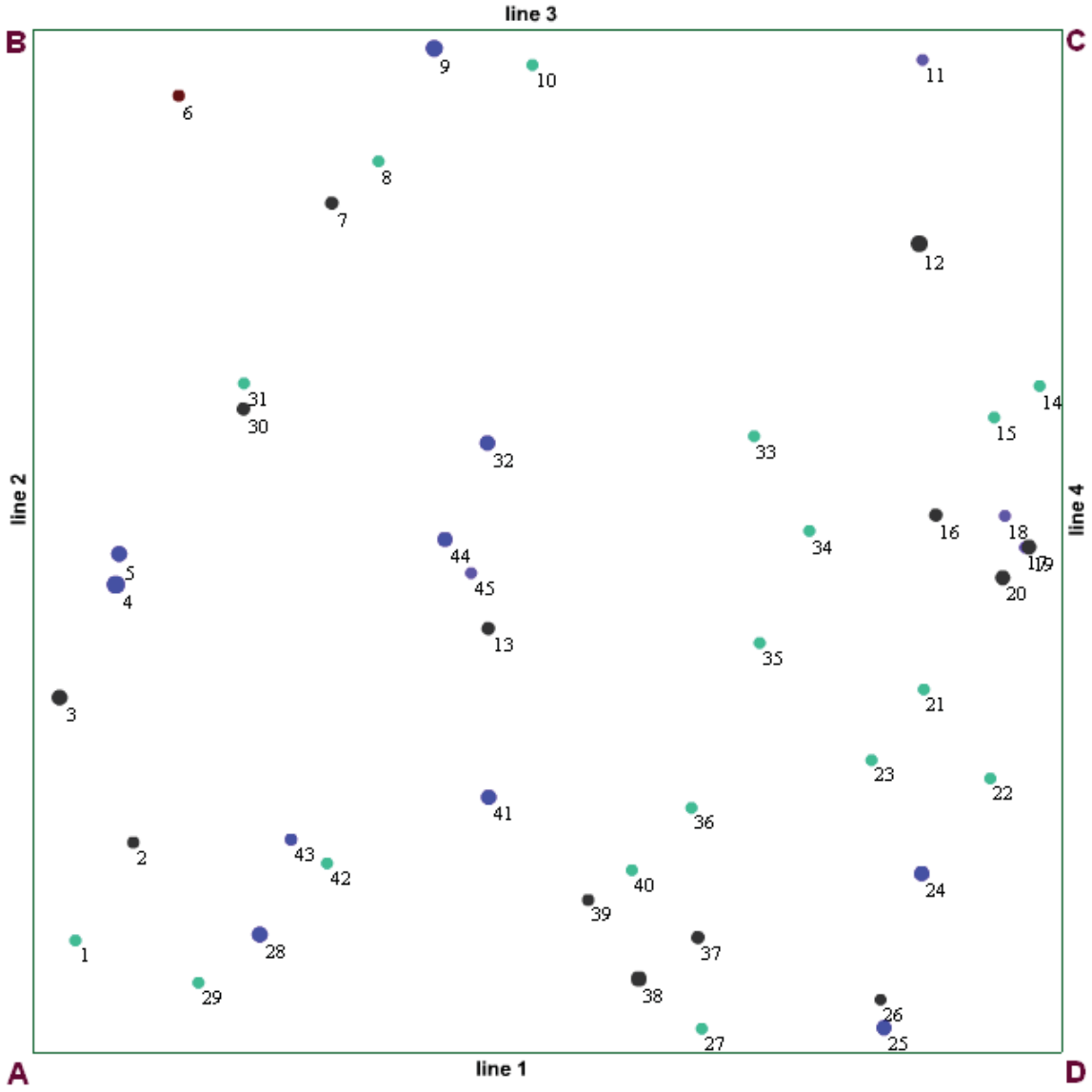
Appendix:

