Long-term Bio-monitoring Plots in the Bois des Esprit Urban Oak Forest Ecosystem Year I: Plot Establishment and a Baseline Data Report



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Executive Summary

The Bois des Esprit area is a newly protected area located in the City of Winnipeg. The area contains cultural and archaeological sites, a multitude of wildlife and waterfowl species and habitat, and serves as an urban green space. The establishment of long term monitoring plots to assess the forest stand health is a result of partnerships between several organizations; the City of Winnipeg, the Province of Manitoba, Save our Seine (non government organization), and the Manitoba Model Forest (MBMF). Monitoring plots were established in 2008 in the oak-dominated river terrace stands.

Based on the initial findings, the stand appears to be in a healthy state. The dominant species included burr oak (*Quercus macrocarpa*), trembling aspen (*Populus tremuloides*), green or black ash (*Fraxinus spp.*), and american elm (*Ulmus americana*). Crown ratings and an assessment of stem defects indicated that a large proportion of the oak trees were alive and healthy. The area also had a thick shrub layer, dominated primarily by arrowood, saskatoon, beaked hazelnut, chokecherry and ash. The ground herb layer was found to be sparse but with a diversity of species including wild sarsaparilla, honeysuckle, and dewberry. Low light transmission to the ground layer in the stand likely prevented the development of a significant amount of vegetation, resulting in overall low percent of ground cover.

Based on our findings the stand appears to be younger and even aged, possibly still growing to its maximum potential height. This represents the first baseline health assessment of forests in the Bois des Esprit area. Re-measurement of the area to assess the long term health of the stand is scheduled for five years in the future.

Introduction

Urban development is rapidly encroaching on once pristine wetland and riparian areas. In some urban areas housing and industrial complexes are built up to the river banks, and in most areas only a small threatened corridor of forest remains. In recent years, more attention has been paid to the negative impacts of development and the urban forest environment. Pollution, habitat for wildlife species, and quality green space have become forefront issues. In Winnipeg, the Seine River has become a concern for citizens due to accelerated expanding development. The Seine River is a small tributary, winding through the city of Winnipeg before emptying into the Red River. It is home to a variety of unique habitats, ranging from rich oak stands, giant cottonwoods, wildlife and waterfowl habitat, and possible Métis historical sites (HTFC 2007).

An area along the Seine River, named Bois des Esprit (Sprit Forest), is a small 107 acre space surrounded by urban development. This area offers a green space, and recently has been improved and become a protected area in the city of Winnipeg. The surrounding area has experienced a significant amount of development in the last few decades and is now completely surrounded by housing and commercial buildings. On April 27, 2007, a planning workshop prepared by the Hilderman Thomas Frank Cram Landscape Architecture & Planning firm (HTFC), was presented to the community describing the area and its challenges. Large portions of the Bois des Esprit area were classified as being areas that are extremely sensitive to disturbance. The area is virtually undisturbed by man or has recovered to an extent where it is similar to its original historical community and structure (HTFC 2007). The City of Winnipeg and non-government organization, Save Our Seine, had encouraged the Manitoba Model Forest (MBMF) to monitor the area, and in 2008 a series of Environment Canada's Ecological and Monitoring Assessment Network (EMAN) protocol vegetation plots were established.

Over the past few years, EMAN has developed national protocols for monitoring and assessing forest stand health. Long term monitoring is essential, and adopting a standard is important. Due to the high susceptibility of the Bois des Esprit area to disturbance, this comparison is invaluable. The advantages of the EMAN protocols are that they are available and reasonable for citizens, environmentalists, and other firms to use. Due to the availability and ease of the protocols, comparisons with other urban forest stands, and subsequent re-measurements can be performed. Also, due to cut backs in environmental funding over past decades, making the protocols and data available to citizens and other volunteer organizations allows for cost-effective monitoring of the environment to continue.

While citizen and volunteer science may be criticised by academic and major environmental groups, it is becoming a reality due to lack of funding. Many citizen-based monitoring protocols now address issues such as quality control and quality assurance. Federal, Provincial, municipal, and city funding is being reduced while concern for the environment is increasing. This also lets those who want to take an active part in environmental and scientific work possible, since the EMAN protocol and database are available to the public.

The Manitoba Model Forest works closely with EMAN, citizen groups, and the provincial and federal government to further facilitate forest-based research. One program the Manitoba Model Forest currently runs is a partnership with local schools. High school students come out and help set up plots to learn sampling techniques, and the importance of science and monitoring for forest health. The students also contribute their data which is added to the national EMAN database. Thus, the students participate directly in an environmental monitoring program with national significance.

Methods

Plot Establishment and Site Selection

Plots were established from June 10 to June 13, 2008. A total of five 20 by 20 metre plots were established in locations around the Bois des Esprit area. A general description of the plots and area is provided in the results and discussion section. Plots were established as far as possible from main walking paths and open areas; however, some plots overlapped trails or the dead woody debris transects ran into oxbows, clearings or marshes due to the patchy landscape.

Plot establishment was performed by marking one corner (A corner), measuring 20 metres, placing another corner pin (B corner) and recording the bearing of the line (AB line). The subsequent two corners (C and D) were placed by turning 90° and measuring an additional 20 metres to form a square (Figure 1). A GPS waypoint including latitude, longitude, and GPS accuracy were recorded at the A corner pin. See appendix I for a list of GPS locations and information for each plot.

EMAN protocols were followed for all of the data collection including the canopy-tree stratum, shrub and small tree layer, ground vegetation layer, and downed woody debris transects, described in detail by Roberts-Pichette and Gillespie (1999). The protocols also can be found on the EMAN website

(www.eman-rese.ca), however, the protocols posted online have been updated and differ slightly from those earlier described by Roberts-Pichette and Gillespie (1999). The protocols used will be generally described below to avoid confusion.

Canopy Tree Stratum

Tree Measurement: In each 20x20 metre plot, trees with a diameter at breast height (dbh) over 10 centimetres were measured, and tagged with aluminum tags. Stand name, plot number, and tree number were etched onto the tag and attached to the tree with a nail and hammer. The position of each tree in the plot was recorded by taking its X and Y coordinates with a laser measurer. In relation to the established plot boundary lines; the AB and CD lines were the Y axis, and the BC and DA lines were the X axis, best described by Figure 1. Mapping the location of each tree in the plot is important for a few reasons. Firstly, tags on trees may go missing, be destroyed, or be pulled off by passing pedestrians. Secondly, trees may go missing, either by being cut down, falling over, etc. Thirdly, it allows for a good overview of the plot using the EMANs online software to visually view the placement of trees. The EMAN software presents a graphical representation of the plot, showing relative dbh, species and location of each tree from a bird's eye view. See appendix II for a printout and view of each plot using the EMAN software.

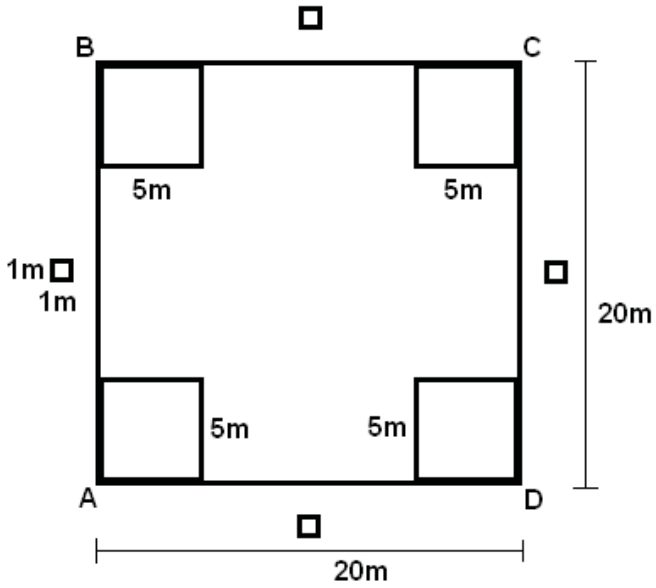

Figure 1: General 20x20 metre plot showing 5x5 metre nested shrub plots and 1x1 metre herb plots outside the plot.

Tree Calculations: Trees were grouped according to their species. Calculations were made for the number of live and dead trees, abundance for live and dead trees, basal area for live and dead trees, density and relative density, dominance and relative dominance, frequency and relative frequency, and importance value for each species and plot. The results were then averaged for each plot to give value that represents the area as a stand. Abundance and basal area were represented per hectare for ease of comparison to other datasets. Density and dominance were represented on a per metre squared basis. Relative density, relative dominance, frequency, and relative frequency were expressed as a percentage based on a comparison to the whole stand.

Abundance is the representation of the number of trees for each species per hectare of the stand. Basal area is the calculation of the dbh of each tree for a species represented as an area, summed and expressed per hectare for the stand. Density is defined as the average number of individuals of a species on a unit basis, or the abundance represented on a square metre basis instead of a per hectare basis for the stand. Relative density is the measure of one species density compared to all of the species. Dominance is the measurement of the area a species occupies in a stand on a unit basis, or the basal area represented on a per square metre rather than a per hectare basis for the stand. Relative dominance is the dominance of a species compared to all of the species. Frequency is the distribution of a species in a stand, or the number of times a species occurs in the stand represented as a percentage. Relative frequency is defined as the distribution of a species compared to all other species. The importance value is an index made of the sum of the relative dominance, relative density, and relative frequency. It gives an indication of the structural role of a species in the stand, and is useful for comparing stands based on the species composition and stand structure (Dupont et. al. 2006; Roberts-Pichette and Gillespie, 1999).

Tree Health: A very coarse classification was used to categorize the tree health for each species. The classifications were: alive standing (as), alive broken (ab), alive leaning (al), dead standing (ds), dead broken (db), or dead leaning (dl). The results are presented as a percentage of each category by species. Dead trees on the ground were not measured or given a classification.

Crown Rating: Crown rating is the degree of mortality of the fine branches found in the crown of the tree and gives a more detailed assessment of tree health. Trees were grouped by species and given a rating of 1 to 5. Each rating is defined by the percentage of fine branch mortality, where category 1 is a healthy tree with less than 10% mortality, category 2 is a tree that has light to moderate decline of 10 to 50% branch mortality, and category 3 is a tree that has severe decline with more than 50% branch

mortality. The last two category, 4 and 5, are for dead trees that are dead naturally or dead due to human causes, respectively.

Crown Class: Trees were grouped by species and given a classification based on the overall height in relation to other trees and the amount of sunlight the tree crown received. Five different crown classes were used. Dominant: the individual is above other trees and receives full sunlight from the top as well sides; Co-dominant: the individual is approximately the same height as others in the canopy and receives full sunlight from above and partial sunlight from the sides; Intermediate: the individual is below the other trees and only a smaller portion of the top of the crown receives full sunlight, with little to no direct sunlight from the sides; Suppressed: the individual receives no direct sunlight and is below other trees in the canopy stratum and; Open: the tree is not near other trees and receives full sunlight from all sides. The results are presented as a percentage of each class by species.

Shrub and Small Tree Stratum

The current EMAN protocol was not followed exactly for shrubs and small tree subplots, but used as a rough guideline. The MBMF has used an earlier version of the shrub and small tree protocol to establish monitoring plots for the last several years. To be consistent with previous MBMF plots, we chose to keep using the older protocols. Notable changes include: all shrubs and saplings (<4cm dbh) were recorded with no minimum height restriction, and; heights were not recorded into height classes but rather to the nearest decimetre. Also, the four 5 by 5 metre subplots were placed inside each corner of the larger 20x20m tree plot.

Most woody non tree species were recorded and classed as a shrub. All seedlings (4-10cm dbh) were tagged similar to regular trees; however crown ratings and crown classes were not recorded. Only saplings had their height recorded. The results are grouped by species and the average number for the stand is represented. See appendix III for a list of all shrub species surveyed.