Appendix I: Maps of the 5 plots in each stand

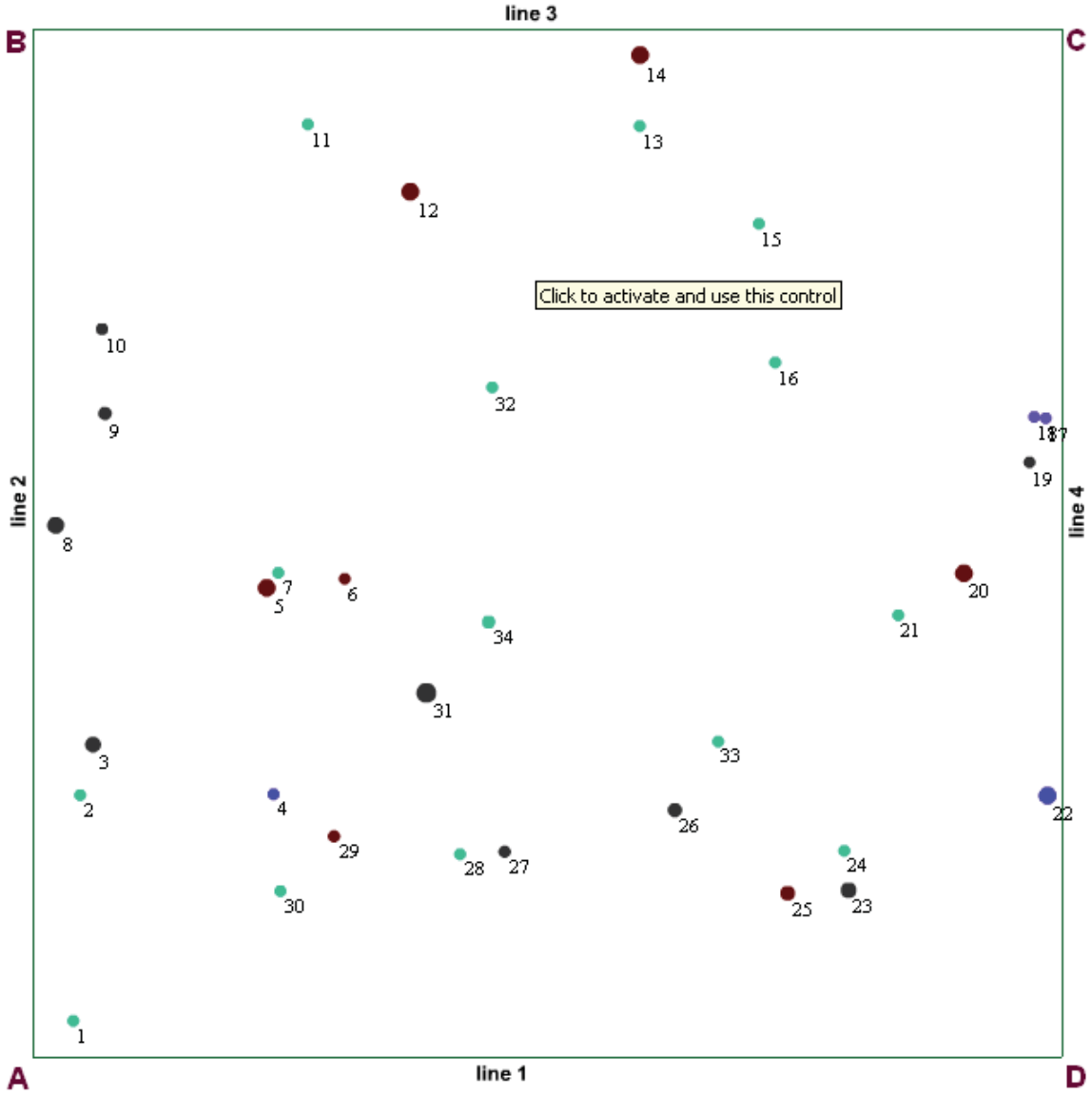
Hollow Water 1912 Jack Pine Plot 1



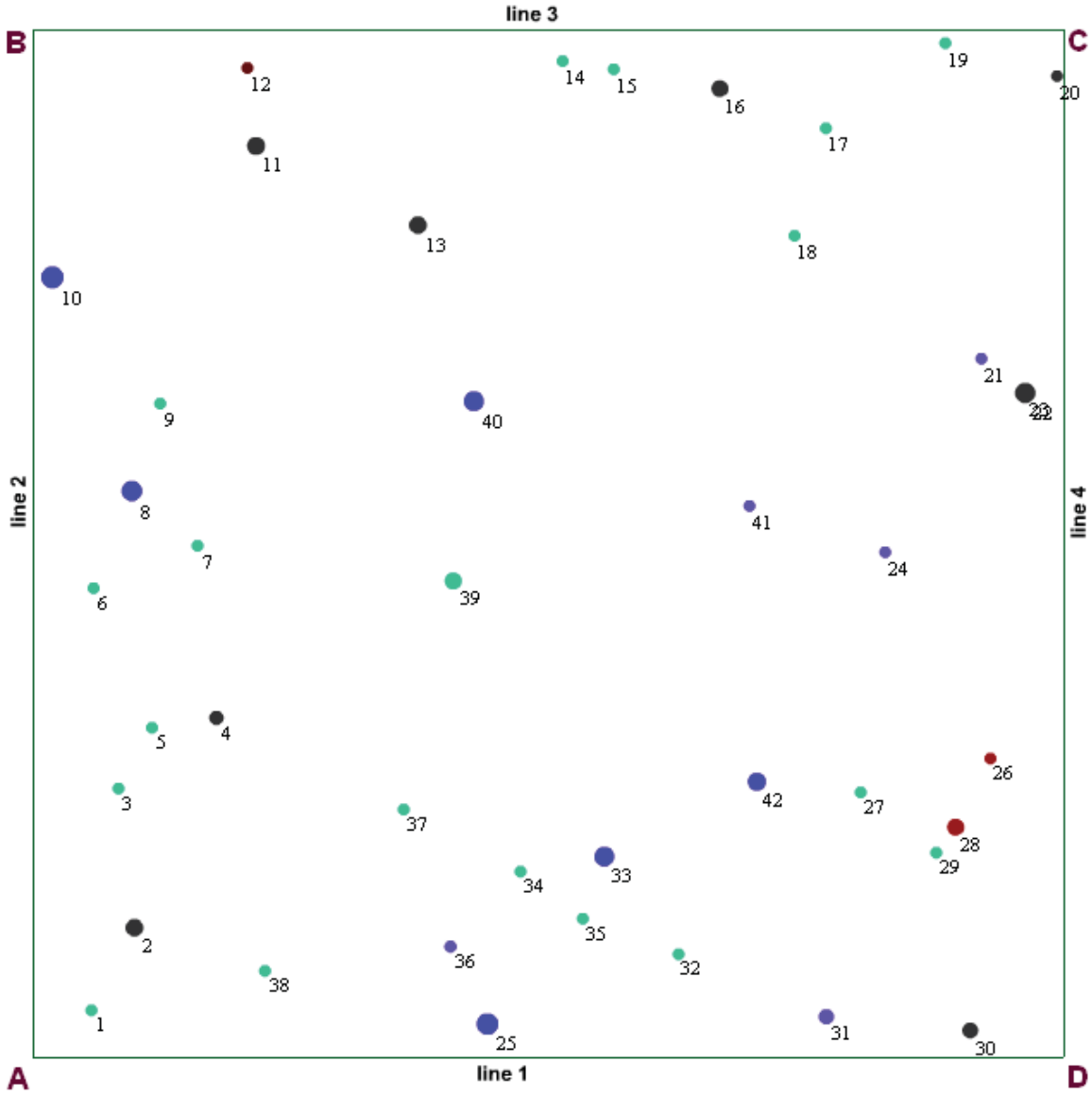
Hollow Water 1912 Jack Pine Plot 2



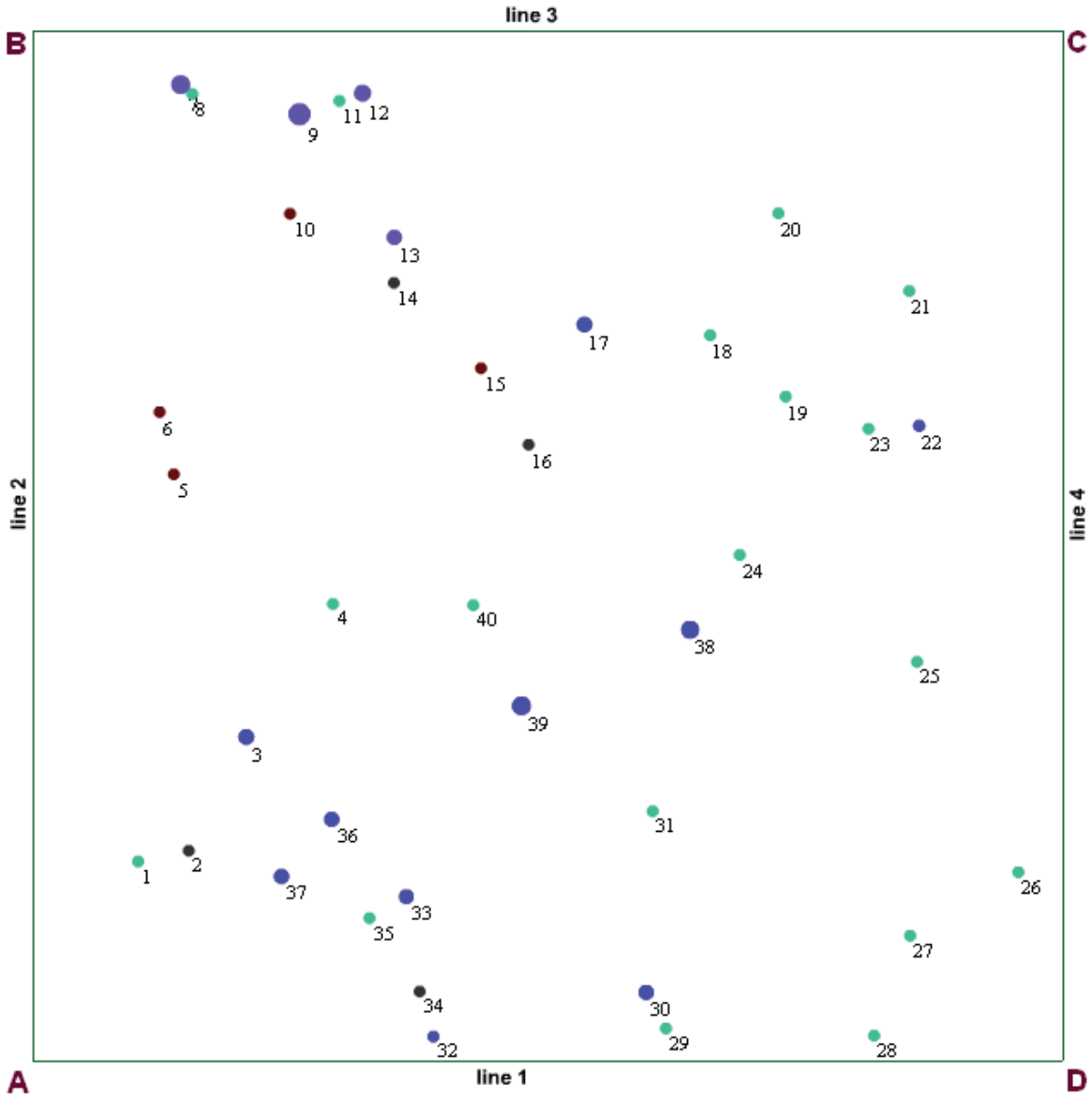
Hollow Water 1912 Jack Pine Plot 3



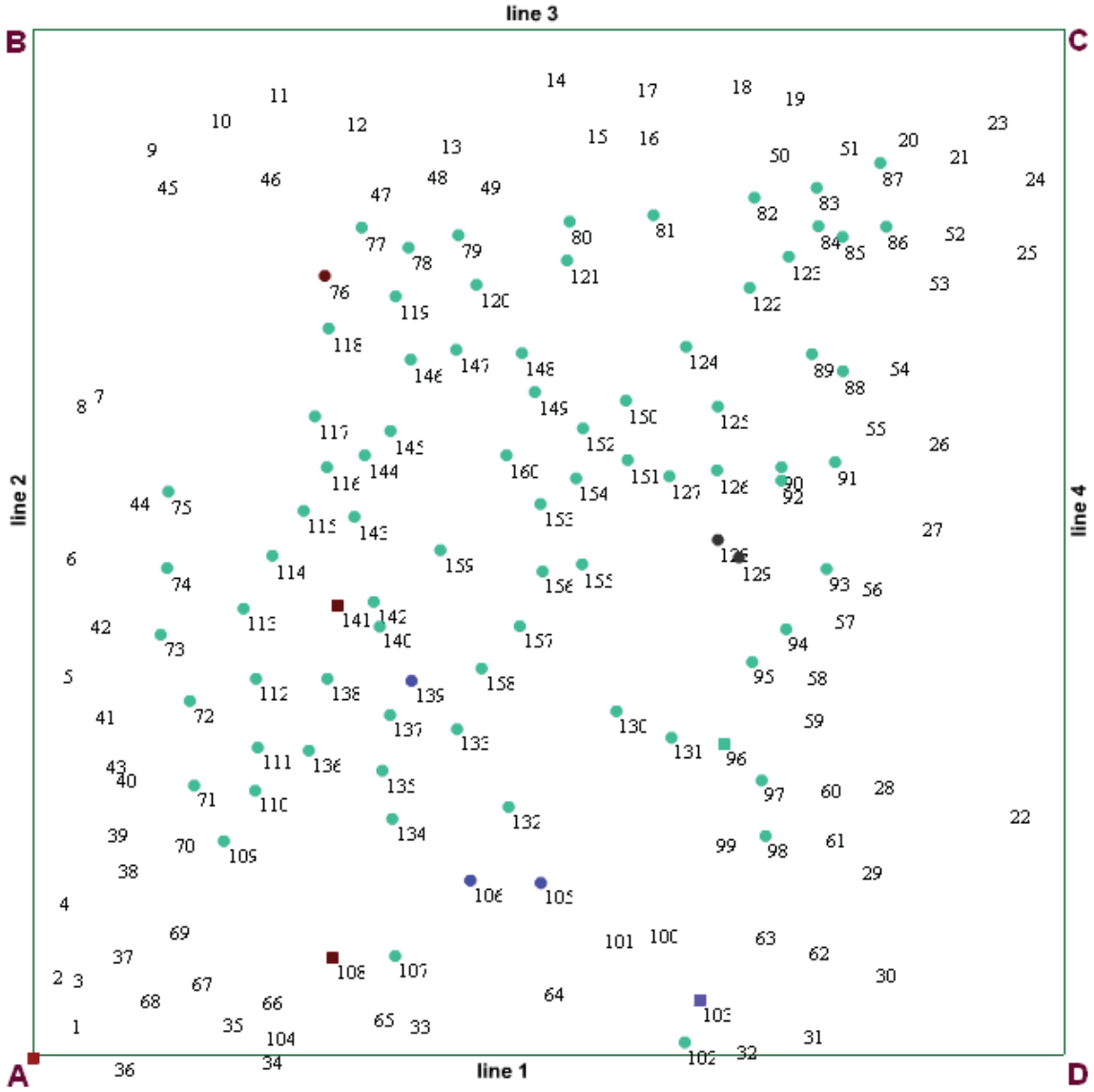
Hollow Water 1912 Jack Pine Plot 4



Hollow Water 1912 Jack Pine Plot 5



Hollow Water 1983 Jack Pine Plot 1



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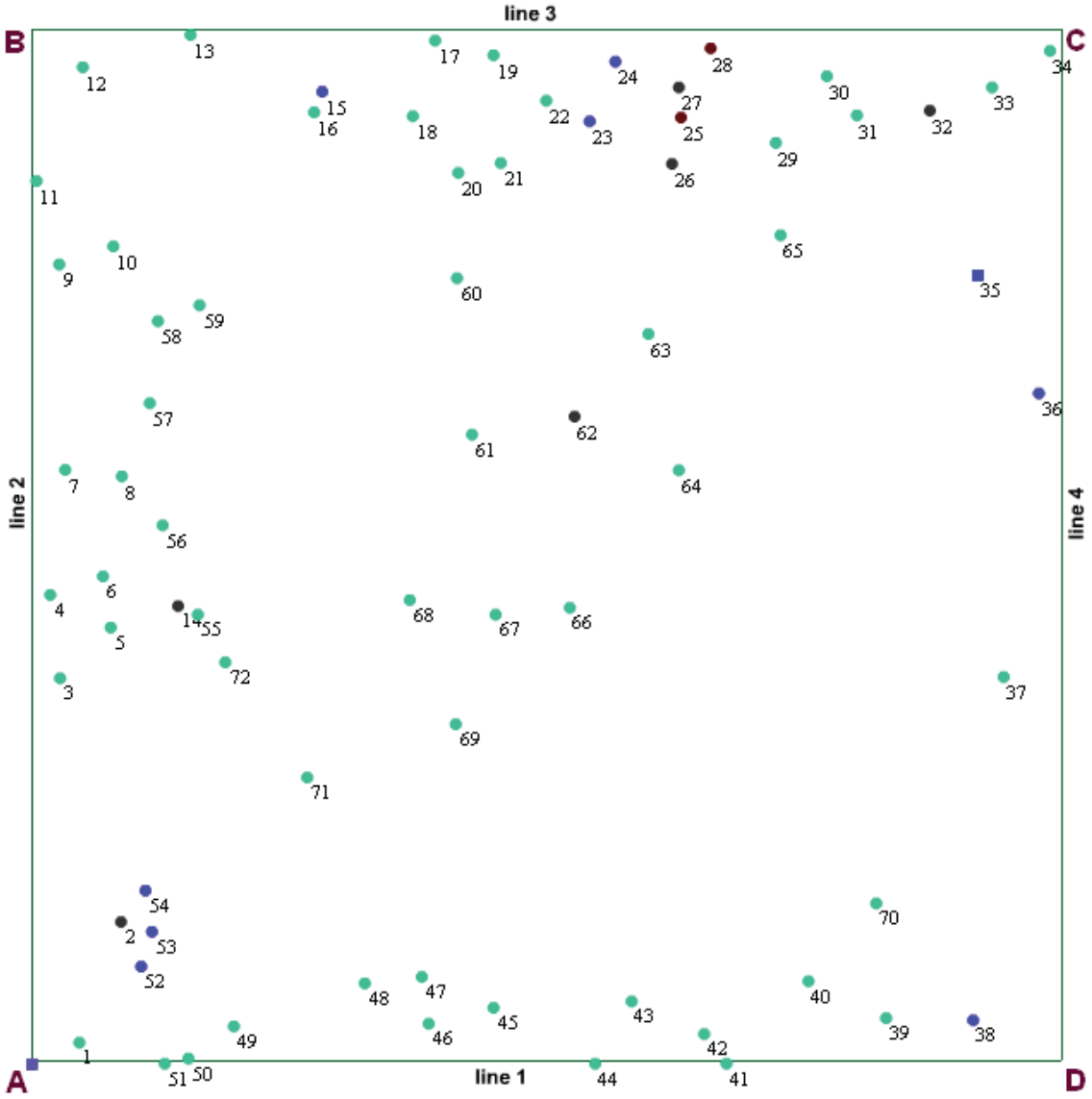

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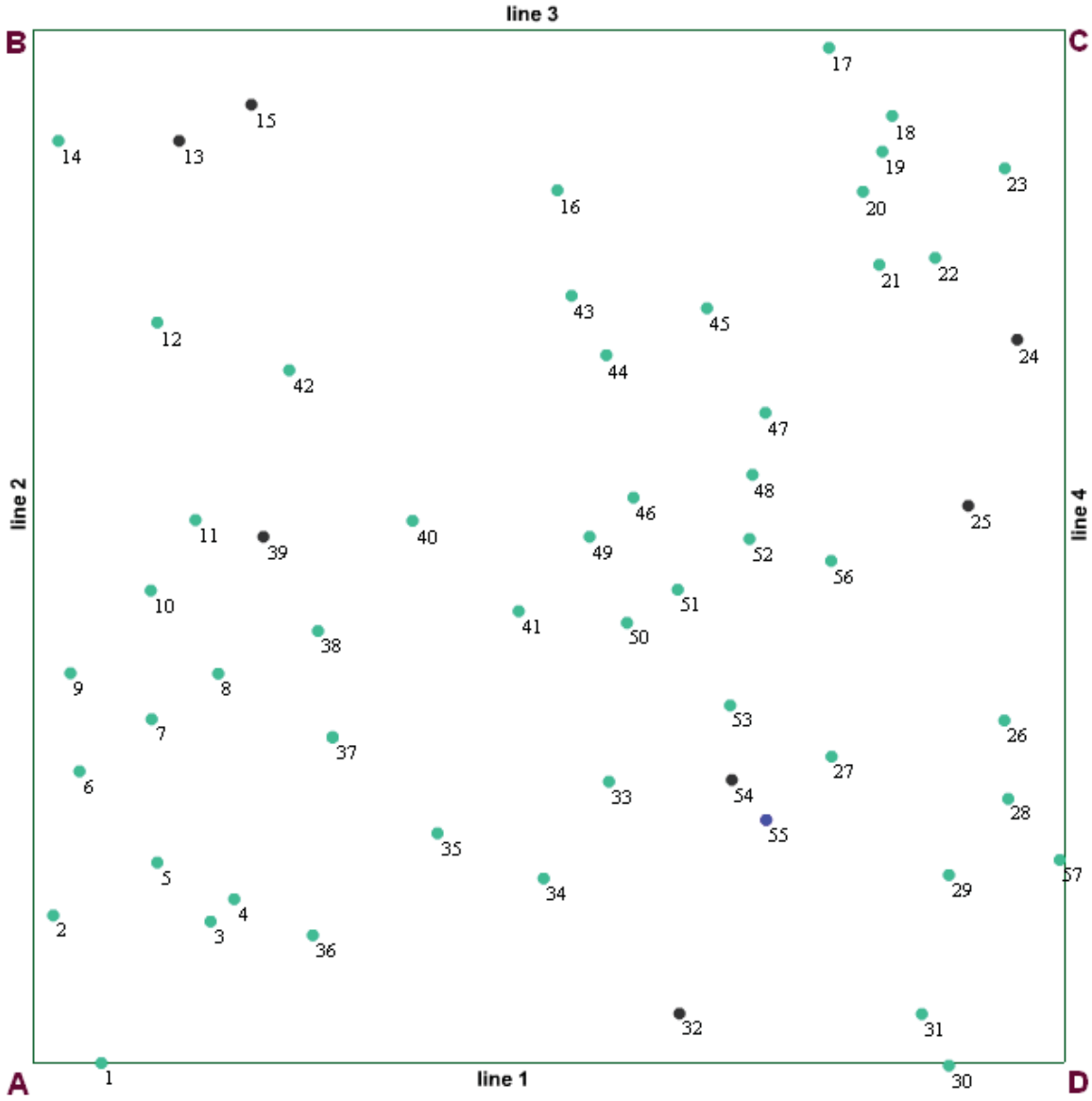
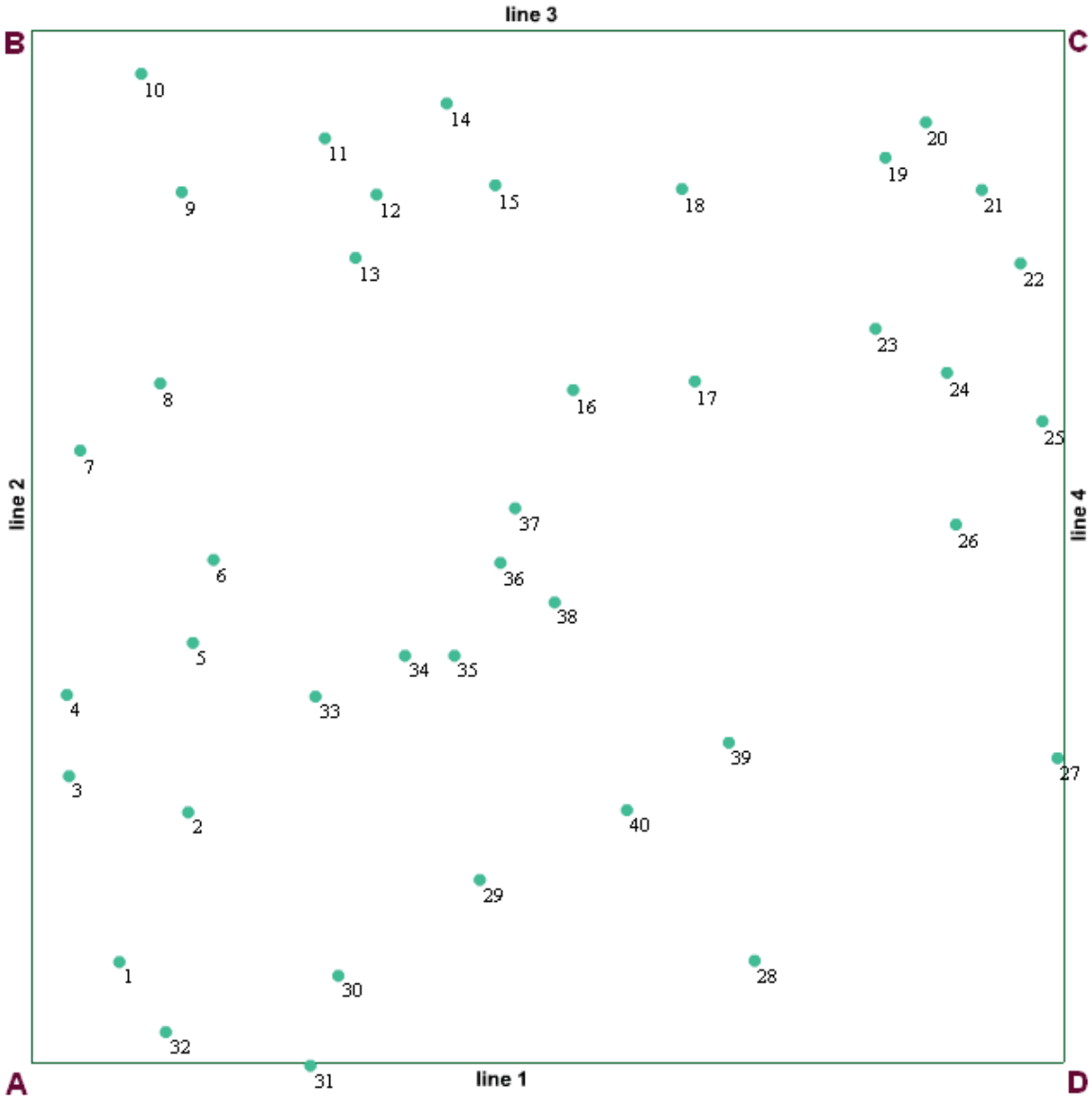


Hollow Water 1983 Jack Pine Plot 4



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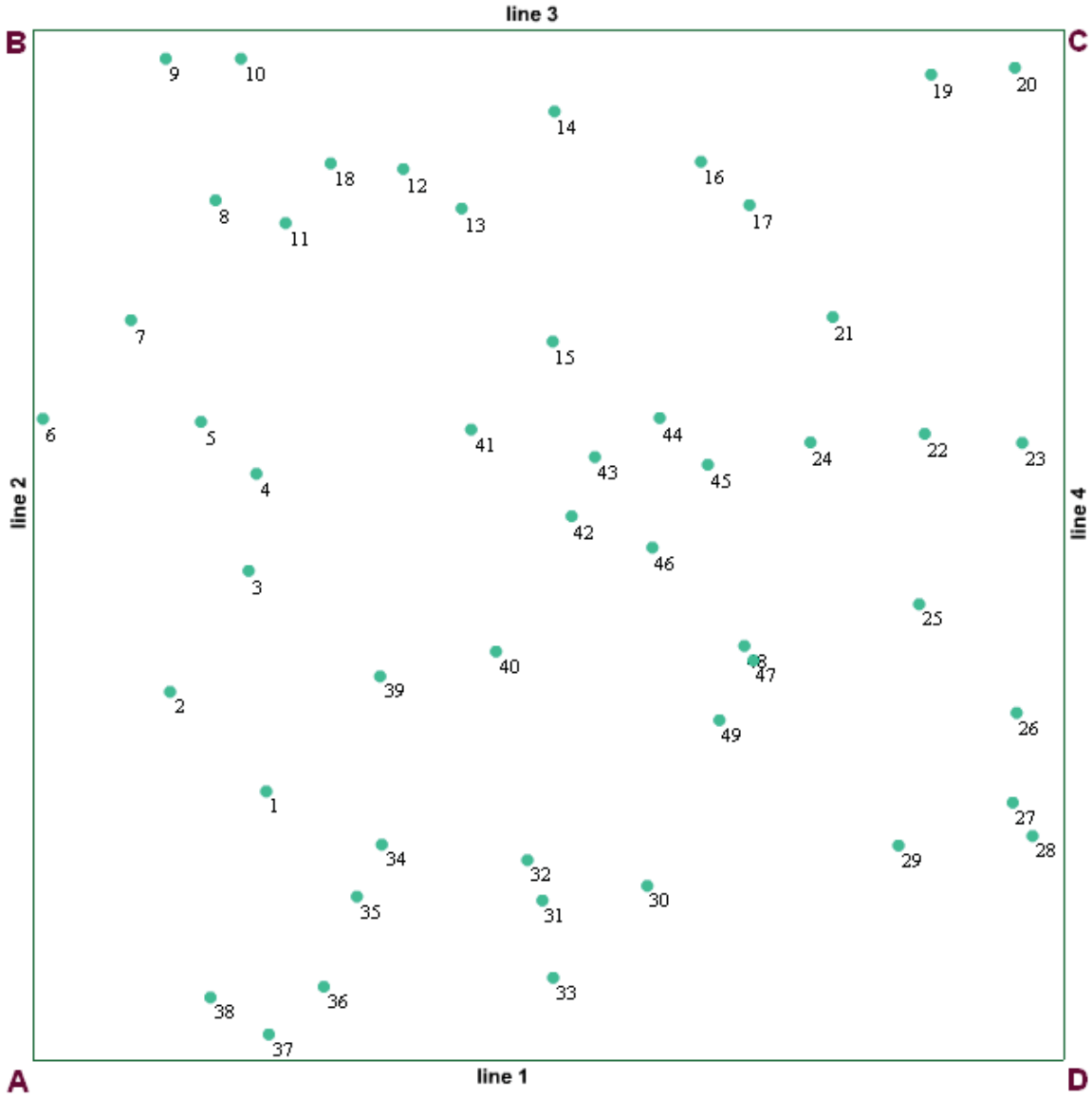
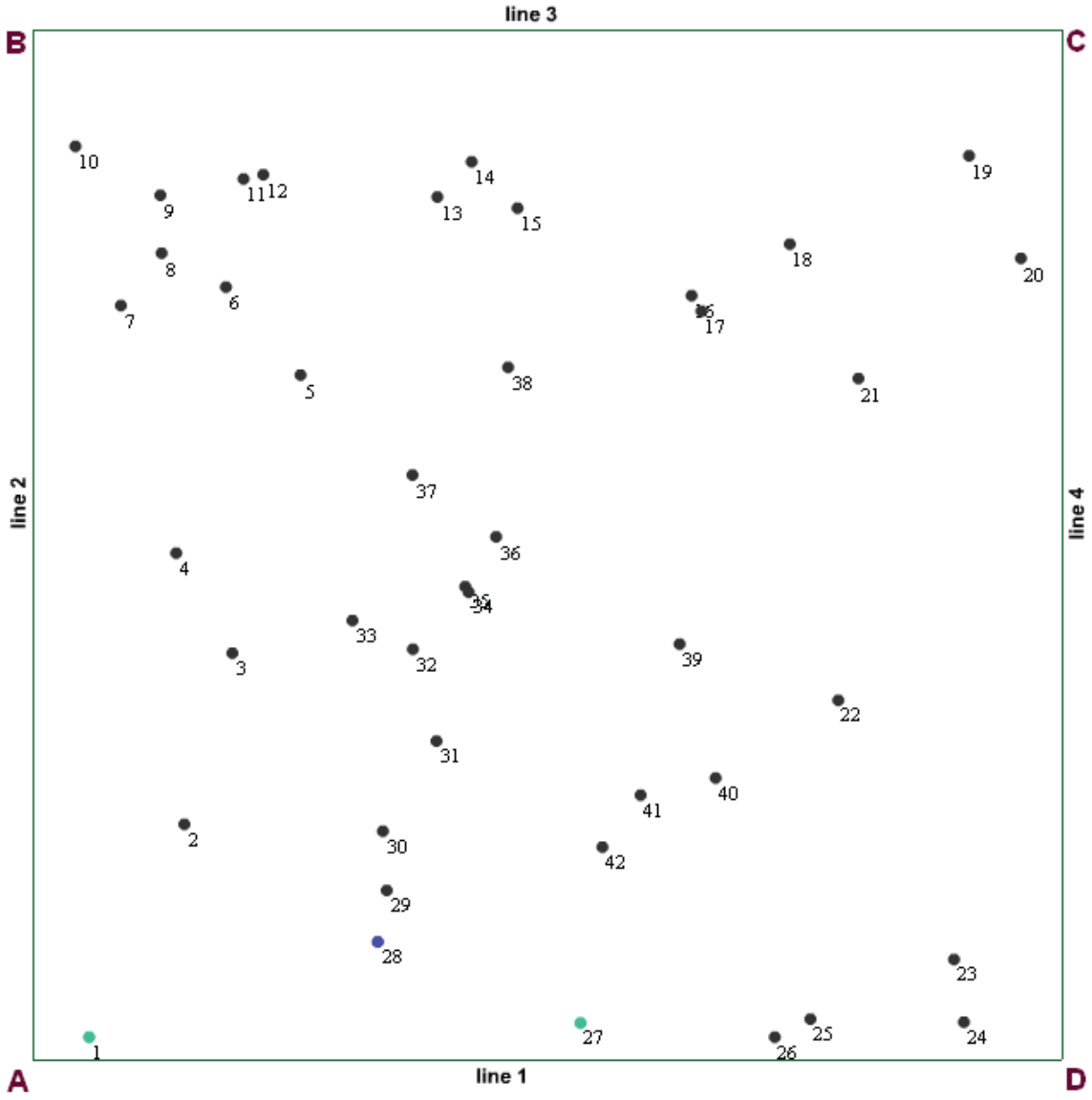