Ground Vegetation Stratum

The ground layer vegetation stratum included all species of vegetation growing in four 1x1 metre subplots. This included ground moss, lichen, ferns, grasses, sedges, fungi, and herbaceous and woody species. For each species present in the subplots, percent cover was estimated. Percent cover was not exclusive and did not add to 100% for each plot due to multiple layers of vegetation being present at one time. All plants hanging over but not originating in the subplot were ignored. The average percent

cover and frequency for each species was calculated for the stand. Appendix III has a list of all species found in the subplots. As it was possible to miss some species due to the small area monitored ($4m^2$), any species inside the 20x20 metre plot not found in the 1x1 metre herb subplots were identified and their presence recorded. This gave a more accurate assessment of the presence of ground vegetation species in the entire 20x20m plot, allowing for a better picture of species composition of the entire forest stand.

Downed Woody Debris

Transects to measure the quantity and condition of downed woody debris (dwd) were established from the corners of the plots. Three transects, each 45.15 metres long were established (if possible). The transects were parallel with the A-B, B-C, C-D, and D-A lines, and originated from a corner post. Preferably, the A-B, B-C, and D-A parallel lines were used; however, the C-D line was used if obstructions prevented use of another line. All dwd 4 centimetres or more in diameter were measured as they crossed the transect. The diameter, species, and decomposition class was recorded for each piece. Decomposition was rated on a scale from 1 to 5, with 1 being the least decomposed (fine twigs and bark present), to 5 being the most decomposed (no or little bark present, twigs and major branches absent, discoloured grey, soft, and powdery). The average decomposition class, number of logs and volume were calculated per transect, then further averaged per plot.

Tree Height

In each plot five height measurements were taken of dominant or co-dominant trees. Species selected for measurement reflected the proportion present in the plot, e.g. a high proportion of burr oak species were measured due to the large number of burr oak present in the plots. Trees were measured using a Sunto Clinometer model PM-5/360PC that measured the height of a tree based on the percentage of the distance from the tree. Heights were averaged in each plot, and then further averaged to reflect the average canopy height of the stand.

Tree Age

Five trees were cored per plot using an increment borer to determine the average tree age in each plot. The same trees used to determine tree height were cored since they were the tallest, thus likely the oldest in the plot. Each average age of the plot was then further averaged to give the approximate age of the dominant trees in the stand.

Light Transmission

Light transmission was measured in each plot by comparing the amount of light transmitted inside the plot under the canopy to an open, non-shaded area. Five measurements in random locations were taken per plot, the percent transmission calculated, and the results averaged. The results from each plot were further averaged to give an average for the entire stand.

Results and Discussion

General Description of the Study Site

Area Description: The protected Bois des Esprit Forest area is situated inside the city of Winnipeg (Figure 2) bordered by residential and commercial areas (Figure 3). To the north, urban development and housing have been present for over the past twenty years. To the west is St. Anne's Road, a major thoroughfare, and commercial and apartment complexes intrude up to the Seine River itself. To the east a new residential development was completed in the past two years, and the south has a mix of

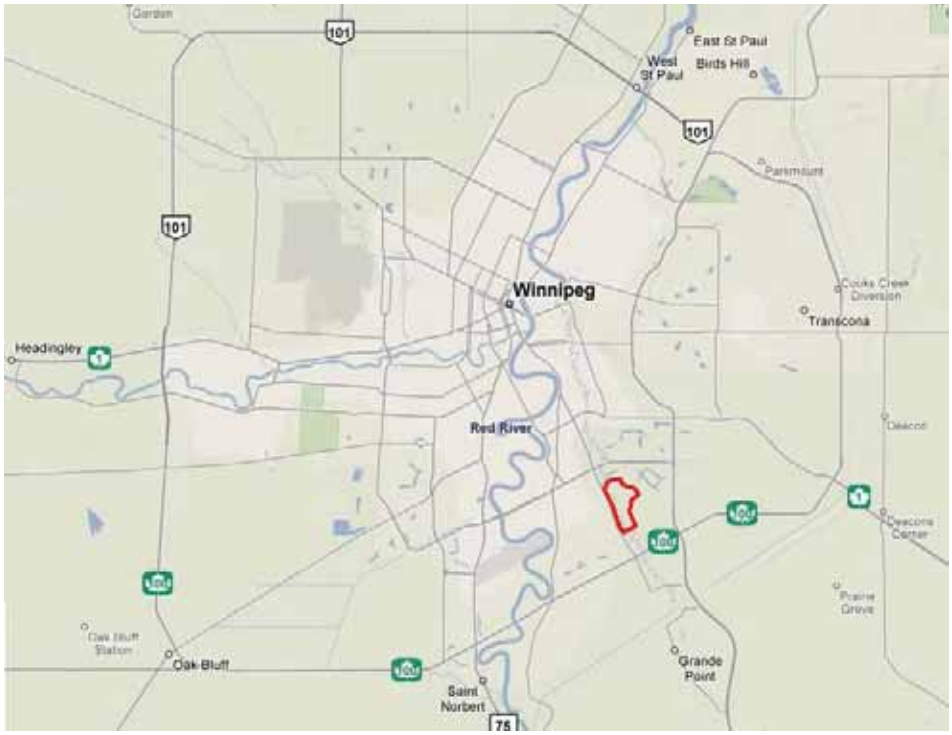

Figure 2: The City of Winnipeg with the Bois des Esprit area highlighted in red.

commercial and industrial complexes up stream on the Seine River. Given the surrounding areas, the Seine River and protected Bois des Esprit area face environmental and sustainability challenges, thus warranting concern by several groups.

Figure 3: Bois des Esprit area outlined in red in the City of Winnipeg. Study plots are marked in purple.

The City of Winnipeg, Province of Manitoba, and the non-government organization “Save our Seine” have been instrumental in establishing this forest area as a protected area. Concern for the area was raised when urban and commercial development had started to replace previously undeveloped green

space inside the city, and along the Seine River. The Bois des Esprit area is one of the few areas along the Seine River still considered pristine and is recognized for the role it plays in the area; it is a valuable green space for public use, a heritage site, and a refuge for wildlife and waterfowl (HTFC 2007).

Area Uses and Purpose: The Bois des Esprit area is a valuable area inside the city. The area has a network of walking and off-road biking trails, picnic areas, letting citizens enjoy nature and the outdoors, and is host to cultural icons.

Figure 4: Woody the Tree Spirit on a walking trail in Bois des Esprit.

Cultural and historical features include Woody the Tree Spirit (Figure 4), the former Mager House site (2006), several giant cottonwoods, a late woodland era archaeological site, and the historical St. Vital/St.

Norbert Parish Boundary (HTFC 2007). An open meadow area northeast of plot 2 is also thought to possibly be a former historic homestead and Métis use site, but has yet to be confirmed (HTFC 2007). These historical sites inside the Bois des Esprit area add more reason to protect and maintain the area.

Lastly, the area has a diverse range of wildlife that use it for living, browsing, nesting, or a refuge from humans (Figures 5 and 6). A survey performed by HTFC Landscaping & Architecture firm (2007) recorded 24 mammal species, 149 bird and waterfowl species, 5 amphibian species, and 6 fish species that live in or around the Bois des Esprit area. Preserving and monitoring the health of the area is imperative to ensuring the continued presence of these species.

Figure 4: Multiple birds forage and live in the area

Figure 5: Deer commonly live and browse in Bois des Esprit.

Habitat Types: Multiple different types of habitat exist in the Bois des Esprit habitat. These include river bottom or riverbank areas (Figure 7), upland oak forest (Figure 8), cottonwood forest (Figure 9), aspen forest, meadow grasslands, and oxbow wetland areas. The diverse range of habitat allows for the multitude of animal species indicated above, to live in the forest, and also creates multiple diverse pockets of flora. The river bottom area contains a number or elm, cottonwood, willow, ash, and aquatic macrophyte species, while the oxbow and wetland areas allow for marsh species like cattails to exist within 100 metres of each other. Both areas also provide breeding areas for specific amphibian species, either in the stagnant marsh areas, or the flowing water in the river. The upland oak and aspen forest also allows for a wide variety of tree and shrub species, providing cover, homes and food for mammal and bird species. Grasslands or meadows also allow mixed grass and flower species to exist in the area (HTFC 2007).

Plot Locations: Study plots were established in upland oak forest areas. These areas also contained aspen trees. Figure 3 indicates plot placement throughout the area. Paths, oxbows and meadows are spread throughout the area, so most plots bordered, or were within 50 metres of an opening in the canopy.

Figure 7: The Seine Rivers bank surrounded by grass, sedge, cottonwood, and oak.

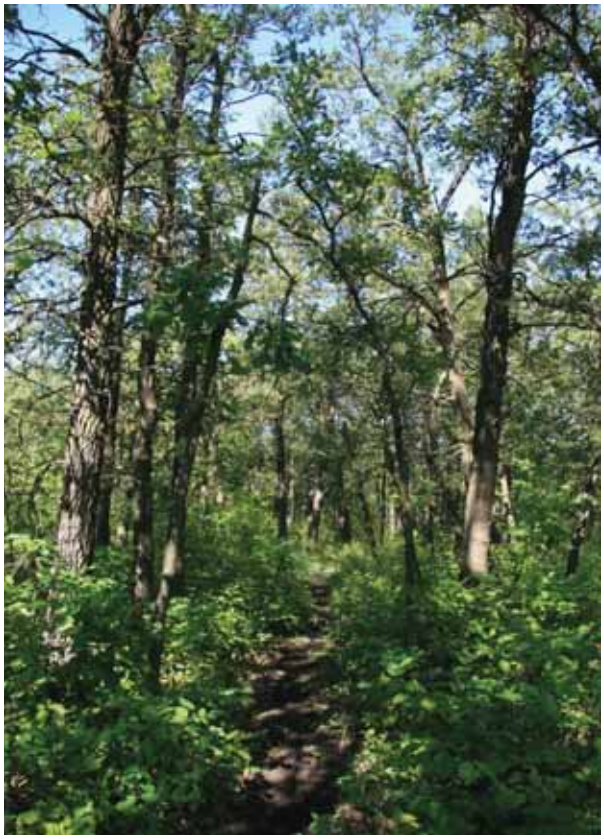

Figure 8: Upland oak forest in the Bois des Esprit area.

Figure 9: A giant cottonwood tree along the Seine River.

Canopy Tree Stratum

Tree Measurement and Calculations:

Our baseline monitoring suggests that the Bois des Esprit area appears in good health. Figure 10 shows that there is over 13 times more live burr oak (*Quercus macrocarpa*) trees than dead ones. There were not any dead american elms (*Ulmus americana*) or green or black ash (*Fraxinus spp.*) trees. The proportion of dead trembling aspen (*Populus tremoloides*) trees was higher than any other species, with more than half of the aspen dead per plot. As well, the number of dead aspen trees equalled that of oak per plot, even though there were 8 times more oak than aspen trees.

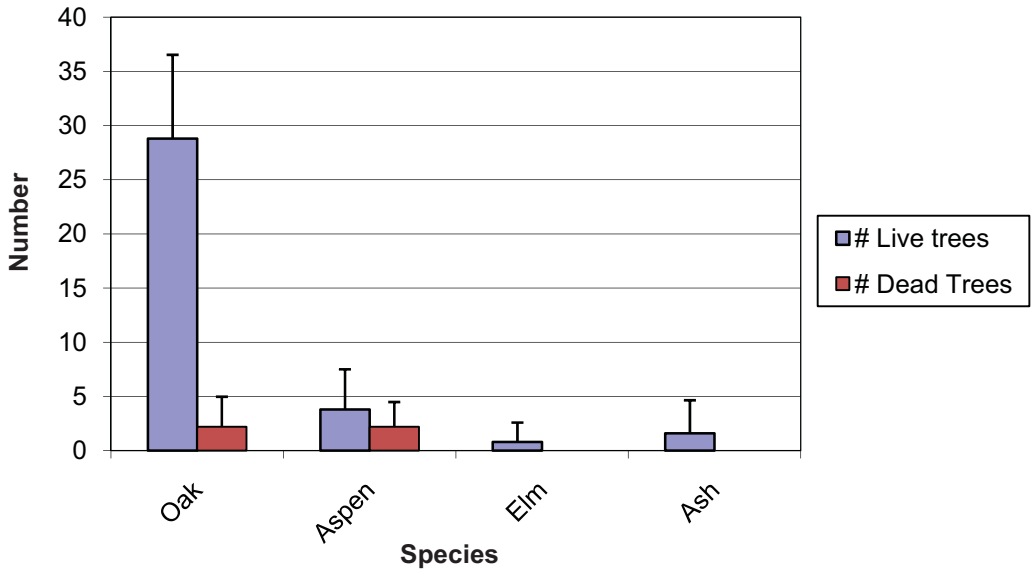

Figure 10: Number of live trees and dead trees per plot in the Bois des Esprit.

In terms of species abundance, oak was the most abundant tree in the stand (Figure 11). Despite the plots being located on a terrace above and a distance away from the Seine River, there were some elm and ash, species more typical of a river bottom habitat. Other tree species closer to the river but not inside the study plots were cottonwood, basswood, and maple species. Aspen trees were present in our plots but did not have a dominant presence. According to a habitat area plan produced by HTFC (2007),

aspen are prominent on the eastern edge of the Bois des Esprit area near the residential area, east of study plots 2, 3, and 4.

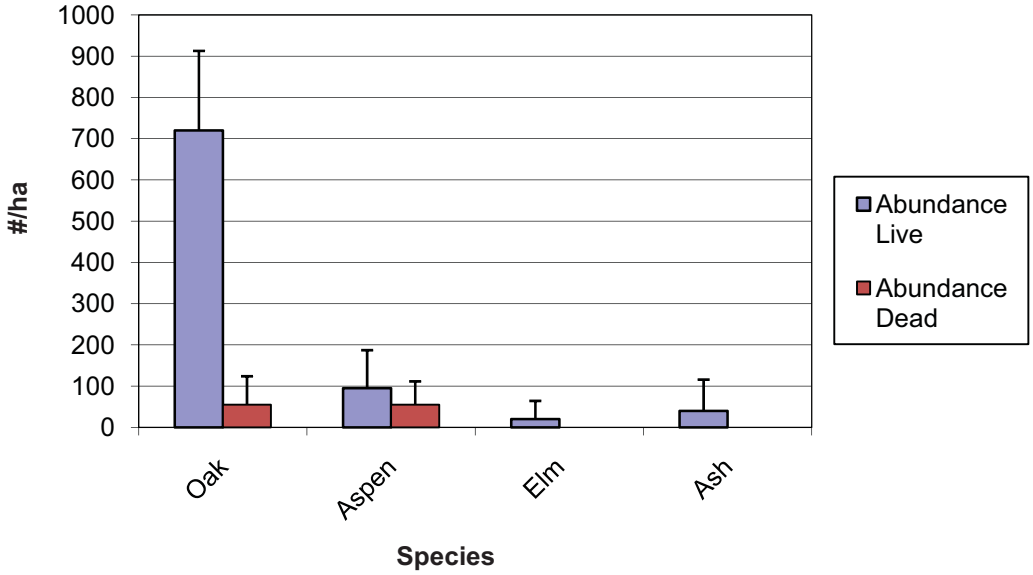

Figure 11: Abundance of live and dead trees (number per hectare).

When comparing the presence of trees in a stand, it is useful to look at basal area as a different comparison. This allows for a comparison of physical presence or space that a certain species occupies, in comparison to only the number which can over emphasize the presence of a species in the stand. Figure 12 shows a similar trend to that of Figure 11, however, there are some differences. In relative amounts, live and dead oak and ash are similar in both figures; however, elm has less physical presence than based on abundance alone, indicating the live trees present are smaller. Also, aspen shows a difference in that the amount of basal area for dead trees is less than half of the live trees. This may indicate dead aspens are likely small suppressed trees.

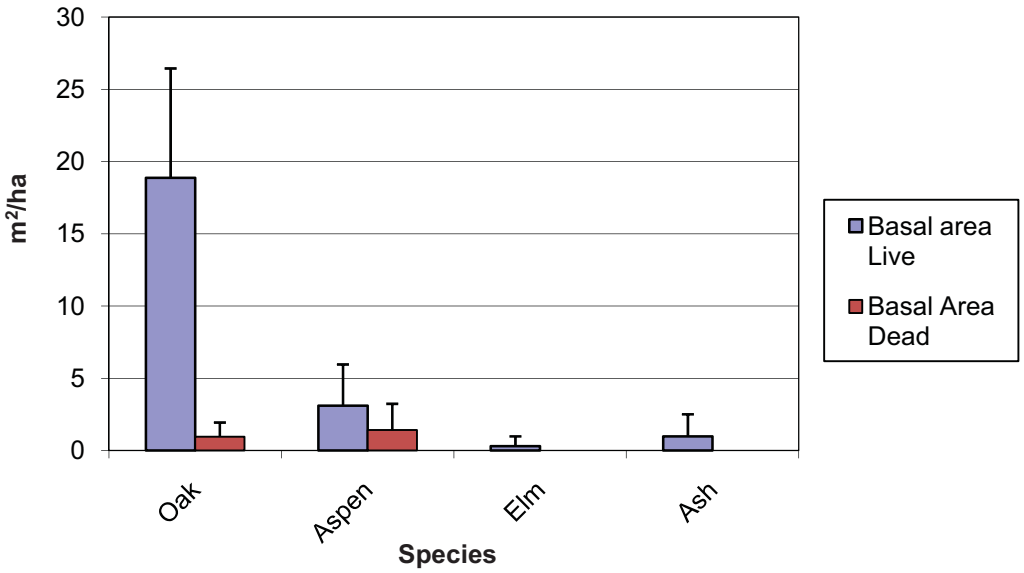

Figure 12: Basal area of live and dead tree species per hectare.

Looking at stand-specific characters such as density, relative density, dominance and relative dominance we see a definite trend (Figures 13 to 16). In all Figures, oak dominates the stand, having a much higher value than all other species combined. Aspen is next closest, but having 6 to 8 times less in comparison to oak. In all cases, elm shows a very small presence, with ash only having slightly more than elm.

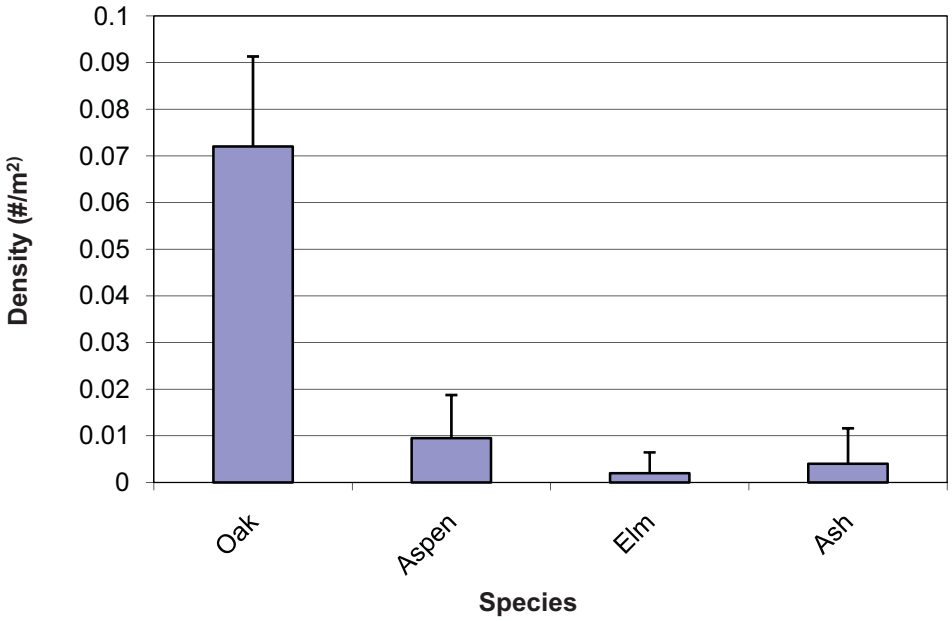

Figure 13: Density of live trees for each species.

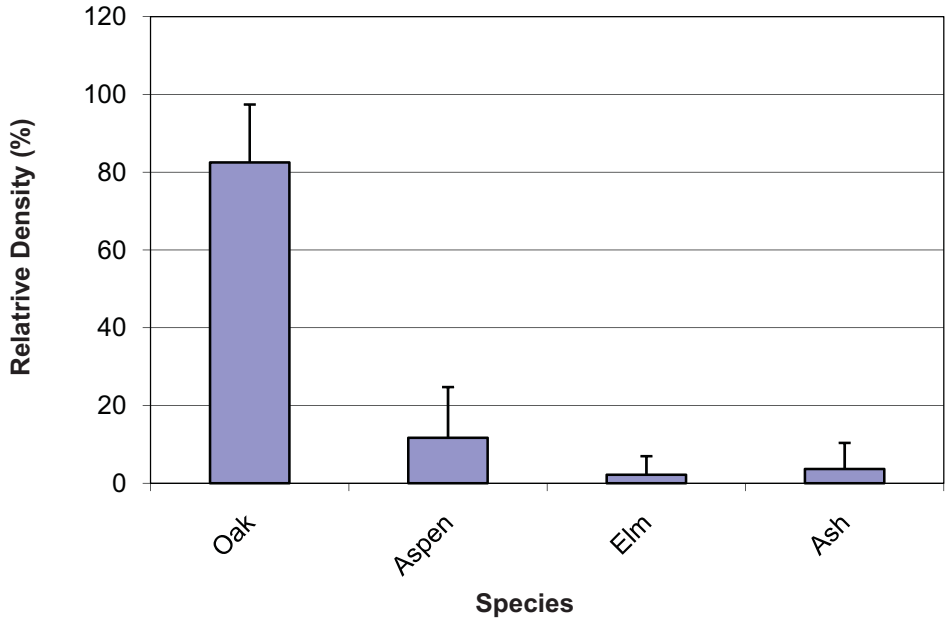

Figure 14: Relative density of live trees for each species.

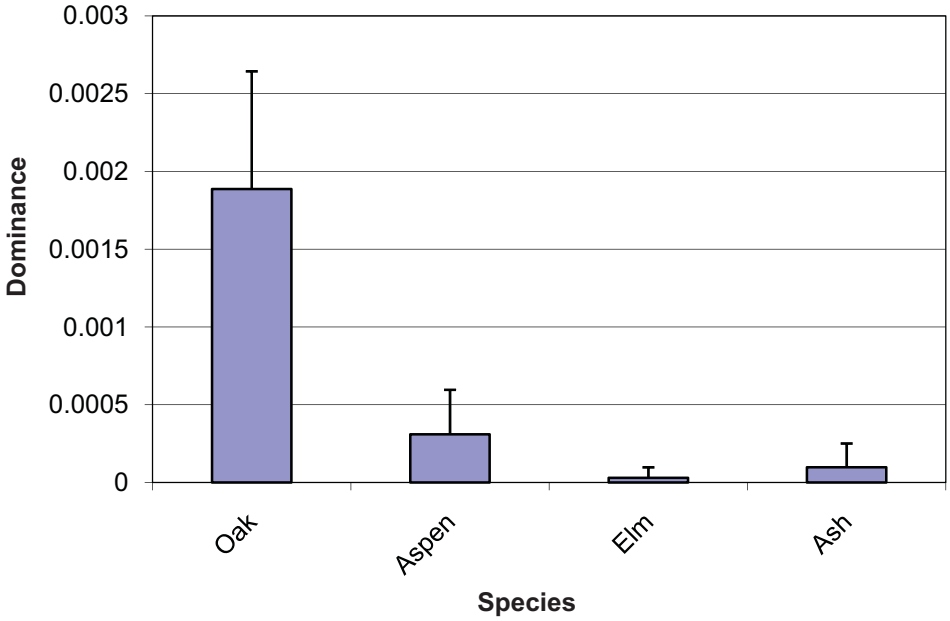

Figure 15: Dominance of live trees for each species.