Hollow Water 1992 Jack Pine Plot 1



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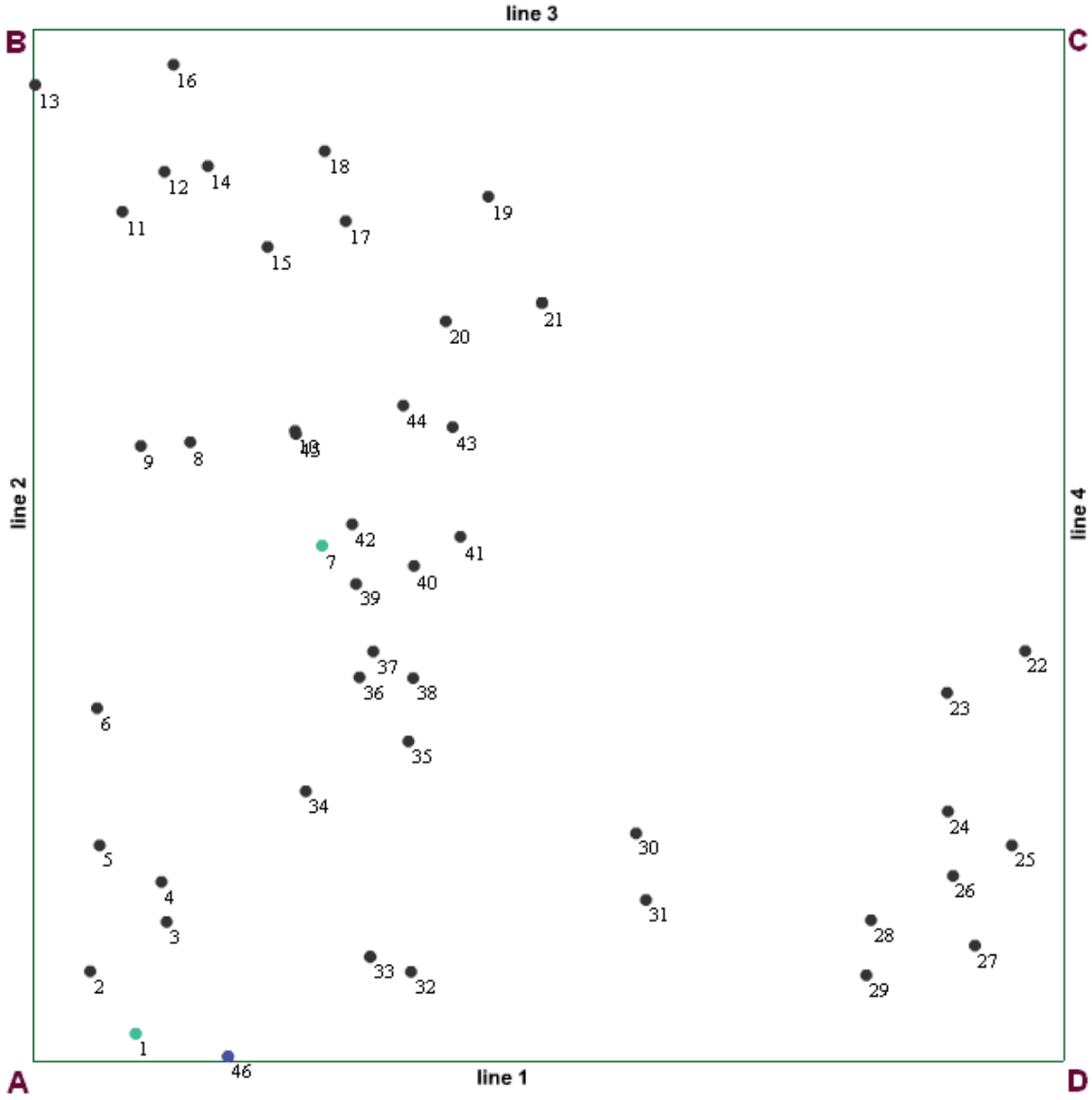
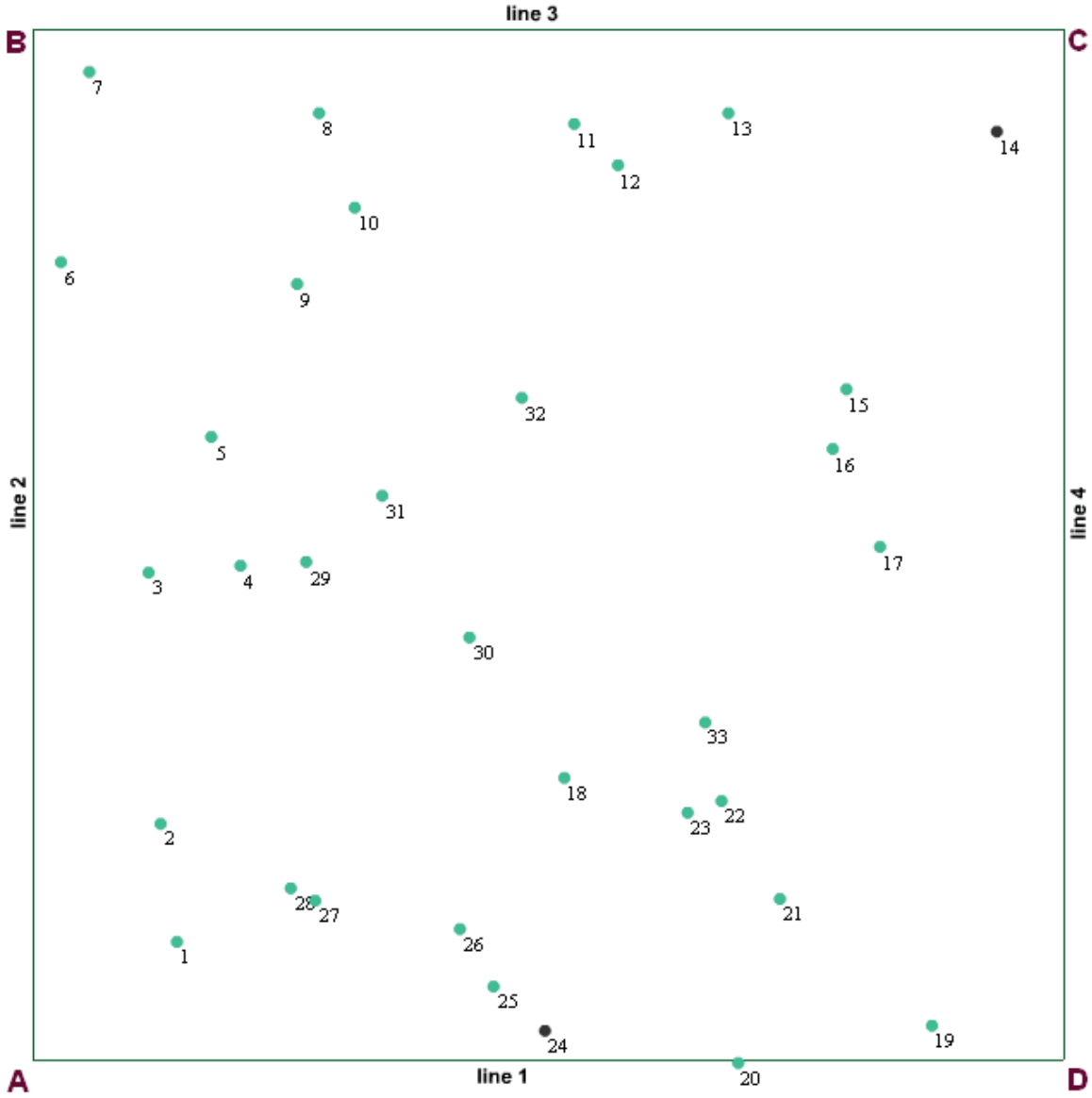
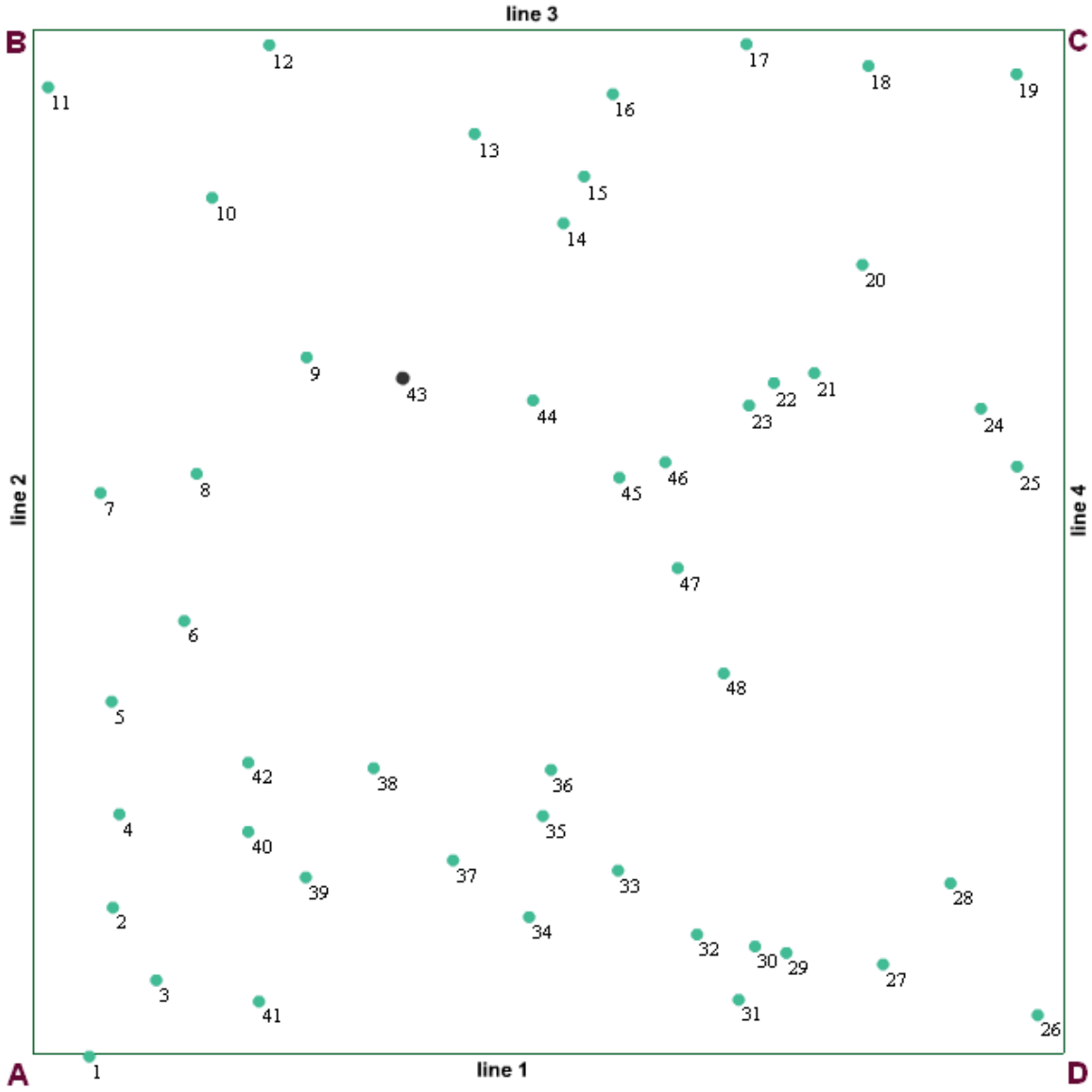


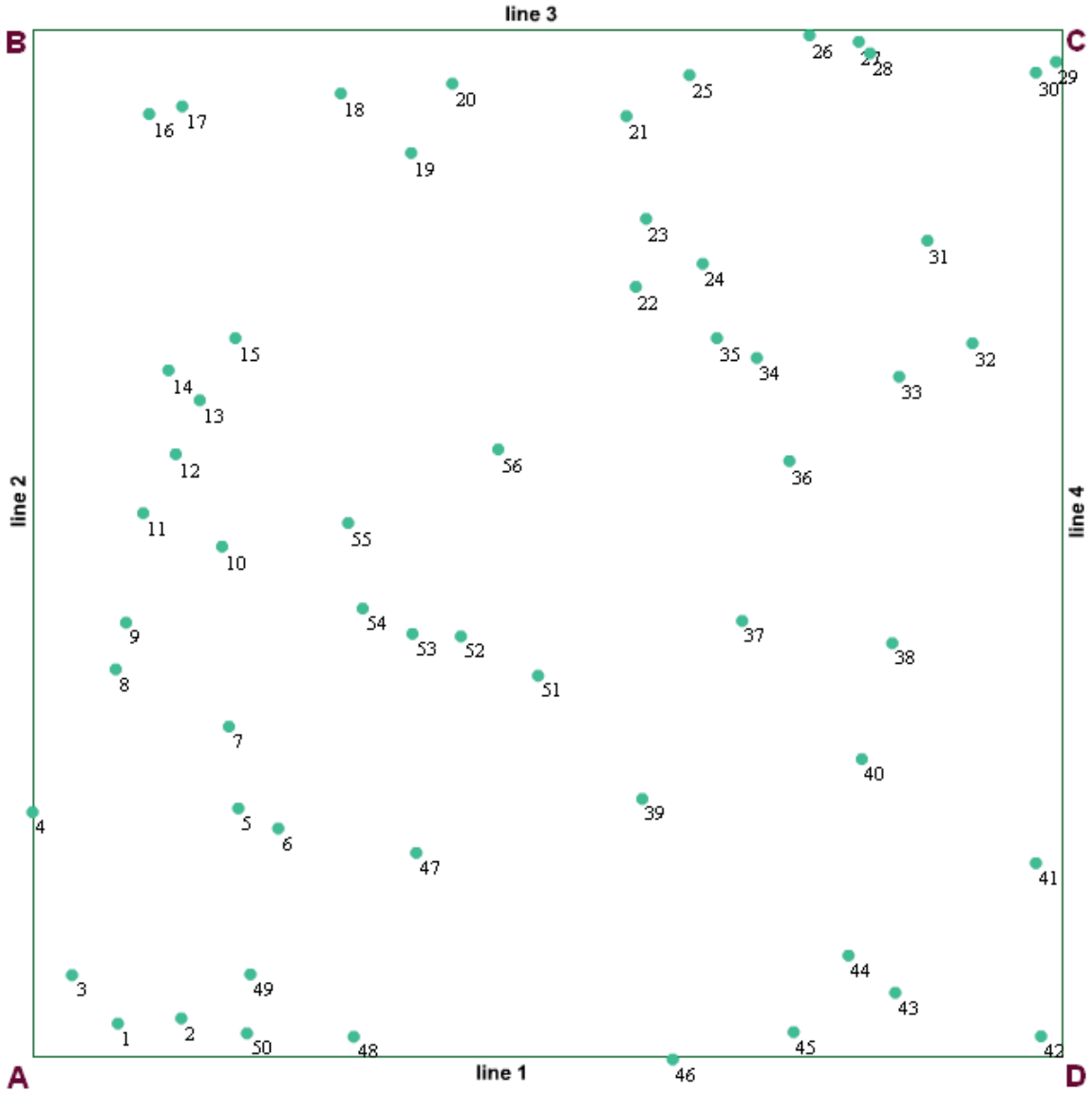
Hollow Water 1992 Jack Pine Plot 3



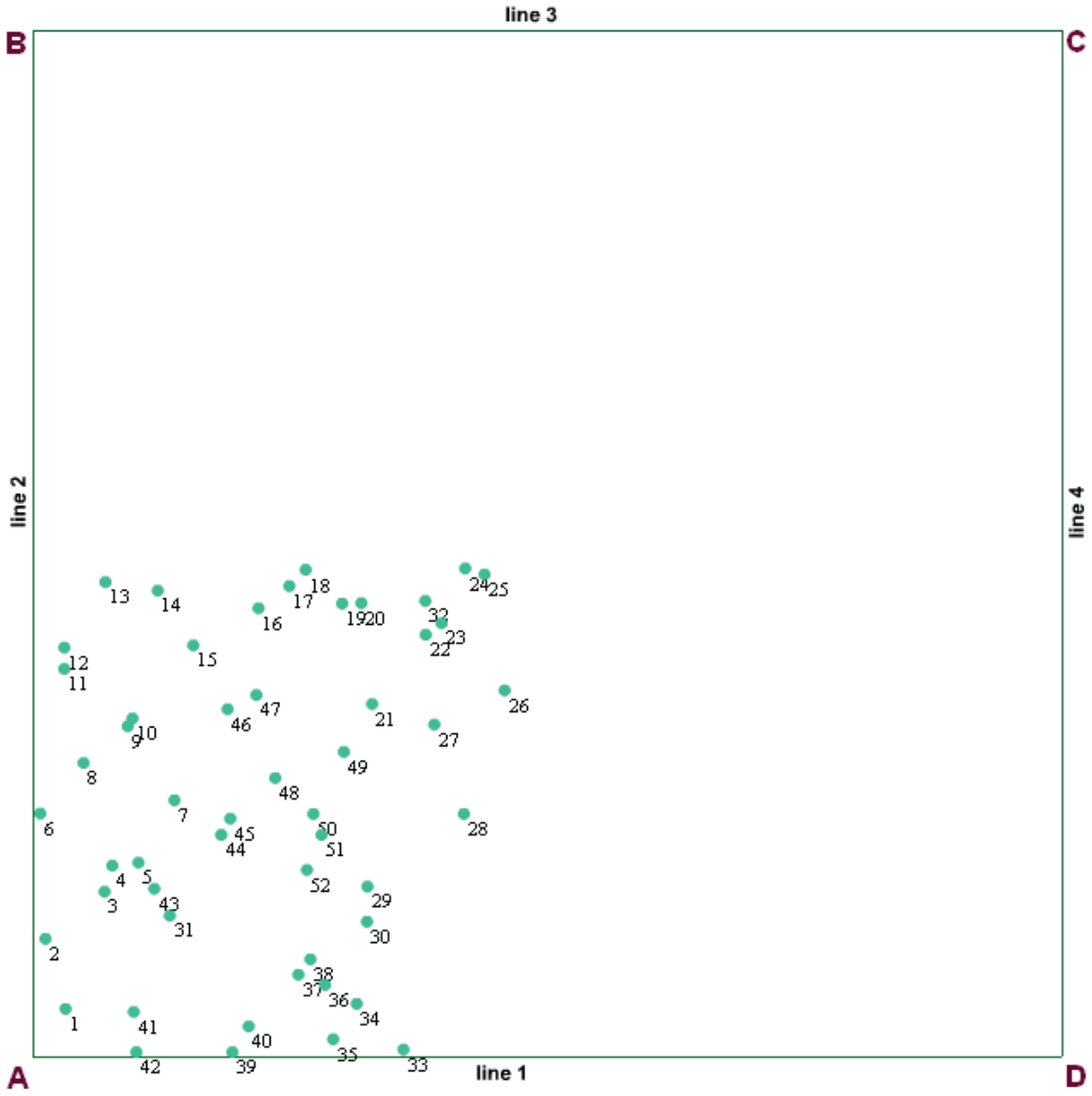
Hollow Water 1992 Jack Pine Plot 4



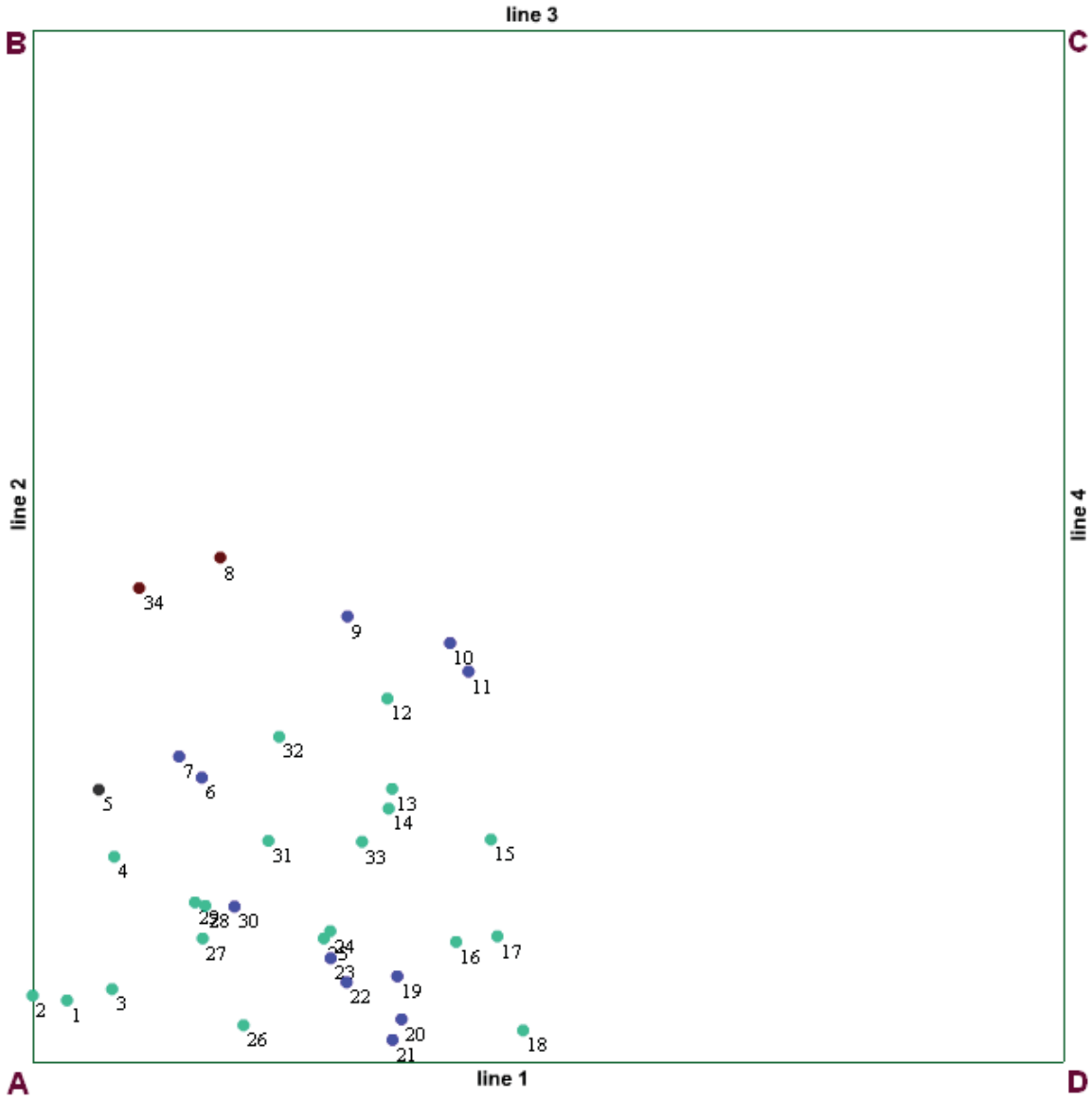
Hollow Water 1992 Jack Pine Plot 5



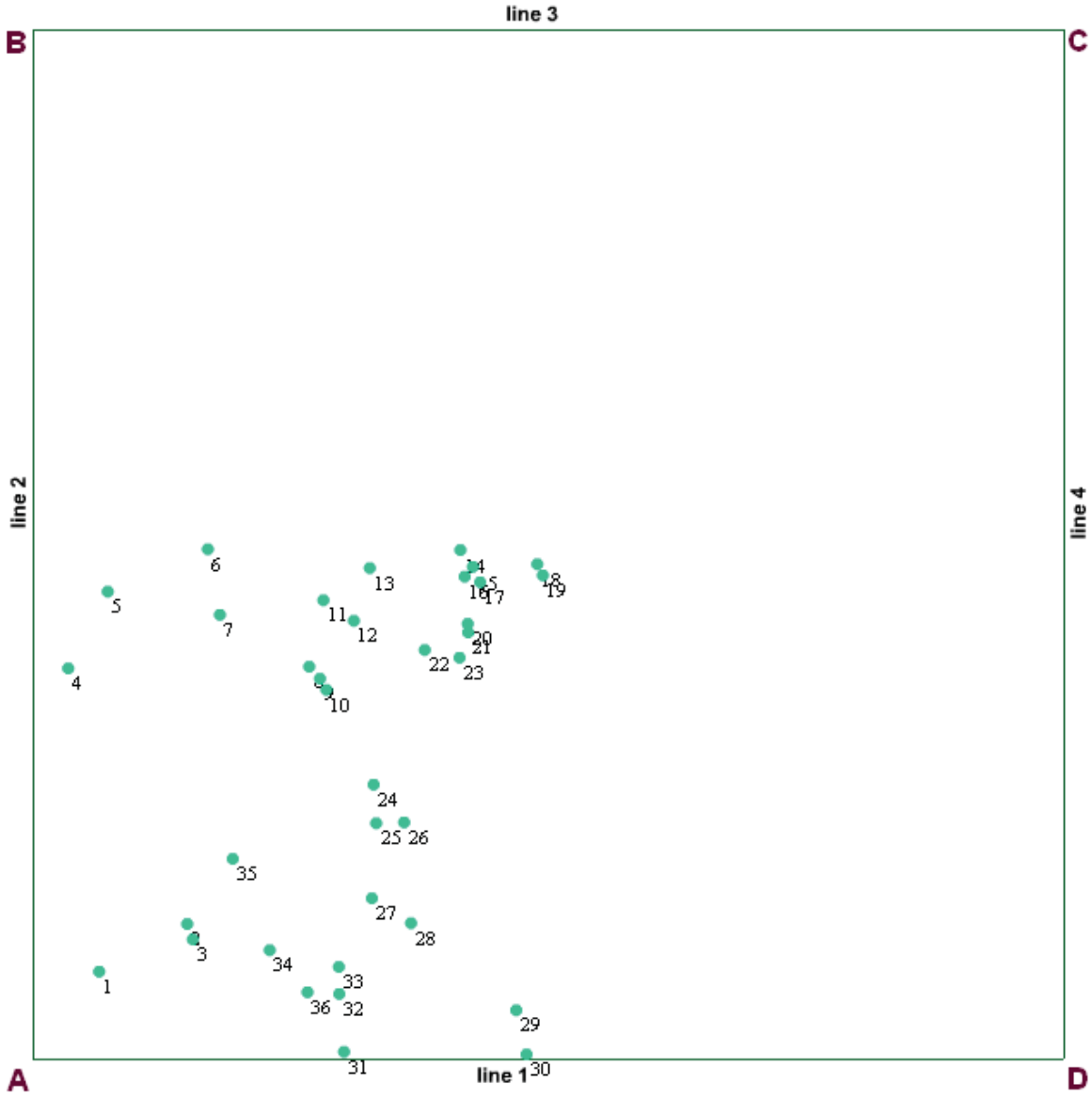
Hollow Water 2000 Jack Pine Plot 1



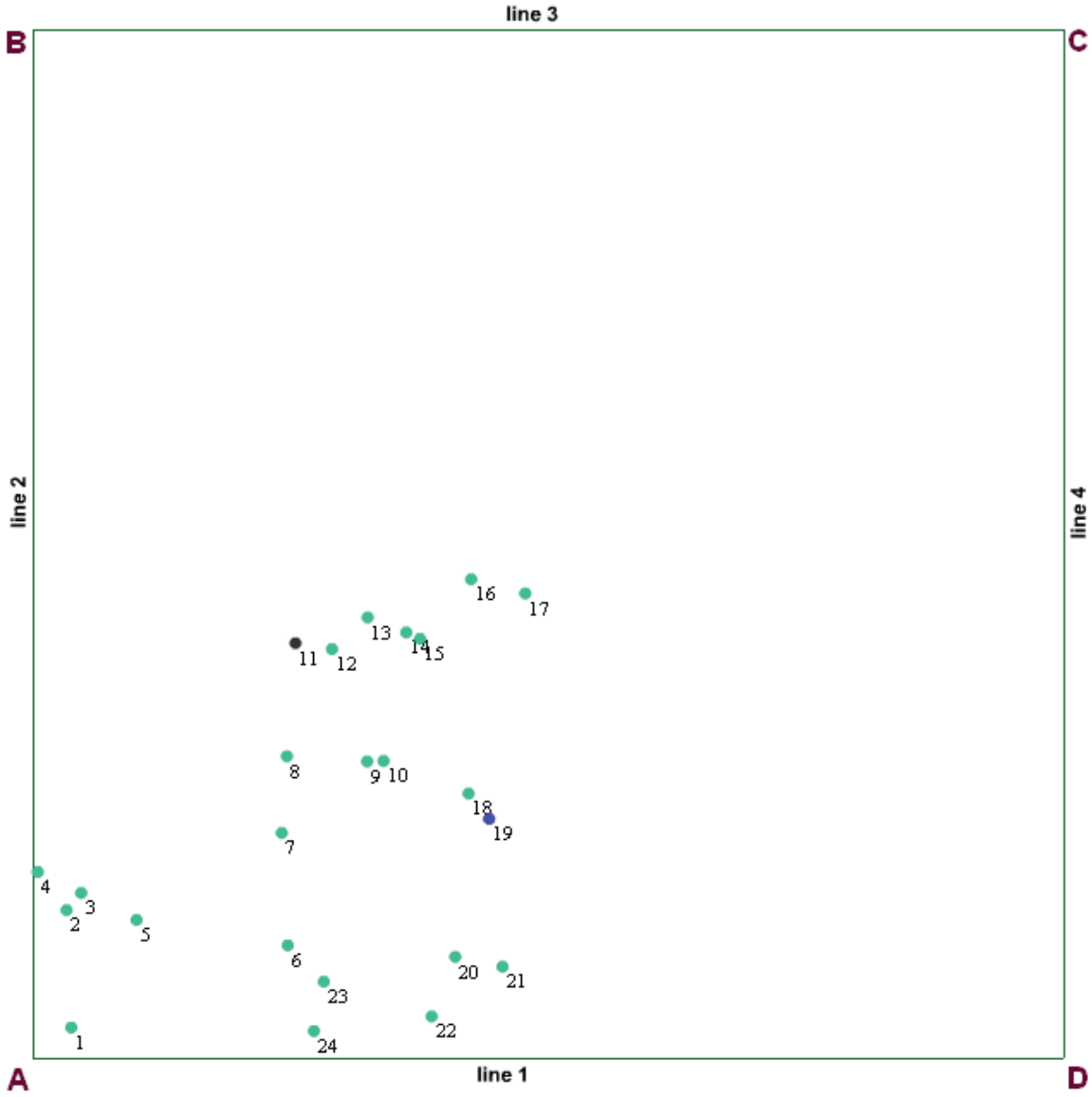
Hollow Water 2000 Jack Pine Plot 2



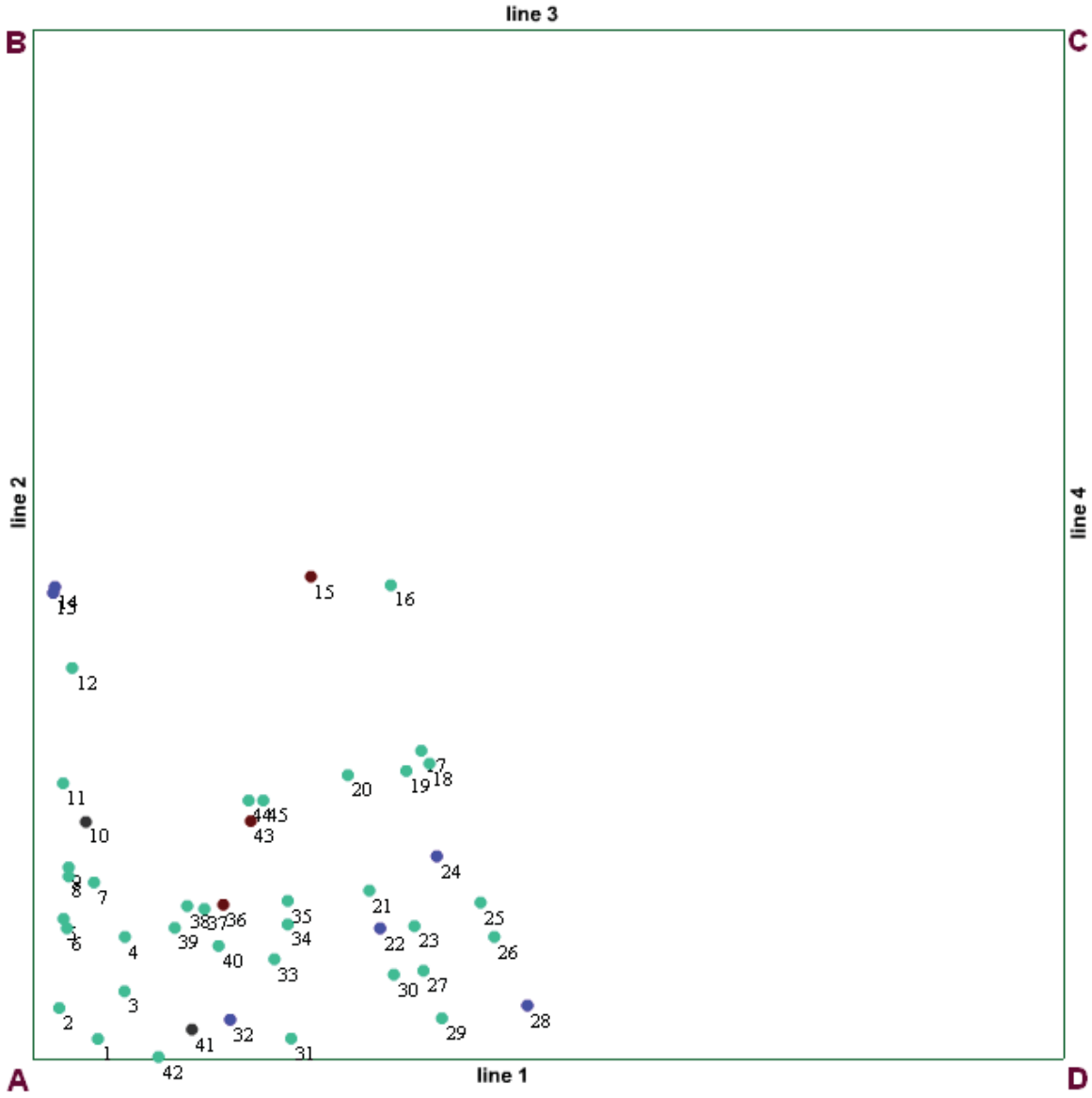
Hollow Water 2000 Jack Pine Plot 3