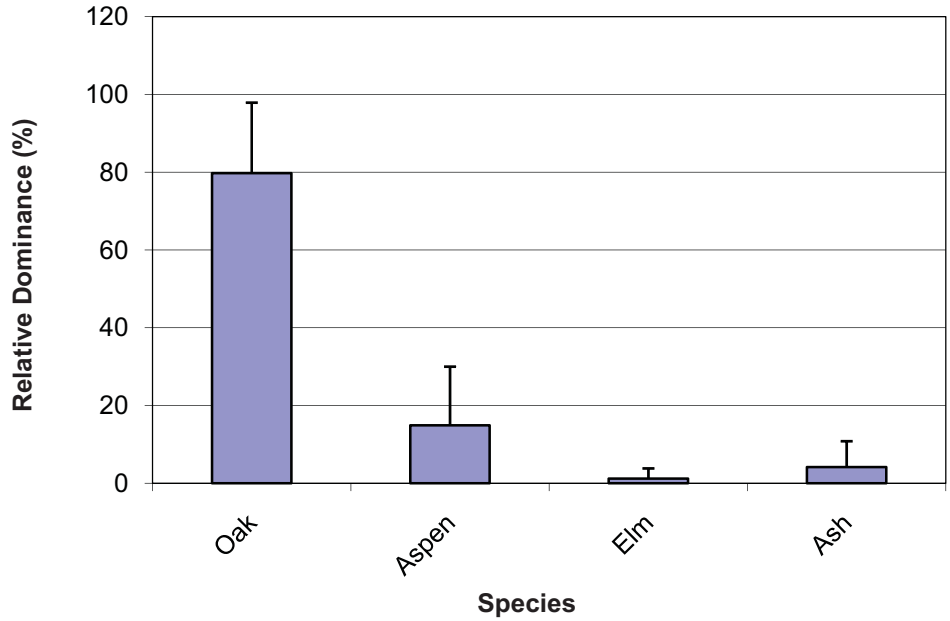

Figure 16: Relative dominance of live trees for each species.

The frequency for which species appeared in the stand followed a different trend than described previously. Figure 17 shows that oak occurred in all plots, while aspen occurred 80% of the time, and elm and ash 20% of the time. Aspen was noted before as having such a small presence compared to oak, however, it was found in most plots. This indicates that aspen is prevalent throughout the stand, however, is subdominant to oak. When we compared each species to all other species (relative density), Figure 18 shows a similar trend as Figure 17. Although each species has a lower percentage, the ratios are similar. This further confirms that aspen is prevalent and a subdominant species in the stand.

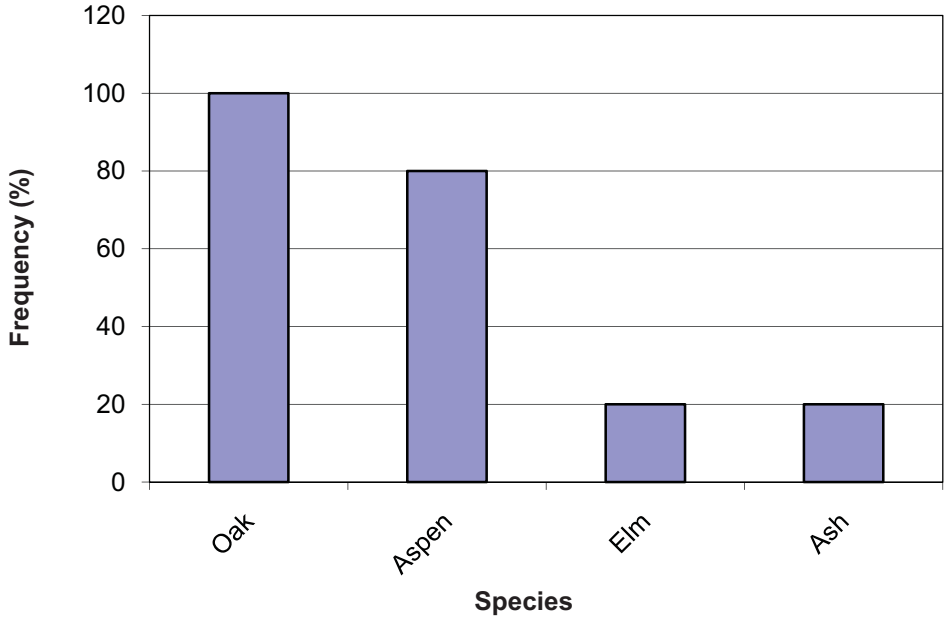

Figure 17: Frequency of live trees for each species.

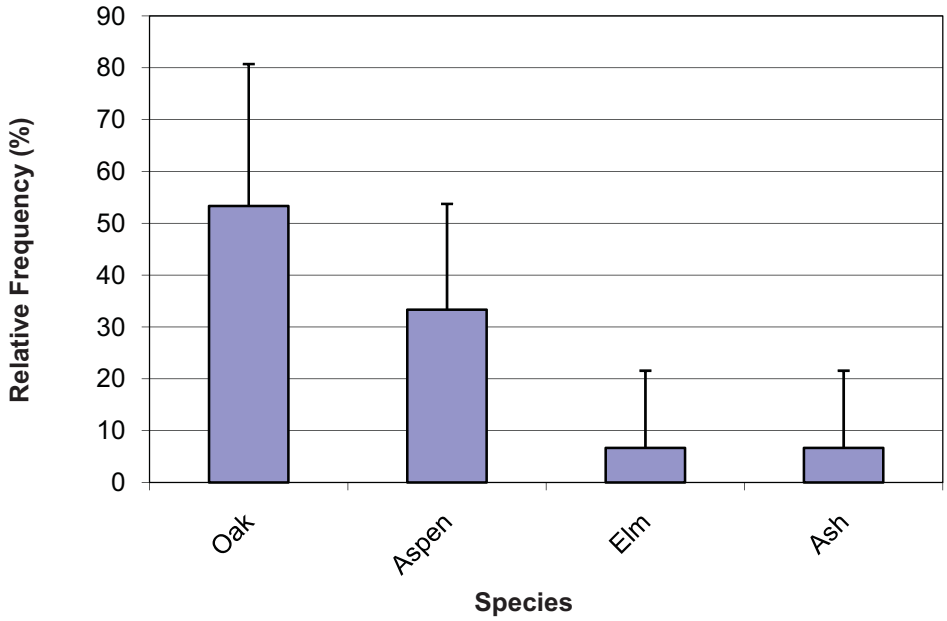

Figure 18: Relative frequency of live trees for each species per plot.

Lastly, we calculated the importance values for the stand. The importance value shows the structural role or importance a species plays within the stand and is made up of the summation of the relative density, relative dominance, and relative frequency values. The maximum value possible in which all species should add up to, is 300 (100 percent added three times for three indexes). Figure 19 shows the importance values for each species, indicating that oak makes up over two thirds of the structural role in the stand. Aspen makes up a much smaller portion, while elm and ash have the smallest importance values. This continues to show the previously noted trends, that oak is the dominant species in the stand, with aspen being a smaller subdominant species, and ash and elm playing minor roles.

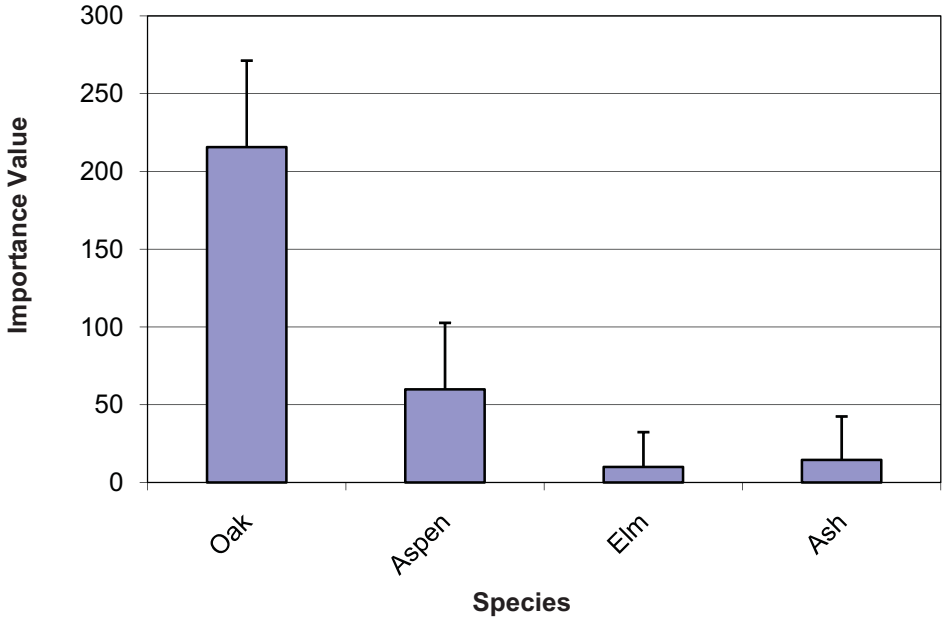

Figure 19: Importance values for each species in the stand.

Tree Health:

Figure 20 shows the percentage of alive and dead trees classified by each health category. For oak, 83% of the trees were classified as alive and standing (as), 9% as alive and leaning (al), and 1% were alive but with the top broken (ab). The remaining approximate 7% of oak trees were dead, either standing (ds), broken (db), or leaning (dl). A large portion of aspen trees (63%) were alive and standing, with the remaining 37% made up of dead trees (standing, leaning and broken). Elm and ash trees were 100% alive, either standing or leaning. Elm and ash had so few trees, so the significance of all of them being alive is little.

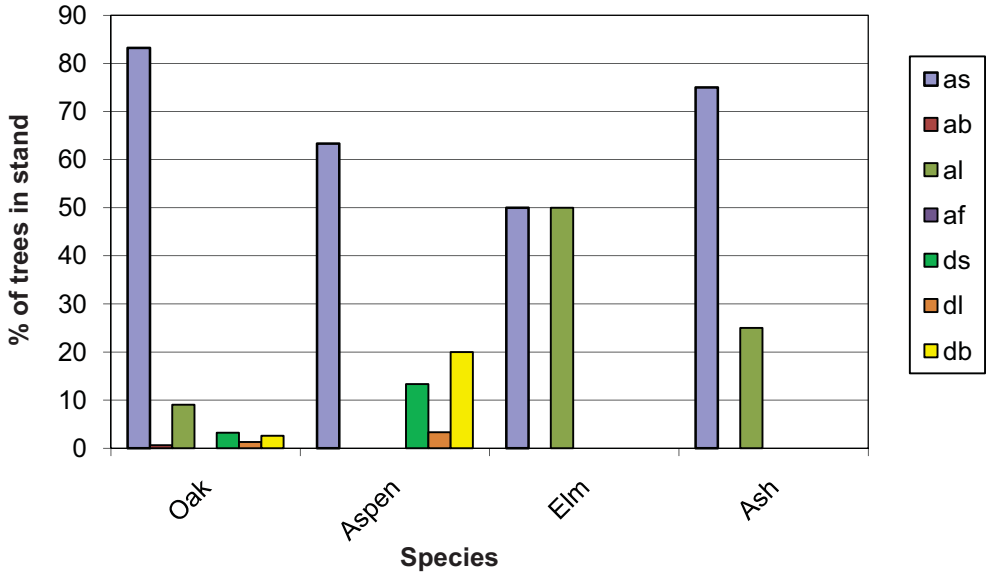

Figure 20: Tree health for each species.