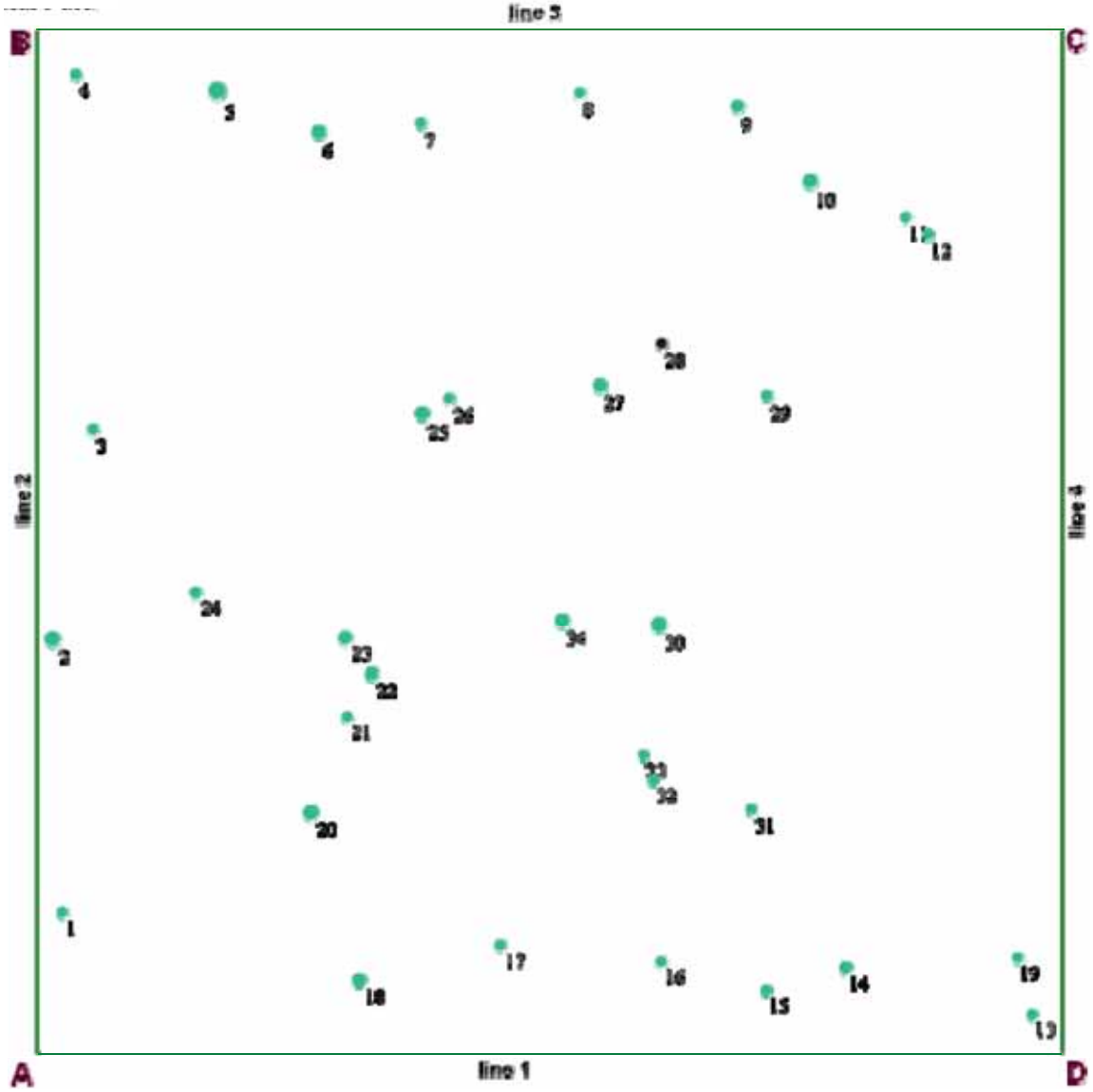
Hollow Water 2000 Jack Pine Plot 4



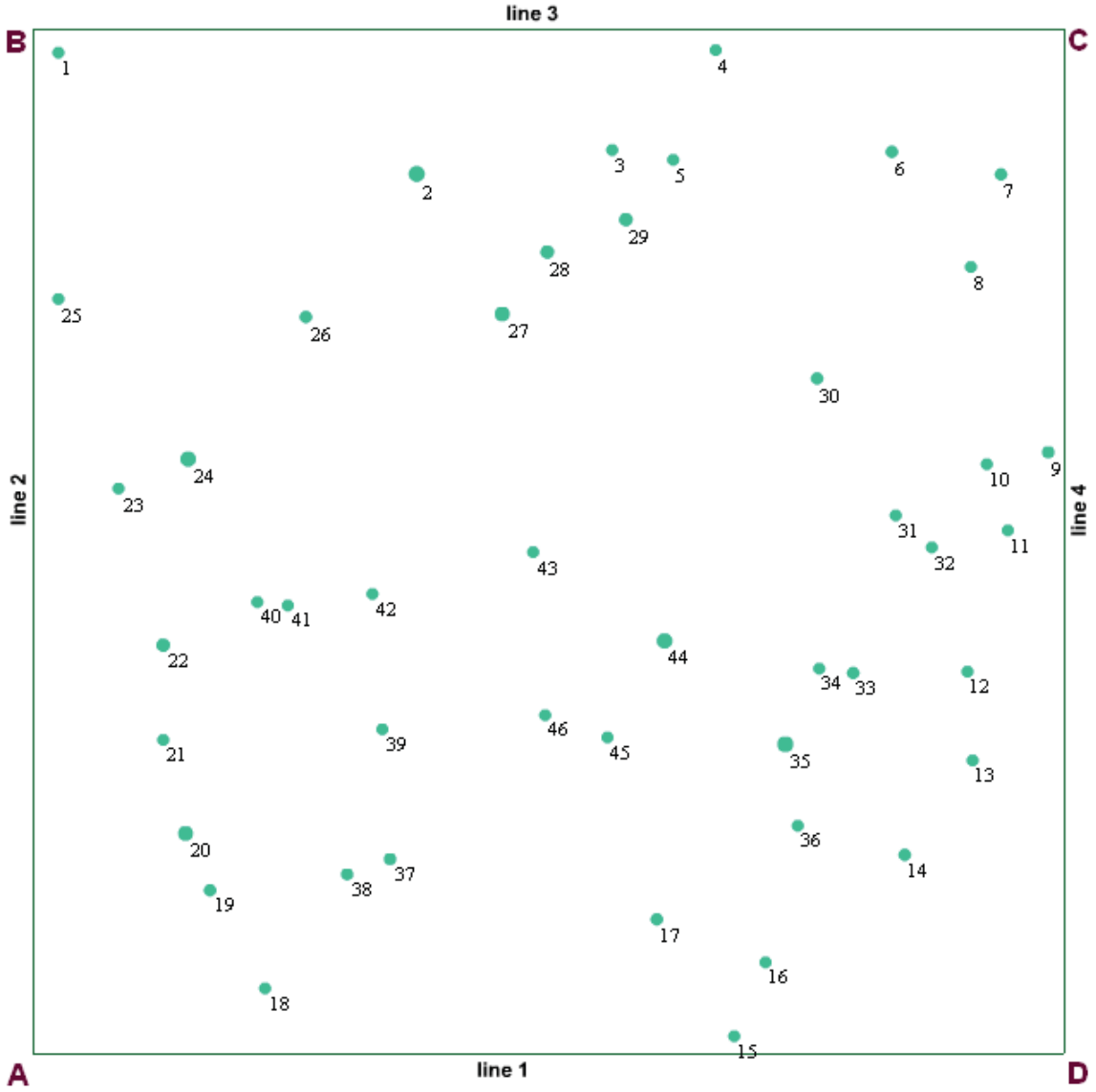
Hollow Water 2000 Jack Pine Plot 5



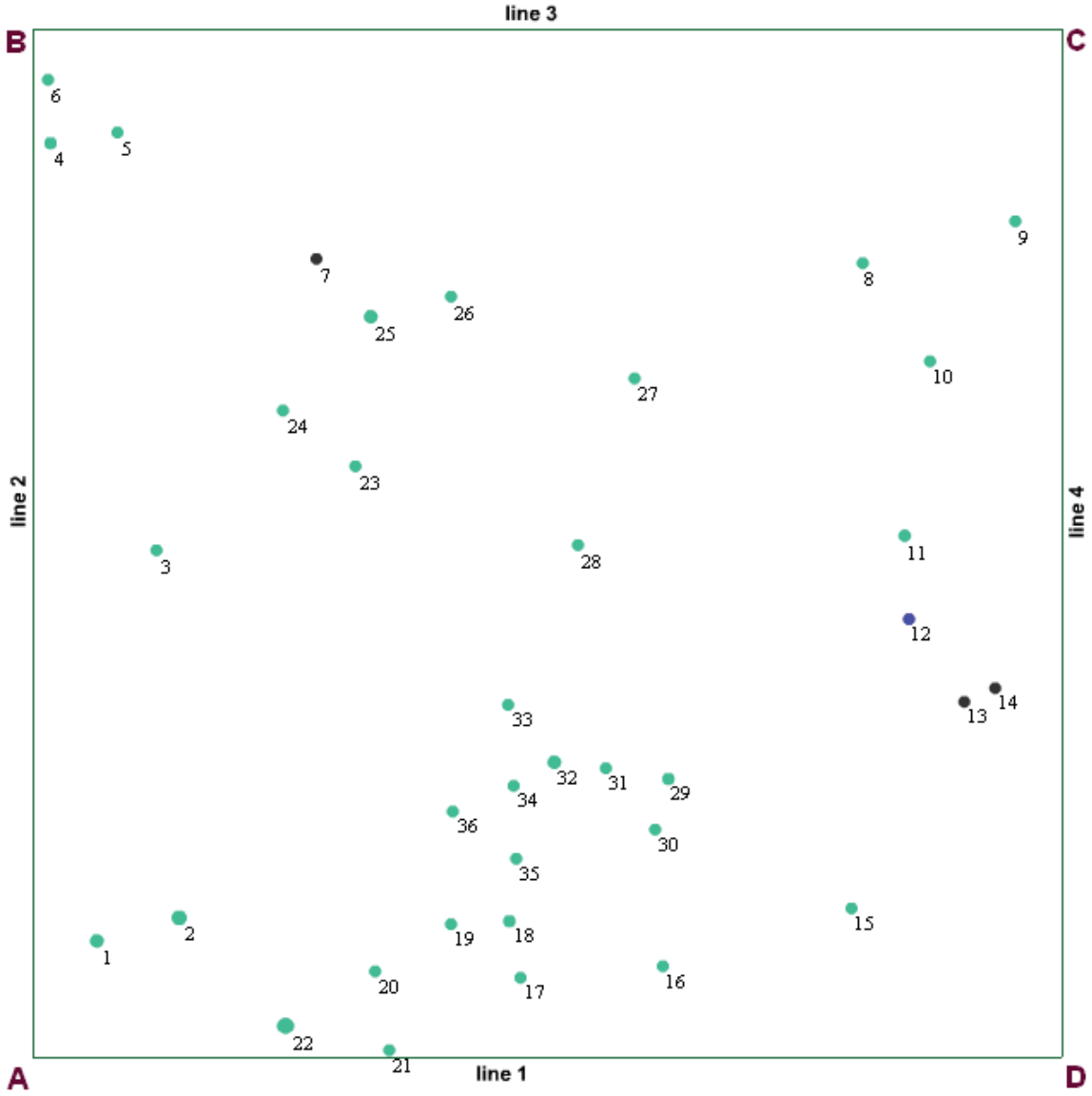
Nopiming North 1920 Jack Pine Plot 1



Nopiming North 1920 Jack Pine Plot 2



Nopiming North 1920 Jack Pine Plot 3



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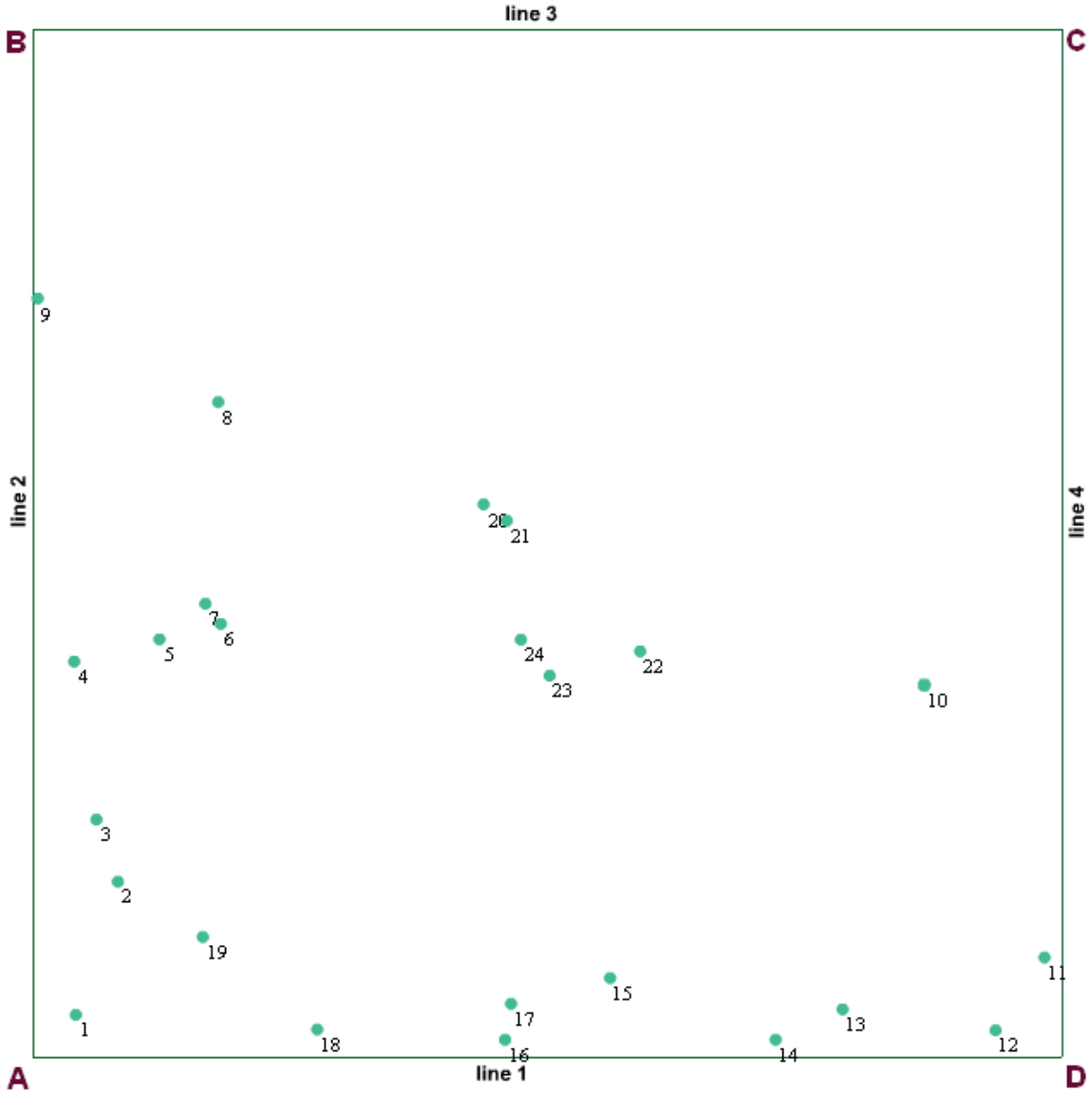
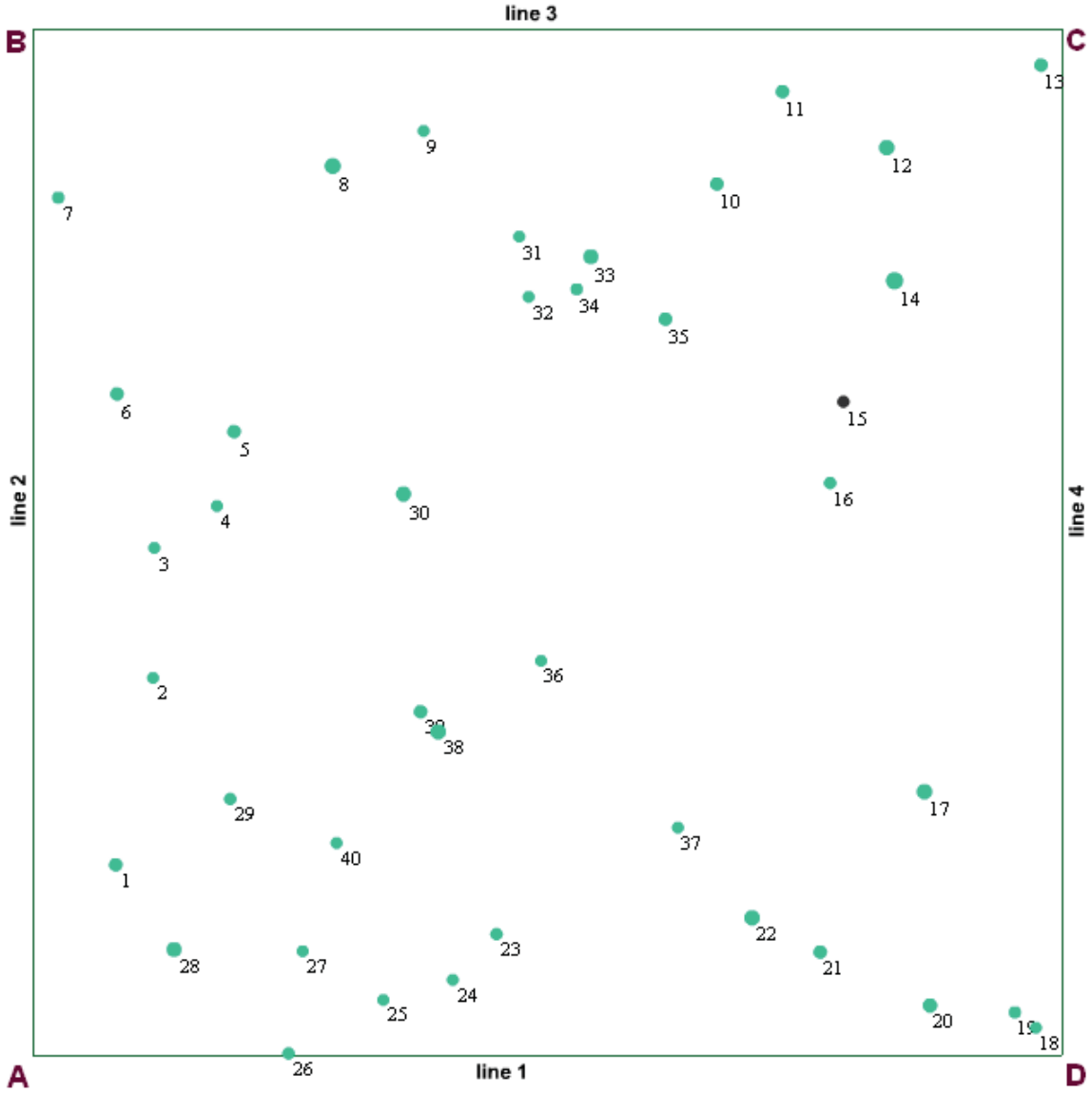
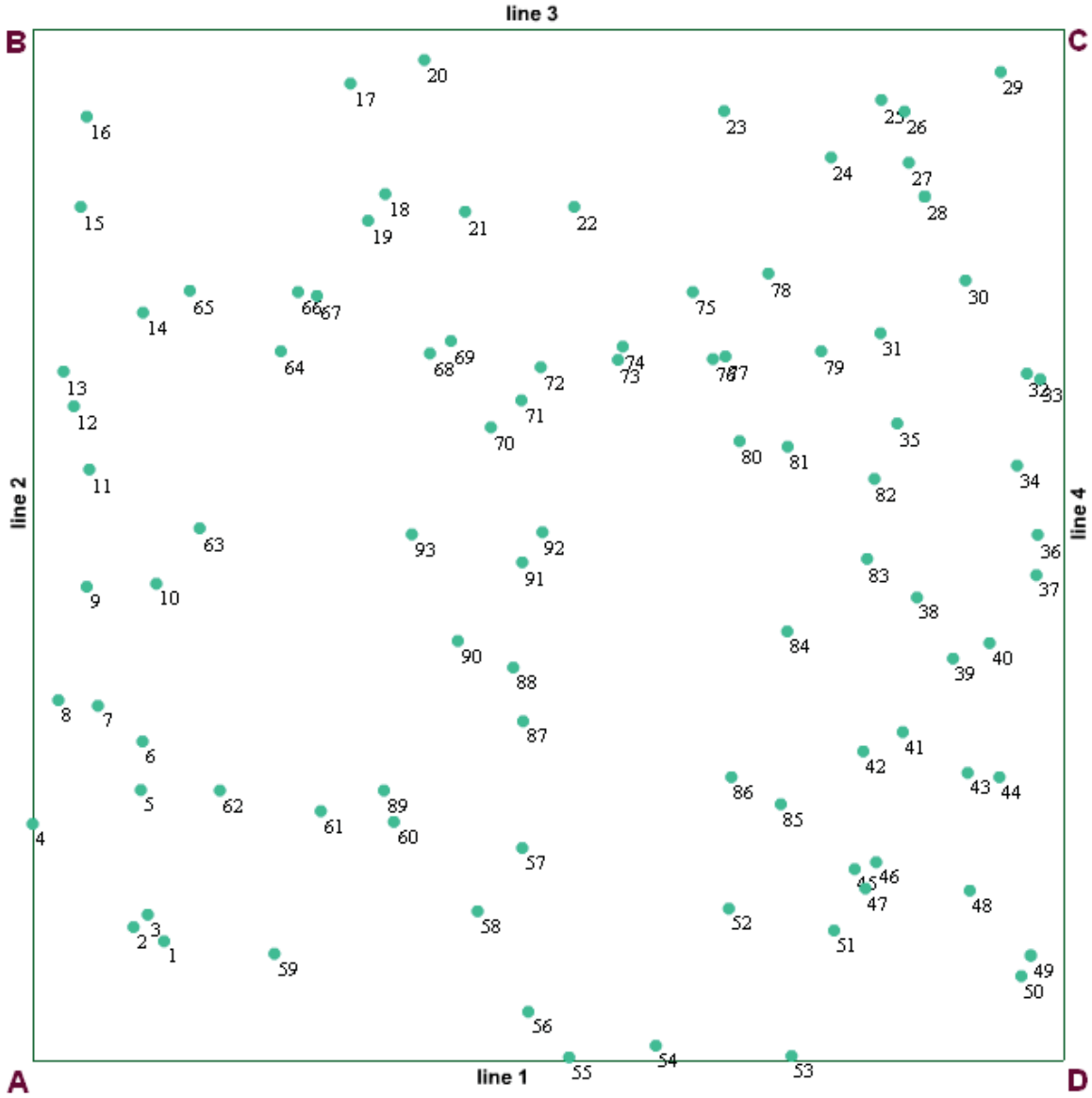