Crown Rating:

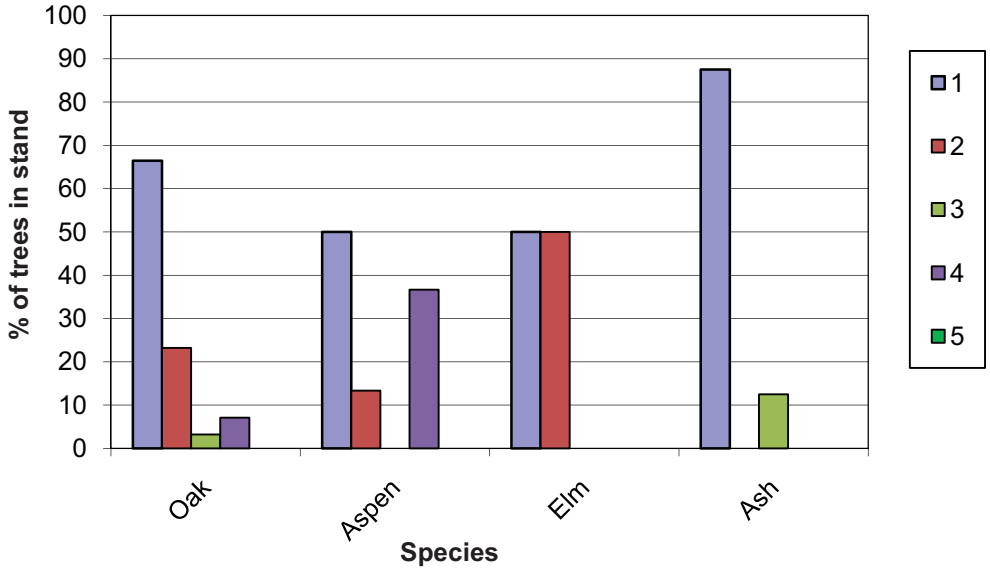

Figure 21: Crown rating for each species.

Each tree was not only assessed for its general overall health, but also the specific branch mortality (crown rating). This lets us examine in more detail how healthy a tree may be. The previous section gives only a very general assessment, and indicating whether trees are alive or not does not indicate if the stand is actually healthy. The categories of 1 (less than 10% branch mortality), 2 (10-50% branch mortality), and 3 (more than 50% branch mortality) allowed us to look at the more specific overall tree health of the stand. This assessment can identify factors affecting trees such as possible disease, parasites, or insect infestations, which measuring dbh and checking whether the tree is simply alive or dead will not do.

As shown in Figure 21, the majority of the trees in the stand were healthy with less than 10% branch mortality; 66.5% of oak, 50% of aspen and elm, and 87.5% of ash were in class 1. In addition, most remaining live trees appeared healthy with less than 50% branch mortality (class 2). Although half of the elms were in class 1 and half in class 2, the number of trees (8 in total) doesn't allow us to draw many conclusions about tree health. Unhealthy or declining trees (more than 50% mortality) were not common, with only 3.5% of oaks and 12.5% of ash trees found in this category. The remaining percentage of trees in Figure 21 include those that appeared dead naturally (rated as a 4). Despite the Bois des Esprit area being situated in an urban area, there were no indications of trees being killed by human causes (rated as a 5).

Crown Class:

Crown class allows us to examine how a species occupies space vertically in the stand. This however, only assesses the live trees in the stand, as dead trees, even if standing, were not given a crown class rating. Therefore, this cannot help us understand whether or not all of the dead trees in a stand (e.g. aspen) were small suppressed trees, or large dominant trees, etc.

A large portion of the oak trees (42%) were co-dominant (Figure 22) and intermediate (35%), with only a few being dominant (9%) and suppressed (14%). In contrast, the majority of aspen trees were dominant (37%) and co-dominant (42%), with only 21% being intermediate, and having no suppressed trees. This can be attributed to aspen growth patterns compared to oak. Aspen has a higher growth rate and is a pioneer or opportunistic species compared to oak trees which grow slower, have harder wood, and are a later successional species.

Elm and ash species by comparison, were usually smaller and not often dominant or co-dominant in the stand. For elm, 25% of its trees were co-dominant and suppressed, while 50% were intermediate. Only 12.5% of ash was dominant and co-dominant, and 37.5% were intermediate and suppressed trees. These low percentages for dominant and co-dominant trees can be attributed to the few trees being present in the stand, and that they may still need to establish themselves in the successional scheme of the stand. It may also indicate that these species are a more dominant component of the canopy closer to the Seine River, rather than on the adjacent terraces.

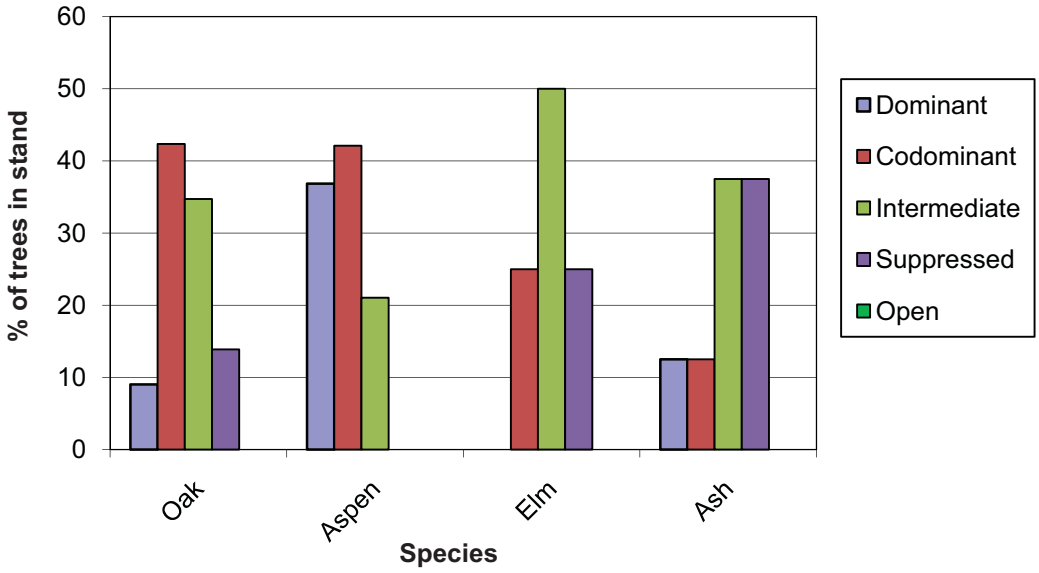

Figure 22: Crown class for each species.

Tree Defects:

There were very few defects observed during the survey. The majority (4) were open wounds on oak trees. In addition, there was some animal damage noted on an elm tree, and some decay fruiting fungus bodies (*Foames* spp.) spotted on an aspen. Overall there were few notable defects, and the boles and bases of trees seemed to be in good health.

Shrub and Small Tree Stratum

The Bois des Esprit area has a thick understory layer made up of several species. The understory ranged from more open low bush areas filled with saplings and raspberry in some areas, to dense high areas filled with arrowood and saskatoons. The average understory height was approximately 83 centimetres, with several quadrats in the plots reaching an average height of one metre or more (maximum of 134 centimetres).

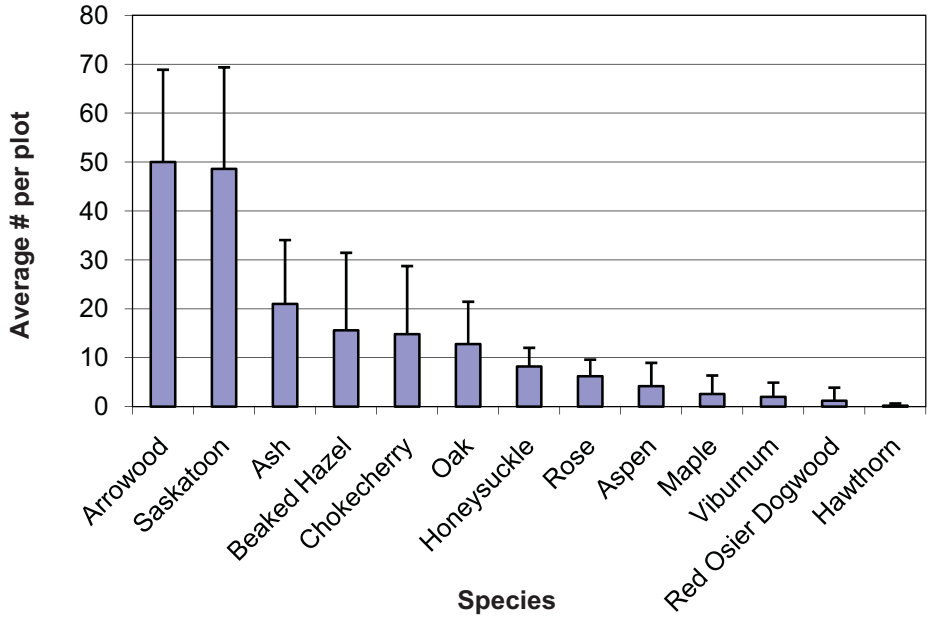

Figure 23: Shrub and small tree species composition and number found in the Bois des Esprit oak stand.

The shrub and small tree composition of the stand is described in Figure 23. Arrowood and saskatoon were the two dominant species in the understory, both in numbers and height, sometimes reaching up to 3.5 metres in height. Beaked hazel was present, but was not as abundant as the two previous species. However, it did exist in dense clumps throughout the stand. Ash saplings were also common, found growing and competing for height with arrowood and saskatoon. Oak saplings were also present throughout the stand, but usually under the taller aforementioned understory species. Chokecherry was also present in the stand and was found growing at varied heights; sometimes taller (one was measured as high as 5 metres) and sometimes shorter like oak saplings (under the other understory).

The other shrub and tree species were less common. Aspen, red osier dogwood and hawthorn were found in some cases to be growing above the rest of the understory, however, were equally found growing as ground cover. Rose, maple, and *Viburnum* spp. were found sporadically and usually were short growing under 1 metre in height.

The frequency of shrub and small tree species found in the five study plots is presented in Figure 24. Ash, oak, honeysuckle, rose, saskatoon, and arrowood were found in all five plots. Other main species included aspen, beaked hazel, chokecherry, *Viburnum* spp. and maple that were found in 3 of the 5 plots. Red osier dogwood and hawthorn were only found in one plot, consistent with the finding that they had the least average number per plot (Figure 23).

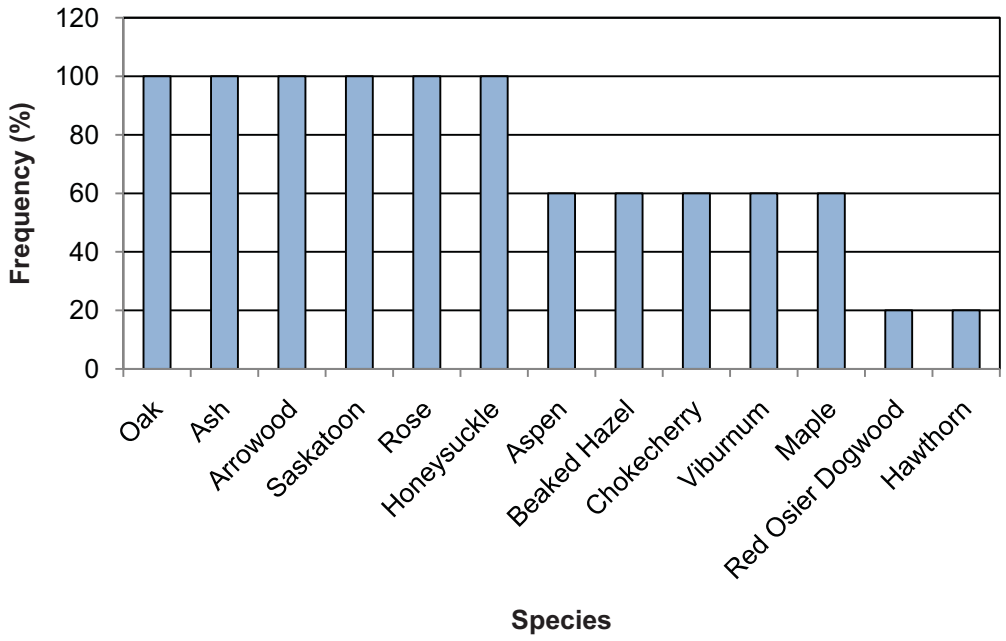

Figure 24: Frequency of shrub and sapling species found per plot.

Ground Vegetation Stratum

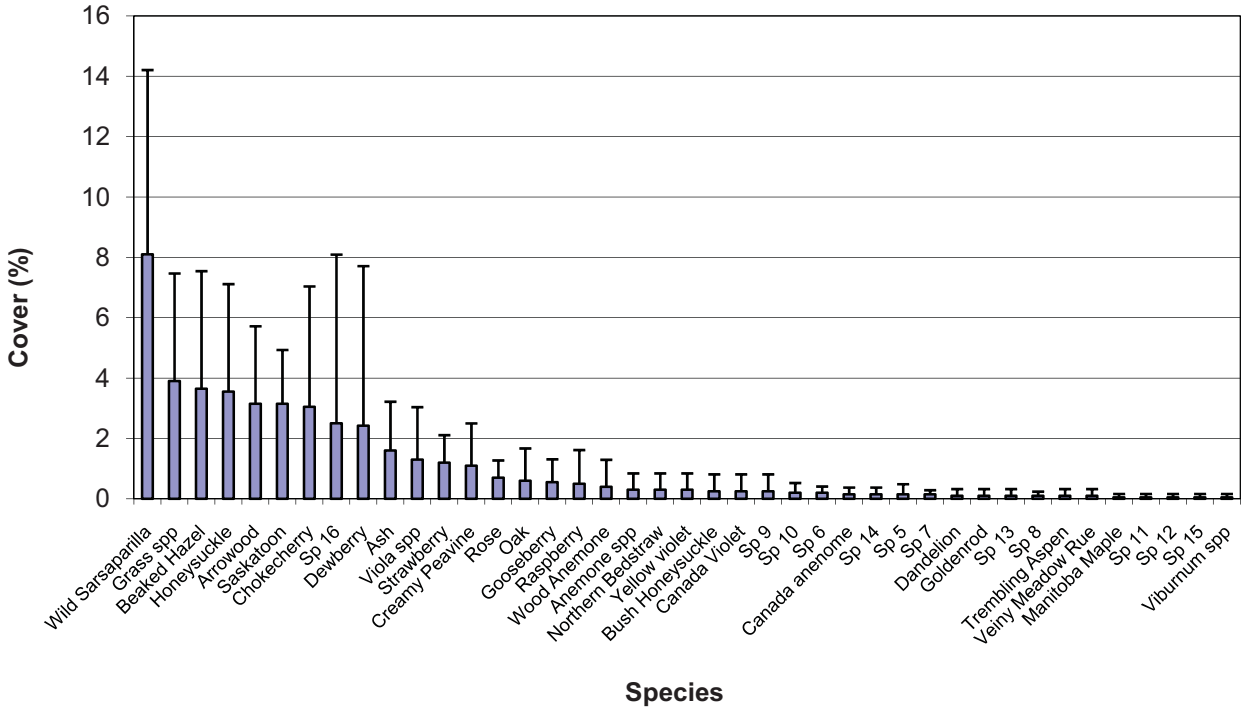

Figure 25: Ground vegetation percent cover for each species.

A multitude of different plant species were found in the 1x1 metre subplots (Figure 25). The Bois des Esprit area had no species that covered a large portion of the area. Wild sarsaparilla had the highest percent cover, at 8.1%. Most species had less than 2% cover, indicating there was sparse cover in most subplots. This was due to the many different types of plants found, and the fact that none occupied a large amount of space in the plot. Also, higher understory from the shrub and small tree layer shaded the ground and likely limited ground vegetation growth; however, it did not cover a large amount of area.

Ground vegetation species composition was very patchy, as demonstrated by the high standard deviations shown in Figure 25, and the frequency of each species in Figure 26. A species with a higher percent cover did not always dictate if it was often found in all the plots. An example of this is unknown species 16 (Sp16), that was found only in one 1x1 subplot in one of the plots, but had a very high percent cover (50%). Thus, it artificially increased its overall cover average up to 2.5% throughout the stand, near that of common species like arrowood and chokecherry.

Each subplot was fairly diverse, with at least 11 unknown/unidentified species present, often found in only one or two plots. A reason for the large number of unidentifiable species may be due to the Bois des Esprit's proximity to urban gardens. Seeds from nearby areas may blow in and grow, thus competing with native species in the stand. As well, there were several species observed in the plot that did not fall into the 1x1 metre ground layer subplots. These included: burdock, clover spp., three-leaved false solomon-seal, sweet scented bedstraw, and wild lily of the valley.

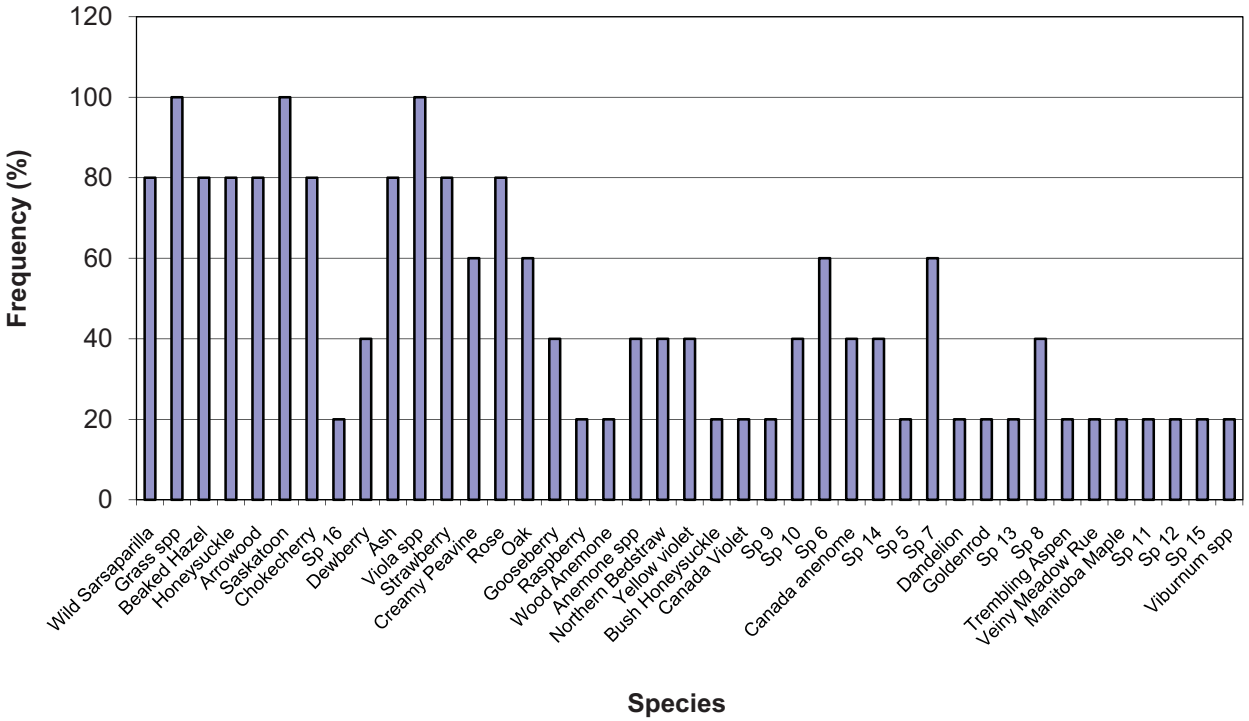

Figure 26: Frequency of ground vegetation plant species found in ground vegetation layer cover estimates per plot.

Downed Woody Debris

Downed woody debris transects were not always established according to the protocol discussed in the methods section. Plot 1 had only two transects instead of three; and plots 1 and 5 used the C-D line for one of the line transects since another location was not possible for measurement (an obstacle was present which prevented a full 45.15 metre line transect). Table 1 shows the results for the number of pieces per transect, diameter, and volume per plot.

There was an average of 7.63 (range of 3 to 14) pieces per transect. The average diameter (9.11cm) was fairly consistent with a small range. Lastly, the average volume of wood found on the line transects was 20.89 cubic metres. Volume was highly variable with a range of 2.15 to 40.93 cubic metres.

Table 1: Summary of downed woody debris data.

	Average	Std. Dev.
No. Pieces per transect	7.63	3.08
Diameter (cm)	9.11	1.90
Volume (m^3)	20.89	11.82

Figure 27 describes the average percentage of pieces found in each decomposition class. The Bois des Esprit area had few recently fallen trees or logs, with only 7.6%, 11.4%, and 15.2% in class one to three, respectively. A large portion of the fallen trees and logs were found to be fairly (41.9%) and very decomposed (23.8%), or class 4 and 5, respectively. Most identifiable logs and fallen trees were oak, with only two aspen logs found. There were however, a large portion of unidentifiable species of logs and fallen trees due to their advanced decomposition state.

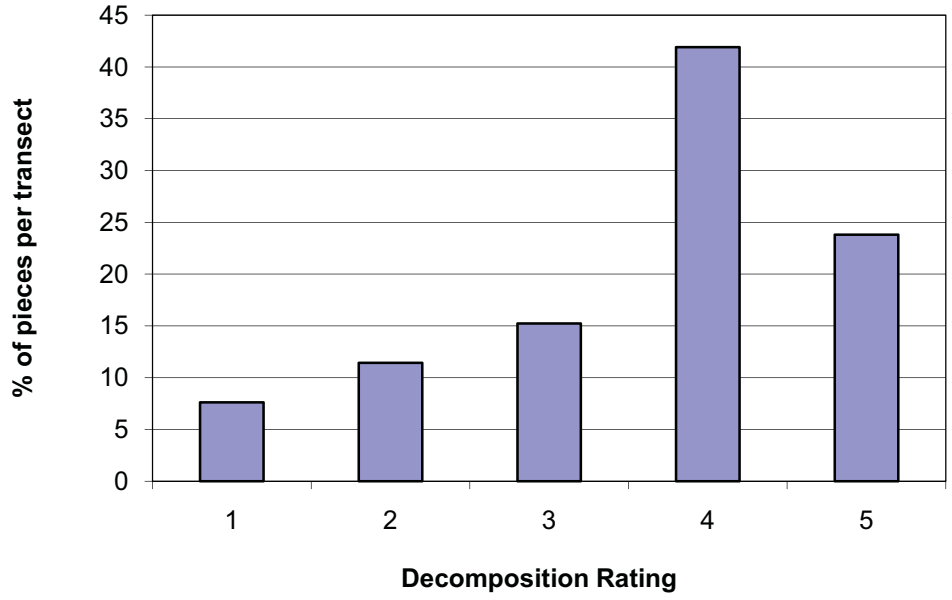

Figure 27: Decomposition class (1-5) shown as a percentage of the total number of pieces.

Light, Tree Height and Tree Age Measurements

Light penetration to the ground was limited, with an average of 32.9% transmission (8.8% standard deviation). This indicates, as suspected above, that the ground layer receives little light. This may explain why ground cover was sparse, since only a third of full sunlight reached the ground through the tree canopy and shrub layer. The maximum was 45.5% in plot 1, and the minimum was 24.6% in plot 3.