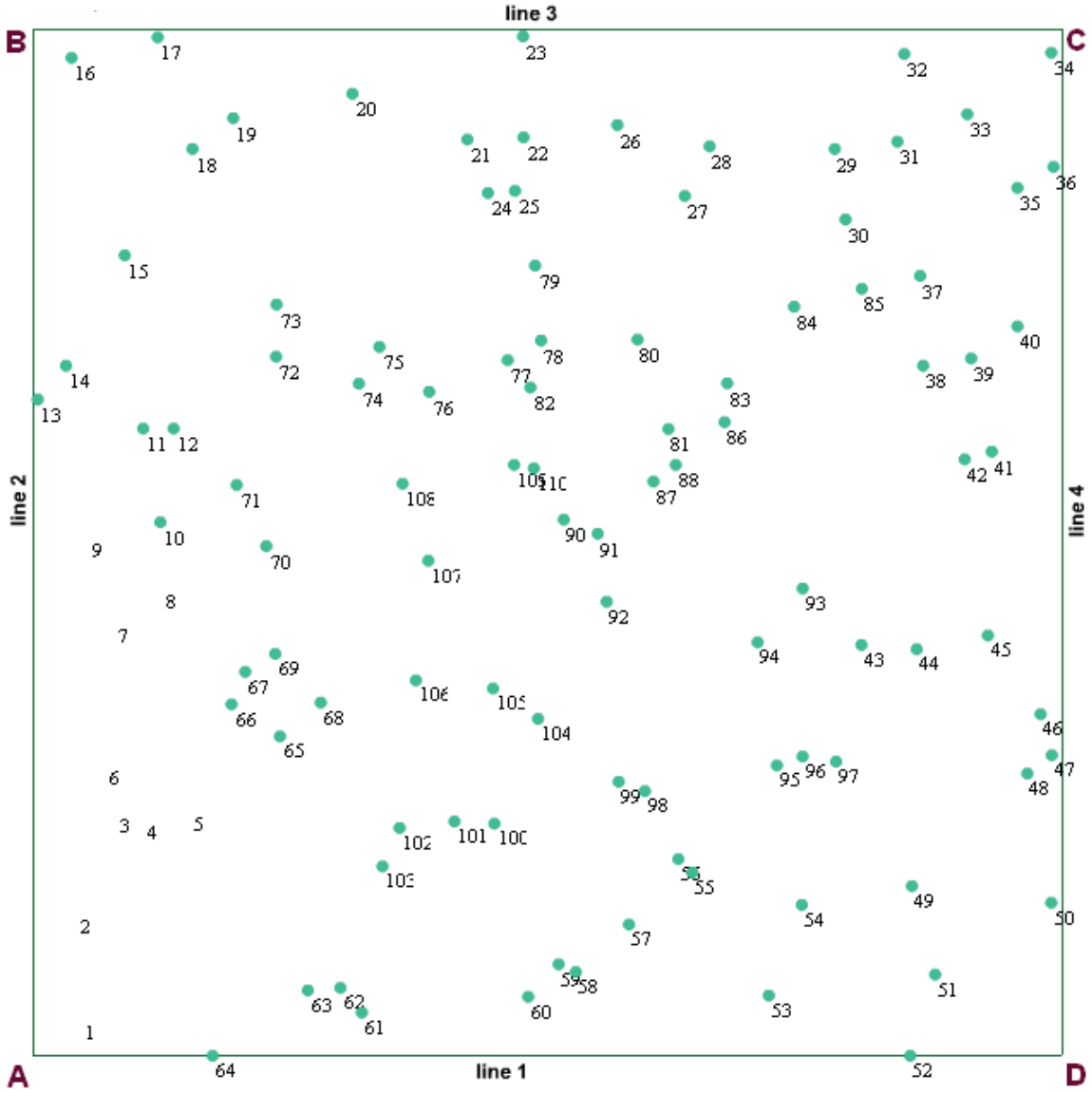
Nopiming North 1920 Jack Pine Plot 5



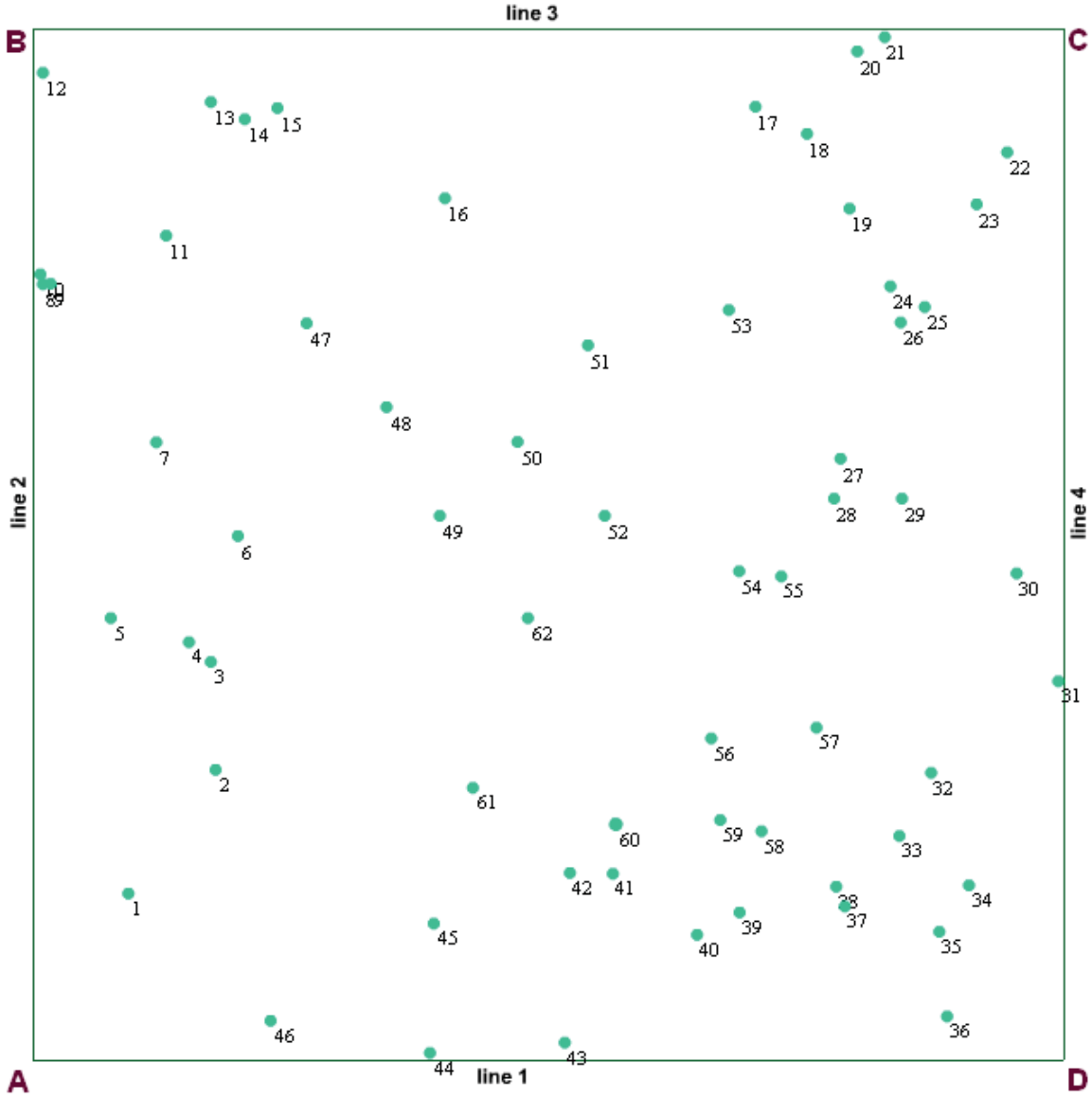
Nopiming North 1900 Black Spruce Plot 1



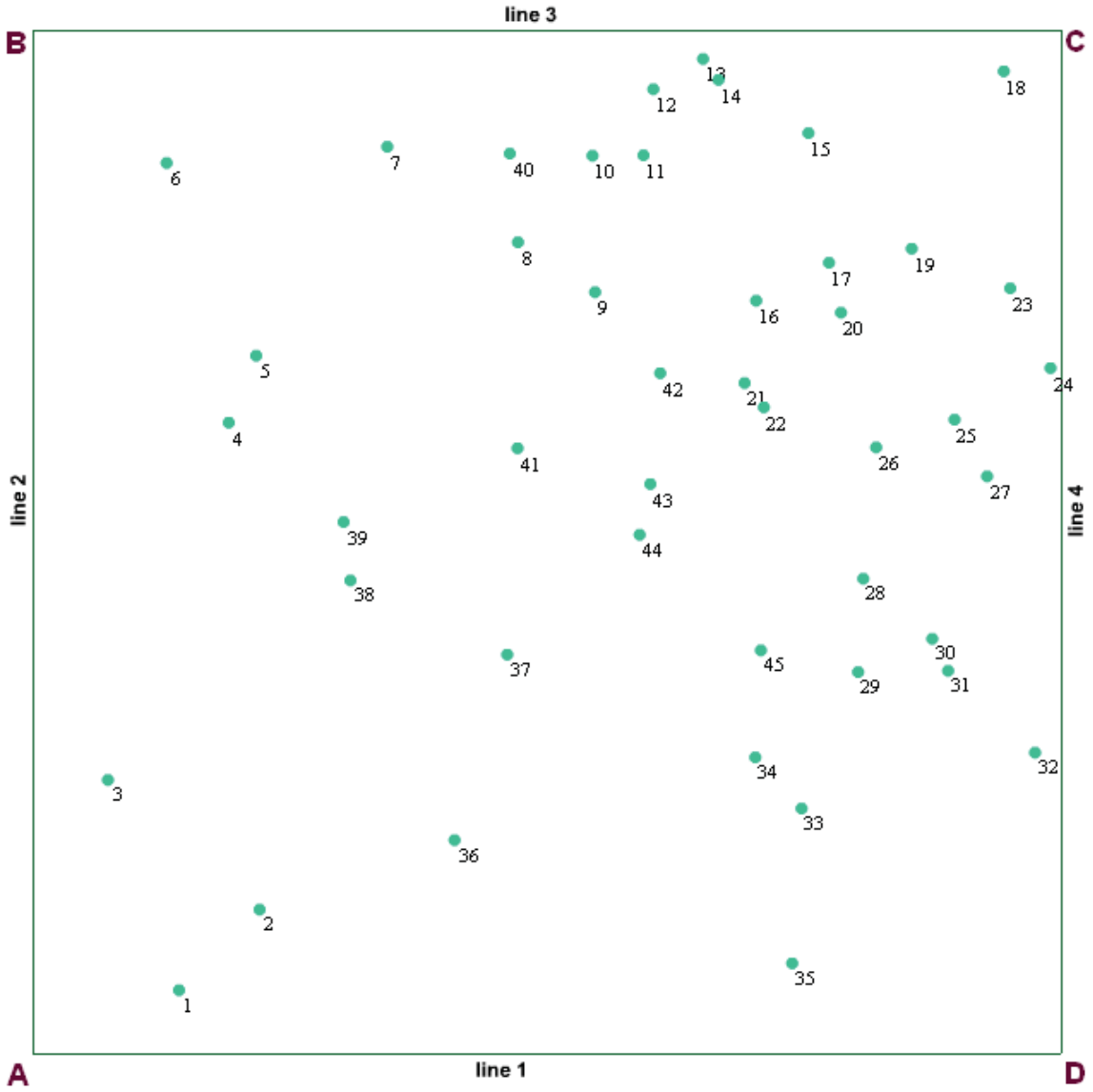
Nopiming North 1900 Black Spruce Plot 2



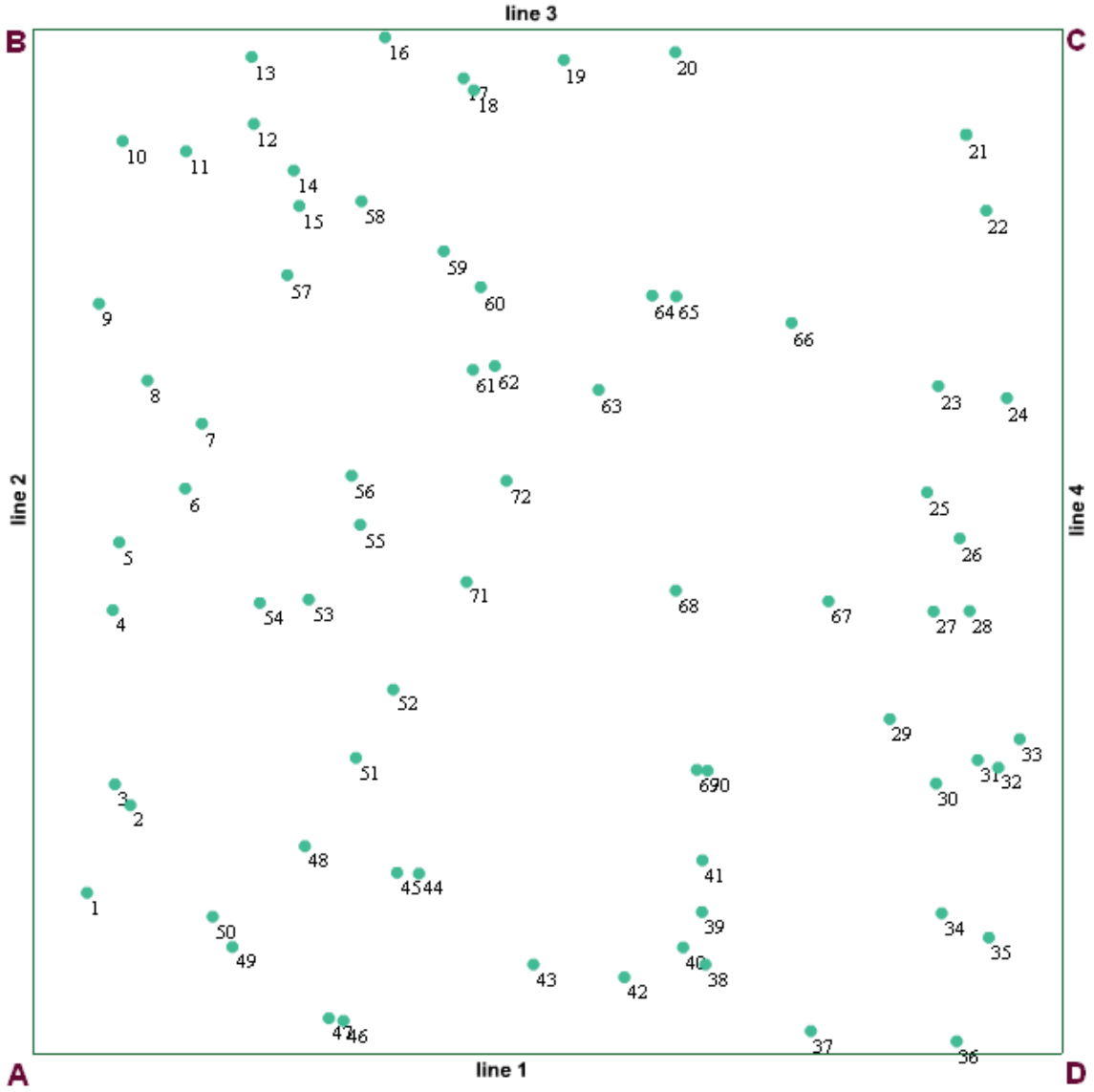
Nopiming North 1900 Black Spruce Plot 3



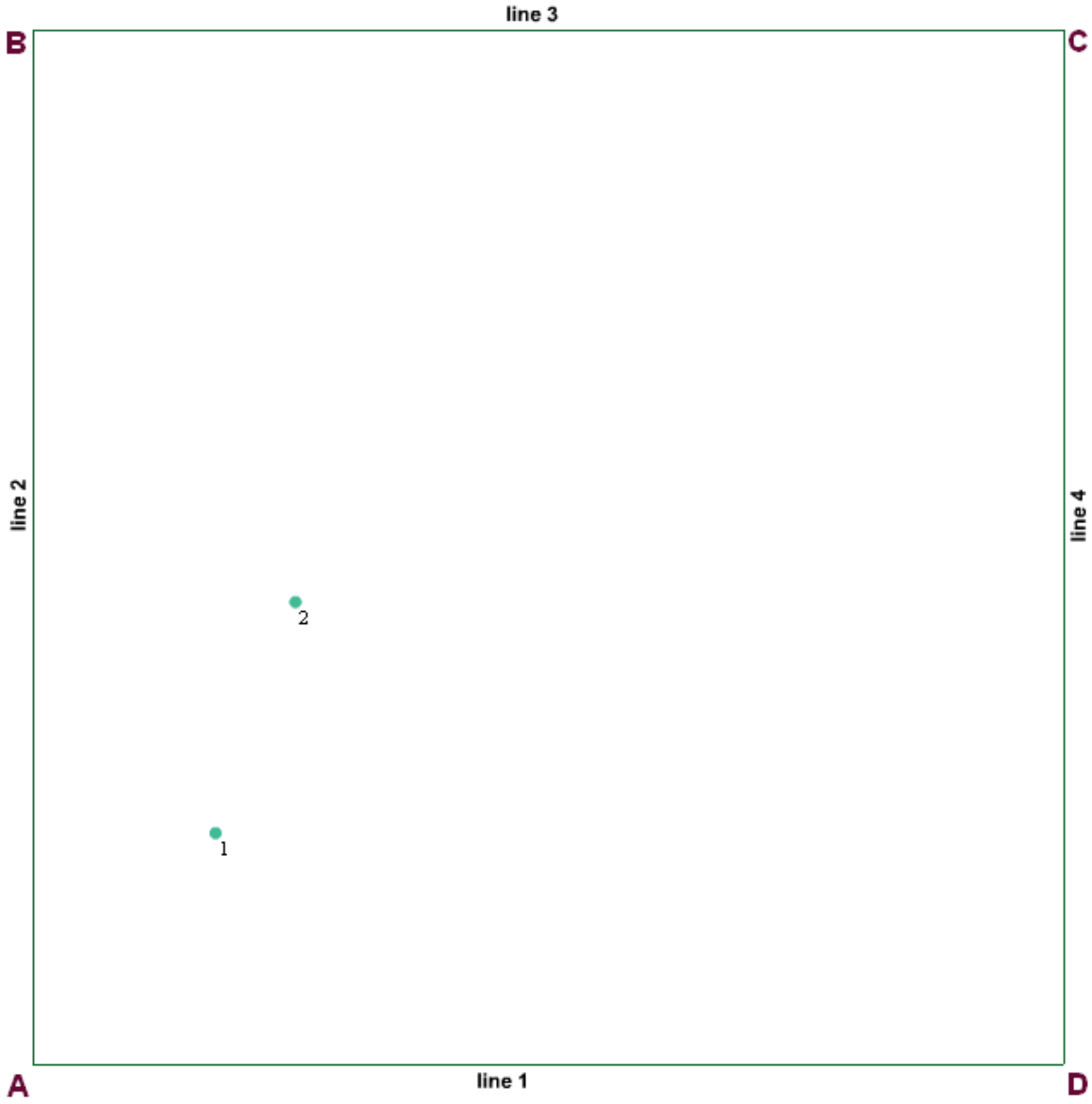
Nopiming North 1900 Black Spruce Plot 4



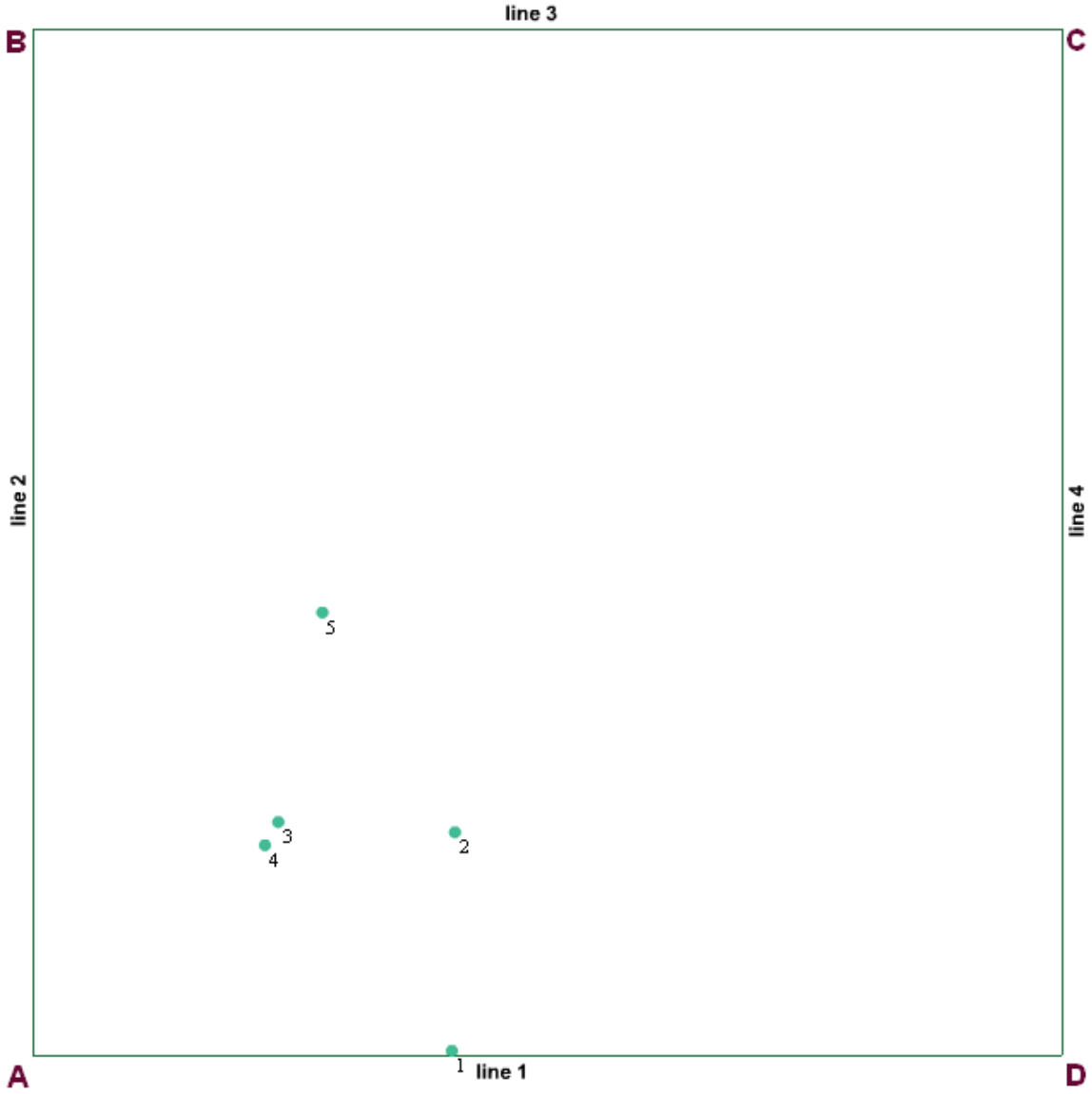
Nopiming North 1900 Black Spruce Plot 5



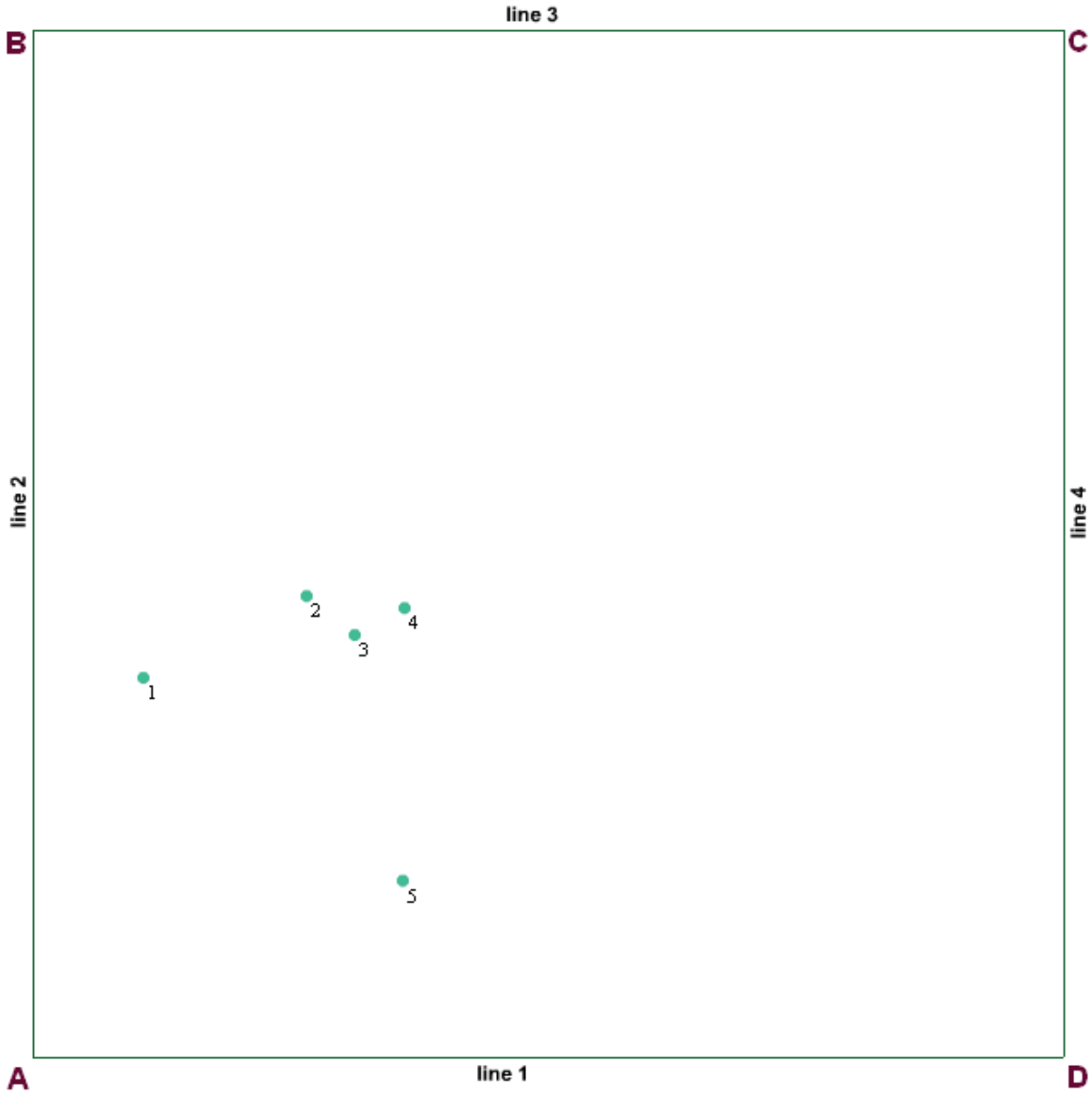
Flintstone Lake 1993 Black Spruce Plot 1



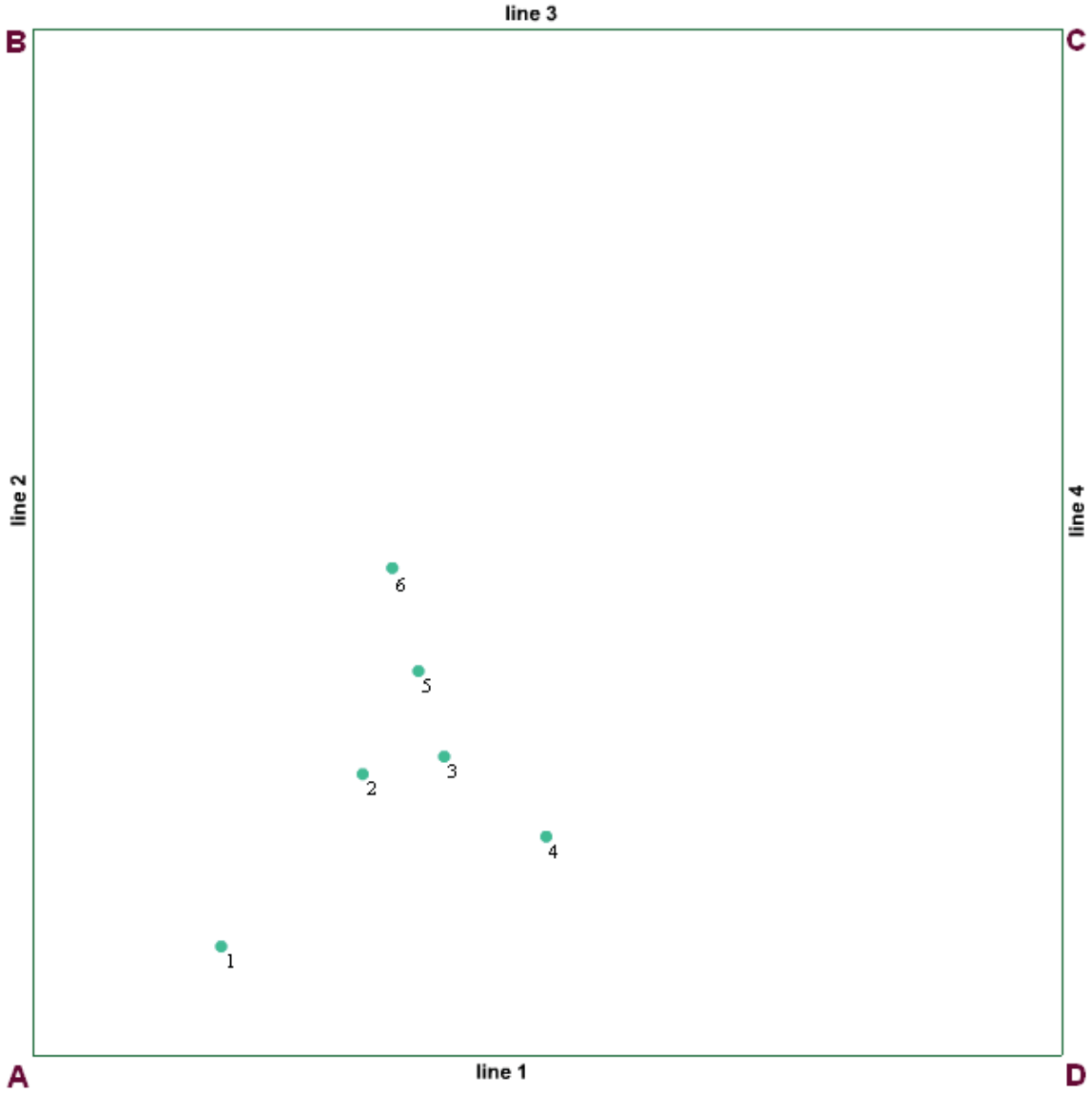
Flintstone Lake 1993 Black Spruce Plot 2



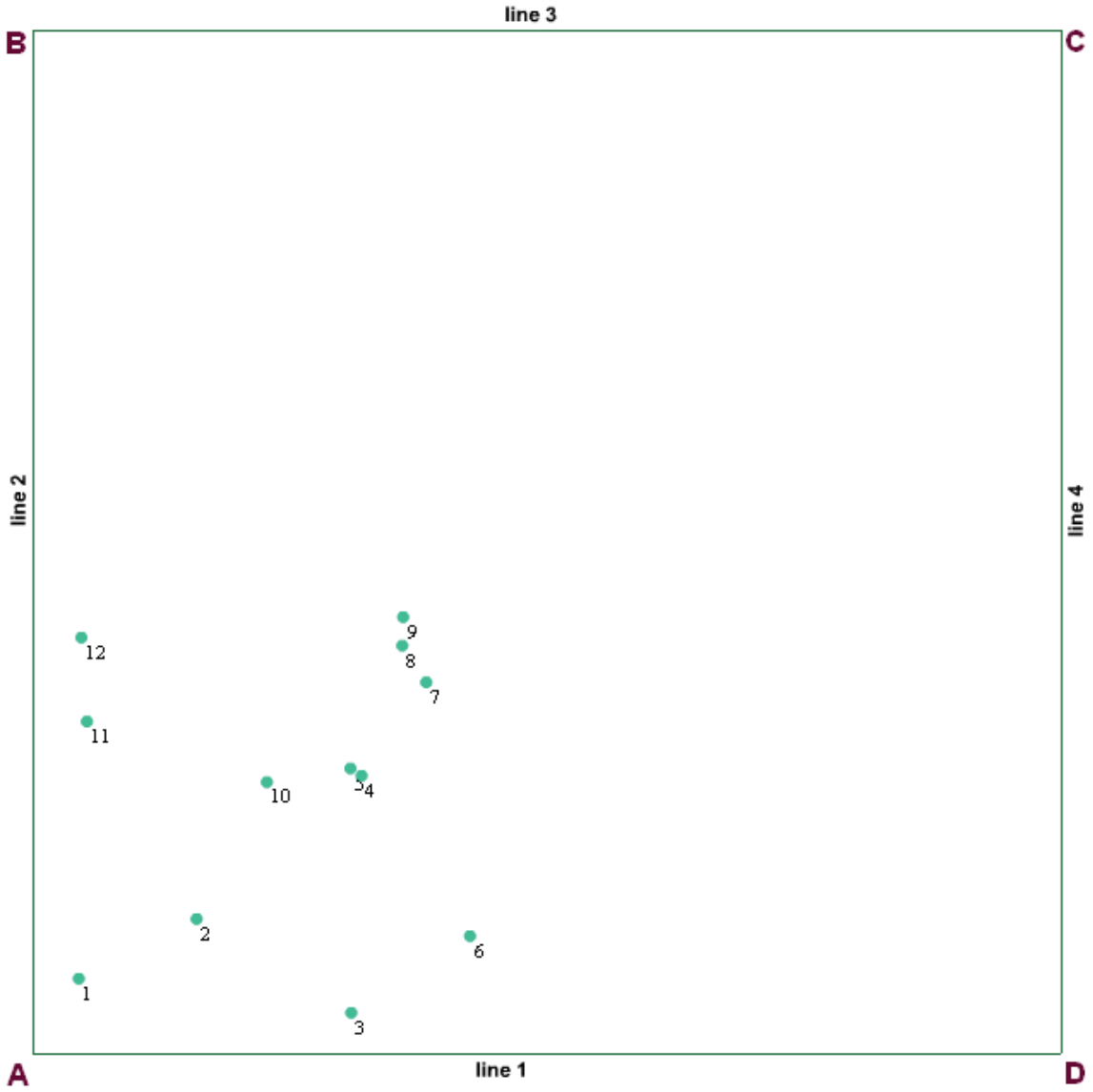
Flintstone Lake 1993 Black Spruce Plot 3