The average height of the dominant tree layer was approximately 13.3 metres (1.1 metre standard deviation). Trees measured were burr oak (17), aspen (7), and one ash tree. This may indicate that the stand is younger, since burr oak trees can grow up to 30 metres in height, and aspen up to 25 metres (Wikipedia, 2008). However, these are approximate maximum heights, as maximum height may be dependent on climatic and soil conditions. Also, most trees in the stand were approximately the same height indicating that the stand is even aged.

Tree ages were determined by coring the same trees which had their heights taken, thereby aging the dominant and oldest in the stand. Oak trees can live up to 300 years, and aspen can reach an age up to 120 years before dieback occurs. The average age of the oaks in the stand was 73.25 years (standard deviation of 5.2 years) indicating that the stand is younger and has not grown to its full potential.

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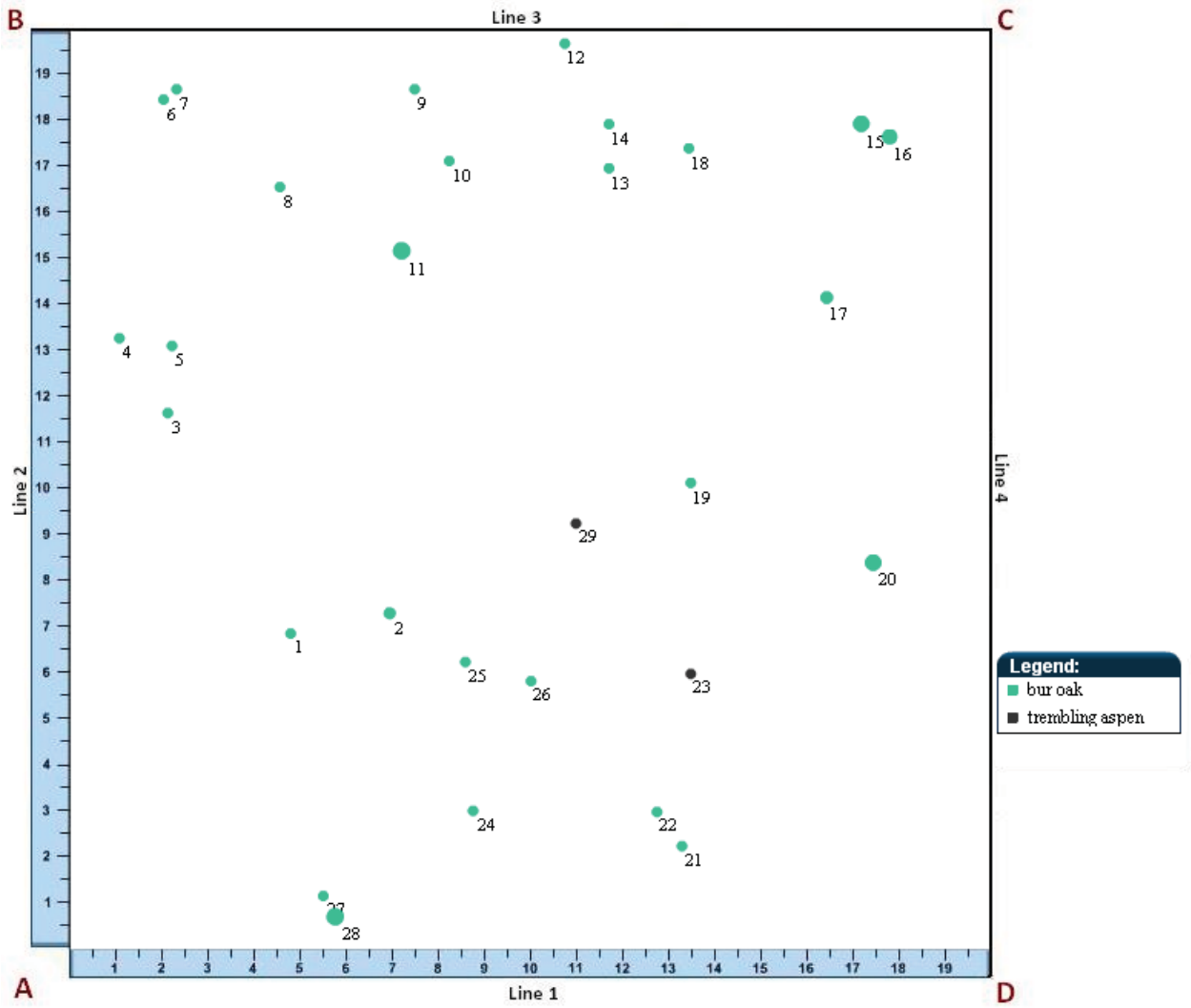
Appendix I: List of Study Plots and GPS Locations

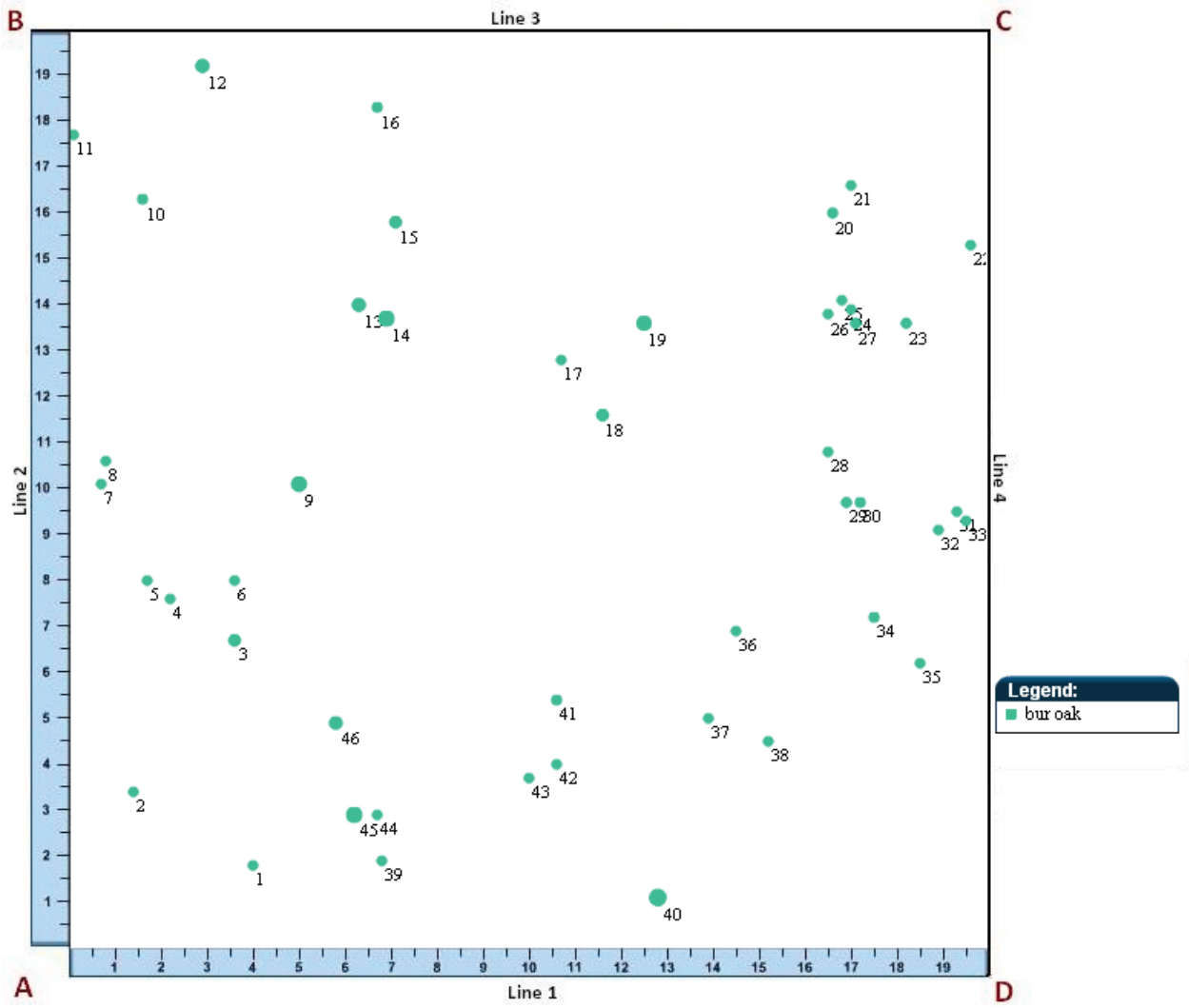
Stand	Plot No.	Latitude	Longitude	Accuracy (±m)	Bearing	Date Sampled (m/d/y)
Bois des Esprit	1	49˚ 49.454	097˚ 04.771	5.7	87˚	06/10/2008
Bois des Esprit	2	49˚ 49.746	097˚ 04.853	1.3	336˚	06/11/2008
Bois des Esprit	3	49˚ 49.846	097˚ 05.008	2.0	47˚	06/12/2008
Bois des Esprit	4	49˚ 49.810	097 ˚ 05.011	2.8	108˚	06/12/2008
Bois des Esprit	5	49˚49.401	097˚04.748	5.5	182˚	06/10/2008