Flintstone Lake 1993 Black Spruce Plot 4



Flintstone Lake 1993 Black Spruce Plot 5



Appendix II: GPS locations of study plots

Stand	Plot #	Latitude	Longitude	Accuracy (m)	Bearing
NN1920JP	1	N 50° 40.774	W 95° 18.412	±12	80°
NN1920JP	2	N 50° 40.826	W 95° 18.722	±11	0°
NN1920JP	3	N 50° 40.780	W 95° 18.581	±8	0°
NN1920JP	4	N 50° 40.752	W 95° 18.462	±6	10°
NN1920JP	5	N 50° 40.794	W 95° 18.620	±12	0°
NN1900BS	1	N 50° 41.480	W 95° 18.989	±10	45°
NN1900BS	2	N 50° 41.518	W 95° 18.924	±7	0°
NN1900BS	3	N 50° 41.506	W 95° 18.816	±14	10°
NN1900BS	4	N 50° 41.529	W 95° 18.999	±5	0°
NN1900BS	5	N 50° 41.559	W 95° 18.937	±14	0°
FL1993BS	1	N 50° 43.960	W 95° 17.920	±7	170°
FL1993BS	2	N 50° 43.957	W 95° 17.878	±7	°[*1]
FL1993BS	3	N 50° 43.972	W 95° 17.839	±5	85°
FL1993BS	4	N 50° 43.943	W 95° 17.837	±6	60°
FL1993BS	5	N 50° 43.930	W 95° 17.881	±6	90°
HW1912JP	1	N 51° 10.284	W 96° 19.482	±7	°[*1]
HW1912JP	2	N 51° 10.260	W 96° 19.481	±12	°[*1]
HW1912JP	3	N 51° 10.253	W 96° 19.561	±7	°[*1]
HW1912JP	4	N 51° 10.207	W 96° 19.538	±7	°[*1]
HW1912JP	5	N 51° 10.186	W 96° 19.582	±8	°[*1]
HW1983JP	1	N 51° 09.905	W 96° 19.986	±7	110°
HW1983JP	2	N 51° 09.947	W 96° 18.596	±12	0°
HW1983JP	3	N 51° 09.839	W 96° 19.948	±7	180°
HW1983JP	4	N 51° 09.780	W 96° 19.939	±7	190°
HW1983JP	5	N 51° 09.734	W 96° 19.974	±8	10°
HW1992JP	1	N 51° 09.928	W 96° 18.637	±13	95°
HW1992JP	2	N 51° 09.947	W 96° 18.596	±12	80°
HW1992JP	3	N 51° 09.976	W 96° 18.594	±9	80°
HW1992JP	4	N 51° 09.780	W 96° 18.532	±16	120°
HW1992JP	5	N 51° 09.984	W 96° 18.463	±11	100°
HW2000JP	1	N 51° 10.085	W 96° 19.146	±8	180°
HW2000JP	2	N 51° 10.127	W 96° 19.142	±8	0°
HW2000JP	3	N 51° 10.083	W 96° 19.101	±8	180°
HW2000JP	4	N 51° 10.104	W 96° 19.088	±7	0°
HW2000JP	5	N 51° 10.084	W 96° 19.027	±6	180°

[*1] - Not recorded

Appendix III: List of species in each stand and master list of species

Hollow Water 1912 Jack Pine	
Trees	
Common Name	**Scientific Name**
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*
White Spruce	*Picea glauca*
Balsam Fir	*Abies balsamea*
Black Spruce	*Picea mariana*
White Birch	*Betula papyrifera*

Hollow Water 1912 Jack Pine	
Seedlings and Shrubs	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
Manitoba Maple	*Acer negundo*
Beaked Hazelnut	*Corylus cornuta*
Trembling Aspen	*Populus tremuloides*
Bush Honeysuckle	*Diervilla lonicera*
Black Spruce	*Picea mariana*
White Birch	*Betula papyrifera*
White Spruce	*Picea glauca*
Saskatoon	*Amelanchier alnifolia*
Alder	*Alnus spp.*
High Bush Cranberry	*Viburnum opulus*

Hollow Water 1912 Jack Pine	
Ground Vegetation	
Common Name	**Scientific Name**
Balsam fir	*Abies balsamea*
Mountain Maple	*Acer spicatum*
Saskatoon	*Amelanchier alnifolia*
Sarsaparilla	*Aralia nudicaulis*
White birch	*Betula papyrifera*
Bark moss	*Brachytheciaceae salebrosum*
Feather moss	*Calliergon spp.*
Prince's Pine	*Chimaphila umbellata*
Sulphur cup	*Cladonia sulphurina*
Blue Bead Lily	*Clintonia borealis*
Bunchberry	*Cornus canadensis*
Beaked Hazelnut	*Corylus cornuta*
Bush Honeysuckle	*Diervilla lonicera*
Fairybells	*Disporum trachycarpum*
Spruce Moss	*Evernia mesomorpha*
Woodland Strawberry	*Fragaria vesca*
Stair-step Moss	*Hylocomium splendens*
Monk's Hood Lichen	*Hypogymnia physodes*
Twinflower	*Linnaea borealis*
Ground Cedar	*Lycopodium complanatum*
Ground Pine	*Lycopodium obscurum*
Wild-lily-of-the-valley	*Maianthemu canadense*
Frog's Pelt	*Peltigera neopolydactyla*
Big Red Stem	*Pleurizium schreberi*
Trembling Aspen	*Populus tremuloides*
Wintergreen	*Pyrola spp.*
Currant	*Ribes spp.*
Prickly Rose	*Rosa acicularis*
Dewberry	*Rubus pubescens*
Rose Twisted Stalk	*Streptopus lanceolatus*
Powdery Beard	*Usnea lapponica*
Old Mans Beard	*Usnea spp.*
Low-sweet Blueberry	*Vaccinium angustifolium*
Blueberry	*Vaccinium myrtilloides*
Kidney Leaved Violet	*Viola renifolia*
Grass	
Knight's Plume Moss	
Lichen	
Moss	

Hollow Water 1983 Jack Pine	
Trees	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
Green Alder	*Alnus crispa*
White Birch	*Betula papyrifera*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*

Hollow Water 1983 Jack Pine	
Seedlings and Shrubs	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
Green Alder	*Alnus crispa*
White Birch	*Betula papyrifera*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*
Willow	*Salix spp.*

Hollow Water 1983 Jack Pine	
Ground Vegetation	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
Bearberry	*Artostaphylos uva-ursi*
Prince's Pine	*Chimaphila umbellata*
Cladina arbuscuala	*Cladina arbuscula*
Green Reindeer Lichen	*Cladina mitis*
Grey Reindeer Lichen	*Cladina rangiferina*
Cladonia	*Cladonia spp.*
Blue Beaded Lily	*Clintonia borealis*
Goldthread	*Coptis trifolia*
Bunchberry	*Cornus canadensis*
Pink Lady Slipper	*Cypripedium acaule*
Fireweed	*Epilobium angustifolium*
Horsetail	*Equisetum spp.*
Creeping Snowberry	*Gaultheria hispidula*
Juniper	*Juniperus communis*
Labrador Tea	*Ledum groenlandicum*
Twinflower	*Linnaea borealis*
Wild-lily-of-the-valley	*Maianthemu canadense*
Black Spruce	*Picea mariana*
Wintergreen	*Pyrola spp.*
Three-Leaved False Solomon's Seal	*Smilacina trifolia*
Starfower	*Trientalis borealis*
Blueberry	*Vaccinium myrtilloides*
Moss	
Grass	
Mushroom	

Hollow Water 1992 Jack Pine	
Trees	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
White Birch	*Betula papyrifera*
White Spruce	*Picea glauca*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*

Hollow Water 1992 Jack Pine	
Seedlings and Shrubs	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
Green Alder	*Alnus crispa*
White Birch	*Betula papyrifera*
Beaked Hazelnut	*Corylus cornuta*
White Spruce	*Picea glauca*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*
Willow	*Salix spp.*

Hollow Water 1992 Jack Pine	
Ground Vegetation	
Common Name	**Scientific Name**
Sarsapairlla	*Aralia nudicaulis*
Bearberry	*Artostaphylos uva-ursi*
White Birch	*Betula papyrifera*
Blue Beaded Lily	*Clintonia borealis*
Goldthread	*Coptis trifolia*
Bunchberry	*Cornus canadensis*
Pink Lady Slipper	*Cypripedium acaule*
Bush Honeysuckle	*Diervilla lonicera*
Horsetail	*Equisetum spp.*
Creeping Snowberry	*Gaultheria hispidula*
Labrador Tea	*Ledum groenlandicum*
Twin Flower	*Linnaea borealis*
Club Moss	*Lycopodium spp.*
Wild-lily-of-the-valley	*Maianthemu canadense*
Black Spruce	*Picea mariana*
Trembling Aspen	*Populus tremuloides*
Wild Red Raspberry	*Rubus idaeus*
Starflower	*Trientalis borealis*
Blueberry	*Vaccinium myrtilloides*
Grass	
Moss	
Fern	

Hollow Water 2000 Jack Pine	
Trees	
Common Name	**Scientific Name**
White Birch	*Betula papyrifera*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*

Hollow Water 2000 Jack Pine	
Seedlings and Shrubs	
Common Name	**Scientific Name**
White Birch	*Betula papyrifera*
Beaked Hazelnut	*Corylus cornuta*
Ash	*Fraxinus spp.*
Tamarack	*Larix laricina*
White Spruce	*Picea glauca*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*
Willow	*Salix spp.*

Hollow Water 2000 Jack Pine	
Ground Vegetation	
Common Name	**Scientific Name**
Spreading Dogbane	*Apocynum androsaemifolium*
Sarsaparilla	*Aralia nudicaulis*
Cladina arbuscula	*Cladina arbuscula*
Grey Reindeer Lichen	*Cladina rangiferina*
Cladonia	*Cladonia spp.*
Blue Bead Lily	*Clintonia borealis*
Goldthread	*Coptis trifolia*
Bunchberry	*Cornus canadensis*
Bush Honeysuckle	*Diervilla lonicera*
Fireweed	*Epilobium angustifolium*
Horsetail	*Equisetum spp.*
Woodland Strawberry	*Fragaria vesca*
Creeping Snowberry	*Gaultheria hispidula*
Lesser Rattlesnake Plantain	*Goodyera repens*
Labrador Tea	*Ledum groenlandicum*
Ground Cedar	*Lycopodium complanatum*
Ground Pine	*Lycopodium obscurum*
Club Moss	*Lycopodium spp.*
Wild-lily-of-the-valley	*Maianthemu canadense*
Currant	*Ribes spp.*
Common Wild Rose	*Rosa woodsii*
Wild Red Raspberry	*Rubus idaeus*
Dewberry	*Rubus pubescens*
Willow	*Salix spp.*
Starflower	*Trientalis borealis*
Twin Flower	*Linnaea borealis*
Blueberry	*Vaccinium myrtilloides*
Fern	
Moss	
Grass	

Nopiming North 1920 Jack Pine	
Trees	
Common Name	**Scientific Name**
White Birch	*Betula papyrifera*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*

Nopiming North 1920 Jack Pine	
Seedlings and Shrubs	
Common Name	**Scientific Name**
Green Alder	*Alnus crispa*
White Birch	*Betula papyrifera*
Juniper	*Juniperus communis*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*
Choke cherry	*Prunus virginiana*
Willow	*Salix spp.*

Nopiming North 1920 Jack Pine	
Ground Vegetation	
Common Name	**Scientific Name**
Sarsaparilla	*Aralia nudicaulis*
Spreading Dogbane	*Apocynum androsaemifolium*
Bearberry	*Artostaphylos uva-ursi*
White birch	*Betula papyrifera*
Prince's Pine	*Chimaphila umbellata*
Cladina arbuscula	*Cladina arbuscula*
Grey Reindeer Lichen	*Cladina rangiferina*
Blue Bead Lily	*Clintonia borealis*
Bunchberry	*Cornus canadensis*
Spiny Wood Fern	*Dryopteris ausriaca*
Fireweed	*Epilobium angustifolium*
Horsetail	*Equisetum spp.*
Creeping Snowberry	*Gaultheria hispidula*
Richardson's Alumroot	*Heuchera richardsonii*
Juniper	*Juniperus communis*
Twinflower	*Linnaea borealis*
Stiff Club Moss	*Lycopodium annotinum*
Club Moss	*Lycopodium spp.*
Wild-lily-of-the-valley	*Maianthemu canadense*
Peltigera	*Peltigera spp.*
Trembling Aspen	*Populus tremuloides*
Three-Toothed Cinquefoil	*Potentilla tridentata*
Wintergreen	*Pyrola spp.*
Common Wild Rose	*Rosa woodsii*
Wild Red Raspberry	*Rubus idaeus*
Wooly Coral	*Stereocaulon tomentosum*
Starflower	*Trientalis borealis*
Blueberry	*Vaccinium myrtilloides*
Violet	*Viola spp.*
Moss	
Grass	
Foliose Lichens	

Nopiming North 1900 Black Spruce	
Trees	
Common Name	**Scientific Name**
Black Spruce	*Picea mariana*

Nopiming North 1900 Black Spruce	
Seedlings and Shrubs	
Common Name	**Scientific Name**
Green Alder	*Alnus crispa*
Black Spruce	*Picea mariana*
Willow	*Salix spp.*

Nopiming North 1900 Black Spruce	
Ground Vegetation	
Common Name	**Scientific Name**
Green Alder	*Alnus crispa*
Bearberry	*Artostaphylos uva-ursi*
Leather Leaf	*Chamaedaphne calyculata*
Grey Reindeer Lichen	*Cladina rangiferina*
Horsetail	*Equisetum spp.*
Creeping Snowberry	*Gaultheria hispidula*
Labrador Tea	*Ledum groenlandicum*
Club Moss	*Lycopodium spp.*
Small Bog Cranberry	*Oxycoccus microcarpus*
Black Spruce	*Picea mariana*
Wild Red Currant	*Ribes triste*
Three-Leaved False Solomon's Seal	*Smilacina trifolia*
Blueberry	*Vaccinium myrtilloides*
Moss	
Grass	

Flintstone Lake 1993 Black Spruce	
Trees	
Common Name	**Scientific Name**
Jack Pine	*Pinus banksiana*

Flintstone Lake 1993 Black Spruce	
Seedlings and Shrubs	
Common Name	**Scientific Name**
Green Alder	*Alnus crispa*
White Birch	*Betula papyrifera*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*
Willow	*Salix spp.*

Flintstone Lake 1993 Black Spruce	
Ground Vegetation	
Common Name	**Scientific Name**
Bearberry	*Artostaphylos uva-ursi*
Leatherleaf	*Chamaedaphne calyculata*
Cladina arbuscula	*Cladina arbuscula*
Grey Reindeer Lichen	*Cladina rangiferina*
Cladonia	*Cladonia spp.*
Horsetail	*Equisetum spp.*
Green Reindeer Lichen	*Cladina mitis*
Labrador Tea	*Ledum groenlandicum*
Club Moss	*Lycopodium spp.*
Small Bog Cranberry	*Oxycoccus microcarpus*
Black Spruce	*Picea mariana*
Trembling Aspen	*Populus tremuloides*
Wild Red Current	*Ribes triste*
Willow	*Salix spp.*
Three-Leaved False Solomon's Seal	*Smilacina trifolia*
Starflower	*Trientalis borealis*
Blueberry	*Vaccinium myrtilloides*
Grass	
Moss	

Master List	
Trees	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
Green Alder	*Alnus crispa*
White Birch	*Betula papyrifera*
White Spruce	*Picea glauca*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*

Master List	
Seedlings and Shrubs	
Common Name	**Scientific Name**
Balsam Fir	*Abies balsamea*
Manitoba Maple	*Acer negundo*
Green Alder	*Alnus crispa*
Alder	*Alnus spp.*
Saskatoon	*Amelanchier alnifolia*
White Birch	*Betula papyrifera*
Beaked Hazelnut	*Corylus cornuta*
Bush Honeysuckle	*Diervilla lonicera*
Ash	*Fraxinus spp.*
Juniper	*Juniperus communis*
Tamarack	*Larix laricina*
White Spruce	*Picea glauca*
Black Spruce	*Picea mariana*
Jack Pine	*Pinus banksiana*
Trembling Aspen	*Populus tremuloides*
Choke cherry	*Prunus virginiana*
Willow	*Salix spp.*
High Bush Cranberry	*Viburnum opulus*

Master List	
Ground Vegetation	
Common Name	**Scientific Name**
Balsam fir	*Abies balsamea*
Mountain Maple	*Acer spicatum*
Green Alder	*Alnus crispa*
Saskatoon	*Amelanchier alnifolia*
Spreading Dogbane	*Apocynum androsaemifolium*
Sarsaparilla	*Aralia nudicaulis*
Bearberry	*Artostaphylos uva-ursi*
White birch	*Betula papyrifera*
Bark moss	*Brachytheciaceae salebrosum*
Feather moss	*Calliergon spp.*
Leather Leaf	*Chamaedaphne calyculata*
Prince's Pine	*Chimaphila umbellata*
Cladina arbuscula	*Cladina arbuscula*
Green Reindeer Lichen	*Cladina mitis*
Grey Reindeer Lichen	*Cladina rangiferina*
Cladonia	*Cladonia spp.*
Sulphur cup	*Cladonia sulphurina*
Blue Bead Lily	*Clintonia borealis*
Goldthread	*Coptis trifolia*
Bunchberry	*Cornus canadensis*
Beaked Hazelnut	*Corylus cornuta*
Pink Lady Slipper	*Cypripedium acaule*
Bush Honeysuckle	*Diervilla lonicera*
Fairybells	*Disporum trachycarpum*
Spiny Wood Fern	*Dryopteris ausriaca*
Fireweed	*Epilobium angustifolium*
Horsetail	*Equisetum spp.*
Spruce Moss	*Evernia mesomorpha*
Woodland Strawberry	*Fragaria vesca*
Creeping Snowberry	*Gaultheria hispidula*
Lesser Rattlesnake Plantain	*Goodyera repens*
Richardson's Alumroot	*Heuchera richardsonii*
Stair-step Moss	*Hylocomium splendens*
Monk's Hood Lichen	*Hypogymnia physodes*
Juniper	*Juniperus communis*
Labrador Tea	*Ledum groenlandicum*
Twinflower	*Linnaea borealis*
Stiff Club Moss	*Lycopodium annotinum*
Ground Cedar	*Lycopodium complanatum*
Ground Pine	*Lycopodium obscurum*
Club Moss	*Lycopodium spp.*
Wild-lily-of-the-valley	*Maianthemu canadense*
Small Bog Cranberry	*Oxycoccus microcarpus*

Master List	
Ground Vegetation	
Common Name	**Scientific Name**
Frog's Pelt	*Peltigera neopolydactyla*
Peltigera	*Peltigera spp.*
Black Spruce	*Picea mariana*
Big Red Stem	*Pleurizium schreberi*
Trembling Aspen	*Populus tremuloides*
Three-Toothed Cinquefoil	*Potentilla tridentata*
Knight's Plume Moss	*Ptilium crista-castrensis*
Wintergreen	*Pyrola spp.*
Currant	*Ribes spp.*
Wild Red Currant	*Ribes triste*
Prickly Rose	*Rosa acicularis*
Common Wild Rose	*Rosa woodsii*
Wild Red Raspberry	*Rubus idaeus*
Dewberry	*Rubus pubescens*
Willow	*Salix spp.*
Three-Leaved False Solomon's Seal	*Smilacina trifolia*
Wooly Coral	*Stereocaulon tomentosum*
Rose Twisted Stalk	*Streptopus lanceolatus*
Starflower	*Trientalis borealis*
Powdery Beard	*Usnea lapponica*
Old Mans Beard	*Usnea spp.*
Low-sweet Blueberry	*Vaccinium angustifolium*
Blueberry	*Vaccinium myrtilloides*
Kidney Leaved Violet	*Viola renifolia*
Violet	*Viola spp.*
Fern	
Foliose Lichens	
Grass	
Lichen	
Moss	
Mushroom	

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