Appendix II: Study Plot Maps Showing Tree Species and Orientation

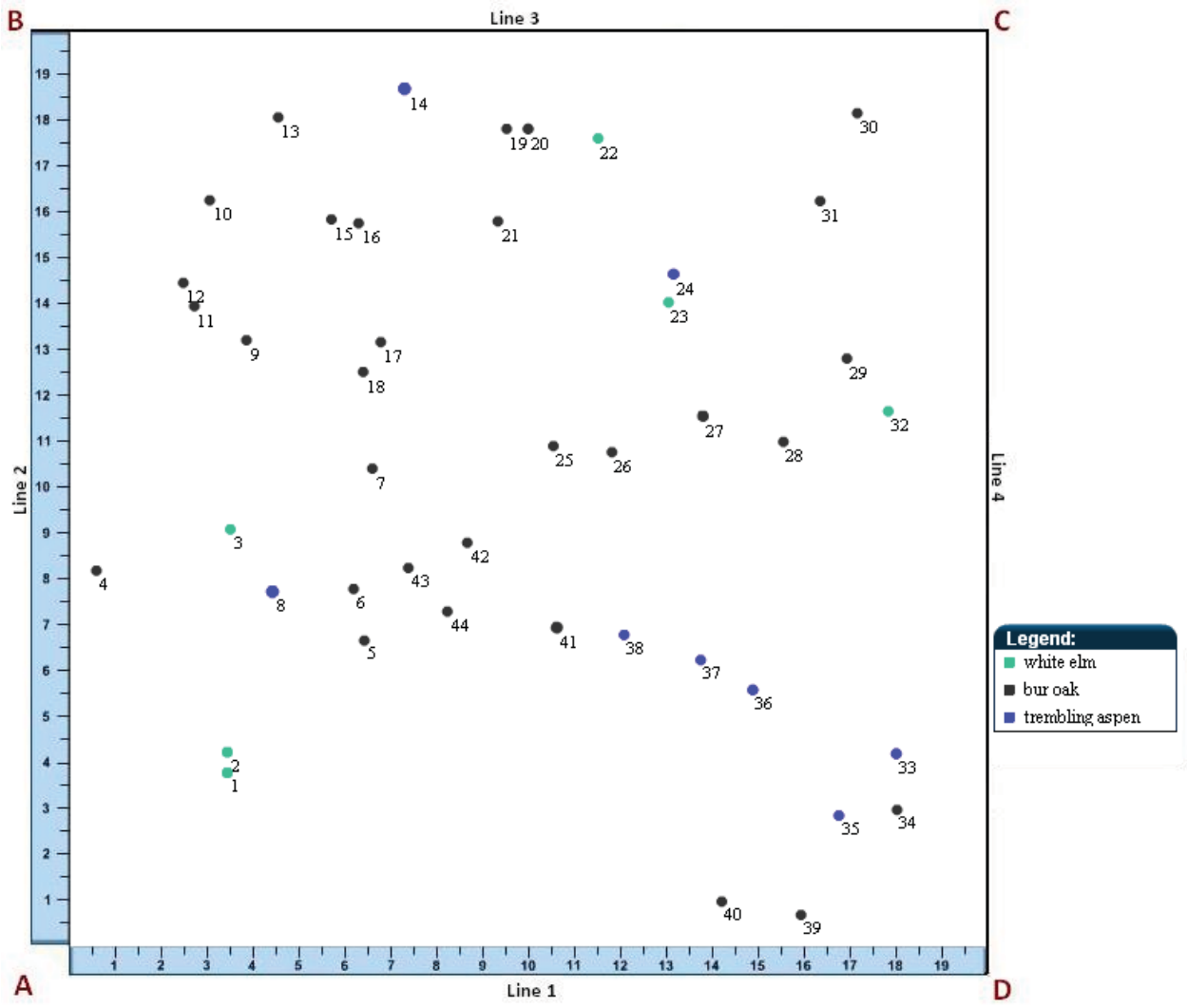
Bois des Esprit Oak Plot 1



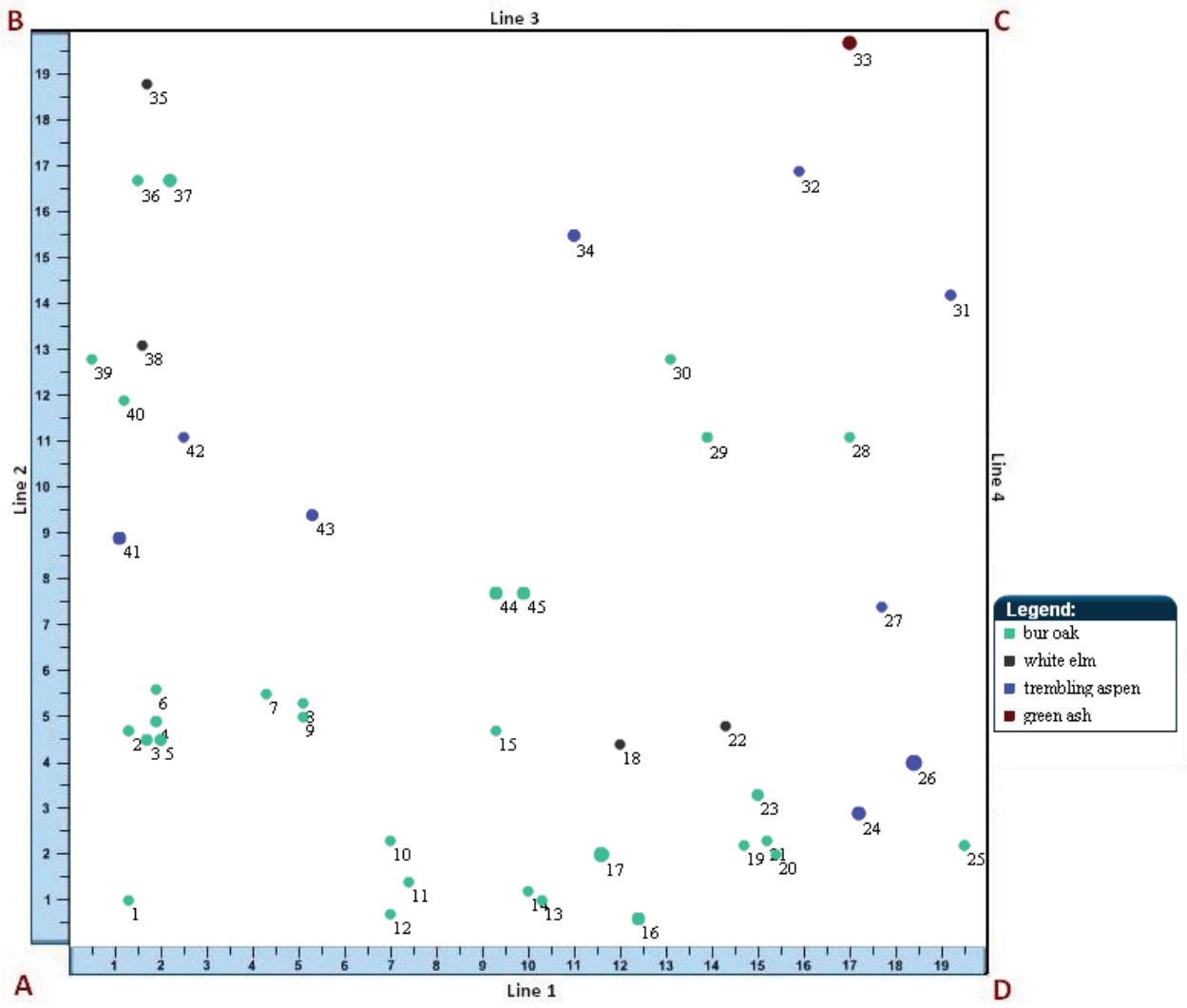
Bois des Esprit Oak Plot 2



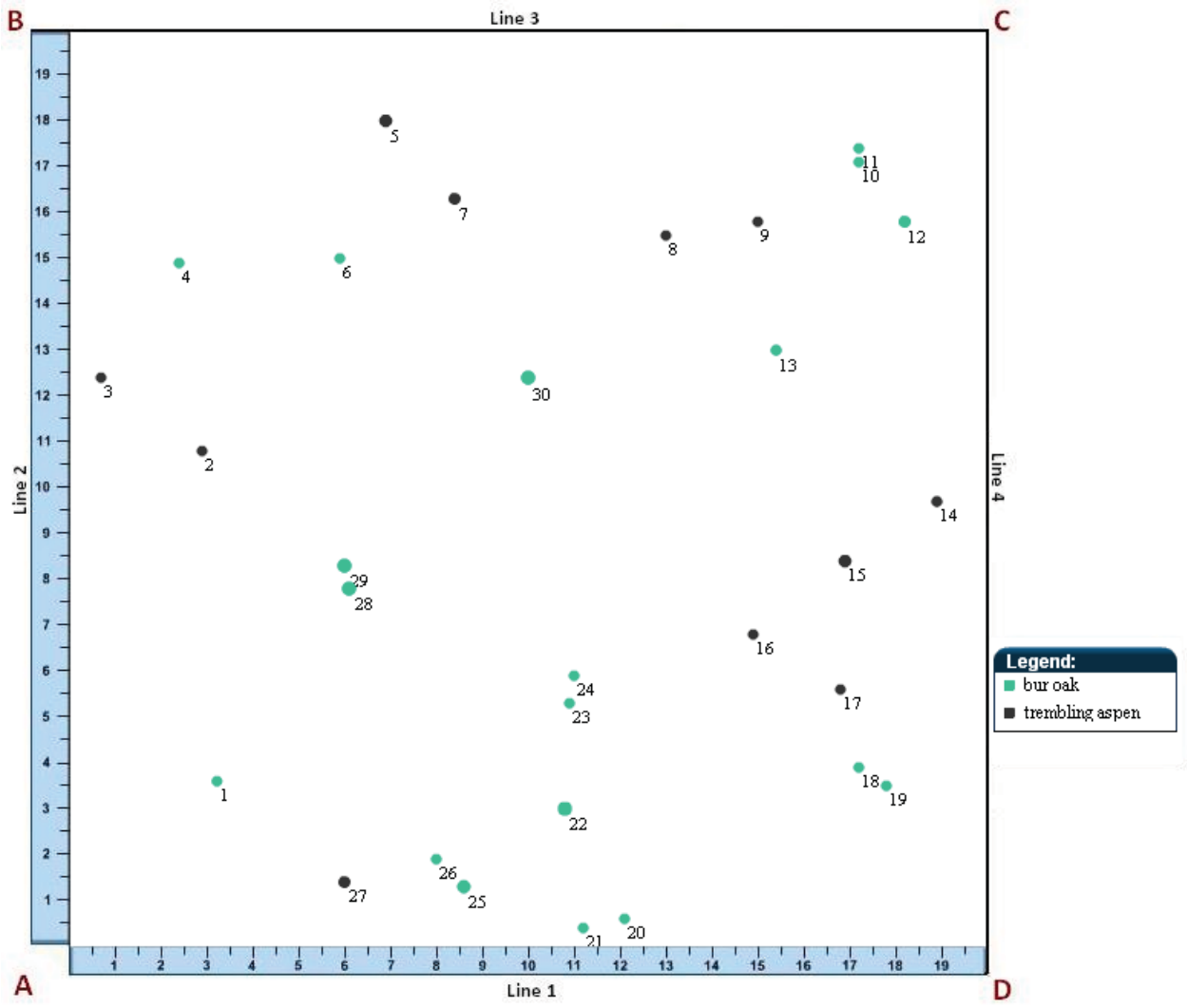
Bois des Esprit Oak Plot 3



Bois des Esprit Oak Plot 4



Bois des Esprit Oak Plot 5



Appendix III: Species list

Trees		
Common Name	**Scientific Name**	**Notes**
Ash	(Green) *Fraxinus pennsylvanica* (Black) *Fraxinus nigra*	Distinction could not be made between Green and Black species
Bur Oak (Oak)	*Quercus macrocarpa*	
Trembling Aspen (TA)	*Populus tremuloides*	
White Elm (Elm)	*Ulmus americana*	

Saplings, Seedlings, and Shrubs		
Common Name	**Scientific Name**	**Notes**
Beaked Hazel	*Corylus cornuta*	
Arrowood	*Viburnum dentatum*	
Chokecherry	*Prunus virginiana*	
Gooseberry	*Ribes oxyacanthoides*	
Hawthorn	*Crataegus coccinea*	
Honeysuckle	*Lonicera spp.*	
Maple	*Acer spp.*	
Red Osier Dogwood	*Cornus sericea*	
Rose	*Rosa acicularis*	
Saskatoon	*Amelanchier alnifolia*	
Sp 11	*Unkown*	
Sp 15	*Unkown*	
Sp 6	*Unkown*	
Sp 9	*Unkown*	
Viburnum spp	*Viburnum edule* *Viburnum trilobum*	Could not differentiate between these two species

Ground Vegetation Layer		
Common Name	**Scientific Name**	**Notes**
Anemone spp	*Anemone spp.*	
Bush Honeysuckle	*Diervilla lonicera*	
Canadian anemone	*Anemone canadensis*	
Canada Violet	*Viola canadensis*	
Creamy Peavine	*Lathyrus ochroleucus*	
Dandelion	*Taraxacum officinale,*	
Dewberry	*Rubus pubescens*	
Goldenrod	*Solidago spp.*	
Grass spp	*Poaceae spp.*	
Manitoba Maple	*Acer negundo*	
Northern Bedstraw	*Galium boreale*	
Raspberry	*Rubus idaeus*	
Sp 10	*Unknown*	
Sp 12	*Unknown*	
Sp 13	*Unknown*	
Sp 14	*Unknown*	
Sp 16	*Unknown*	
Sp 5	*Unknown*	
Sp 7	*Unknown*	
Sp 8	*Unknown*	
Strawberry	*Fragaria virginiana*	
Veiny Meadow Rue	*Thalictrum venulosum*	
Viola spp	*Viola spp.*	
Wild Sarsaparilla	*Aralia nudicaulis*	
Wood Anemone	*Anemone quinquefolia*	
Yellow violet	*Viola spp.*	There are several possible species; most likely *V. pensylvanica*

Also Found in Plots		
Common Name	**Scientific Name**	**Notes**
Burdock	*Arctium spp.*	
Clover	*Trifolium spp.*	
Three-leaved False Solomen-seal	*Smilacina trifolia*	
Sweet scented bedstraw	*Galium triflorum*	
Wild Lily of the Valley	*Maianthemum canadense*	