THE MANAGEMENT PLAN AND FOREST INVENTORY OF A PRIVATE WOODLOT IN SOUTHERN ONTARIO

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ABSTRACT

In Southern Ontario, private landowners hold the majority of forested land because of privatization. These property owners face degraded forests because of past logging practices. Other challenges faced by these owners are the threat of invasive species. Management plans offer the advantage of using proper silvicultural treatments to restore forest's productivity biodiversity. The purpose of this study is to develop a management plan for a private woodlot which was degraded by past logging events. The goal of the plan is to improve the productivity of the forest through silviculture treatments. Through the collection of data during the timber cruise an accurate forest composition will be documented. With this inventory and composition, a management plan will be developed in order to improve the degraded forests. The results of this work shows that the woodlot has four different forest types which are at different states of maturity. The management plan will focus on the elimination of infected trees caused by invasive species and shade intolerant trees. The targeted goal of the management plan is to create tolerant and mixed wood forest within the property.

Key words: Management plan, Silviculture, Single tree selection, Shelterwood, Emerald Ash Borer, Beech Bark Disease, Gypsy Moth, Tolerant hardwood, Mixed wood forest

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1.0 INTRODUCTION

Southern Ontario has a vastly diverse forest with many different species and ecosystems which need to be protected and managed properly. As a result of the high privatization of land in Southern Ontario, large portions of land have been utilized for urban spaces and cleared for farmland. This leaves the southern portion of the province with very little first cover. These forests are small, fragmented woodlots which are owned by the private sector making up the majority of the forest land in Southern Ontario. Private landowners are an important part of the conservation of biodiversity of Ontario's forest. As more people move from the city and purchase land in the country, there needs to be more awareness for the importance of properly managed forests. These managed woodlots will carry high biodiversity and provide habitat for many endangered species.

1.1 STUDY OBJECTIVE

The objective of this study is to determine the state of the woodlot by collecting the inventory of the property and understanding the composition of the forest. The management plan considers the components of forest inventory, sustainable management, potential logging volume/revenue, future growth projections and the conservation of wildlife habitats and biodiversity. The management plan will consider the owners property goals and create a management plan which will increase the future health of the stand and follow the guidelines for the conservation of biodiversity.

2.0 LITERATURE REVIEW

2.1 PRIVATE WOODLOT MANAGEMENT IN ONTARIO

Ontario woodlot owners play an important role in the conservation of ecosystems and the sustainability of forests. In Ontario there are approximately 170,000 owners of private woodlot which equates to 6.1 million hectares of land (OMNR, 2017). The majority of these properties are located in Southern Ontario where 95 percent of the forested land is owned by the private sector (Rotherham, 2002). The historic forest of Southern Ontario was a vast area of continuous forest cover consisting of tolerant hardwood and mixed wood stands. This provided the extensive interior forest habitats which species have adapted to for thousands of years.

Considering the expansion of human activity since the European settlers, the continuous forest cover of Southern Ontario has disappeared, leaving behind only fragmented forest patches (Parker,1993). These patches of forest are small in size, consisting of forest lands from 20-100 hectares in size (Rotherham, 2002). Result of the increase of small forest patches on private land, forest edge habitat has increased, reducing the important interior habitat which the species of Ontario need (Parker,1993). Large, forested tracts of land are recognized to be important for the conservation of biodiversity and the protection of important watersheds. These privately owned forested areas are key to having a healthy and biodiverse ecosystem in Southern Ontario (Hilts,& Mitchell, 2009).

The Ontario government relies on the importance of private woodlots in Southern Ontario because they make up the majority of the forested lands. These forested lands are important for the conservation of southern Ontario biodiversity and the economic gain from logging high quality hardwood (Hilts et al., 2009). In Ontario, there is no regulation set by the government which requires landowners to practice good forest management. In order to conserve these sensitive areas, the government of Ontario has developed a program which reduces taxes to land owners who conduct forest management practices. This program is called Managed Forest Tax Incentive Program (MFTIP) which reduces the tax of the property by 75%. A management plan of the forest is conducted by a Managed Forest Plan Approver (MFPA). The requirements for this program is that the property needs to be larger than 10 acres, has to be a wooded area with a certain amount of trees on it and be a canadian citizen. When a management plan is written, it must follow the same regulations as provincial standards in harvesting. This allows the conservation of biodiversity and the protection of sensitive areas (OMNR, 2012). As of 2014, over 15 thousand landowners had agreed to join MFTIP, thus ensuring the proper management and protection of around 680,000 hectares in some of the most important places in Ontario (OMNR, 2017). These small woodlots are the only remnants left of the once mighty forests that grew in Southern Ontario. All efforts should be made to conserve them for the future.

2.2 HARDWOOD SILVICULTURE IMPROVEMENT

Hardwood forests in Southern Ontario are very diverse and have developed into the tolerant hardwood forests seen now in Ontario. Considering the nature of how these forests grow, the use of silviculture practices has the capacity to improve timber stands (Jarvis, 1956). Improper logging in the past has degraded the present forest in Ontario and the creation of silvicultural practices in order to increase the quality of the Canadian forests. The development of silviculture systems over the past century have created forest prescriptions which increase the forest's biodiversity (Howe, 1923). Foresters have the capacity to change the genetics of hardwood forests in which silvicultural systems they choose. This is because, during a harvest operation, the species which remain in the stand carry the genetics of future regeneration. If the foresters decide to leave trees which are high in quality and vigor, it will represent itself in the next regeneration. A stand which is high-graded, and has lower quality trees remaining, will produce a regeneration with these inferior traits. Foresters are also able to manipulate future forests by producing crown opening and tree spacing conditions that create the best conditions for natural regeneration. Since these practices are used within every cutting cycle, the quality of the timber increases; and the forest which was once degraded has the chance to improve in quality.

Hardwood lumber is an important resource for many industries because a hardwood tree can produce a valuable product. Foresters are striving to achieve higher goals in pricing veneer and sawlogs out of these forests. The improvement done to the genetics of the stands will have everlasting effects on timber quality and volume (Calvert, 1977).

2.3 SINGLE TREE SELECTION

Single tree systems involve the removal of individual trees in order to achieve an even-age structure throughout a stand. This system is used to recreate small natural disturbances that can arise naturally from disease, pest or wind damage within a stand. The goal of single tree selection is to open up the crown in order to have proper conditions so that the regeneration of tolerant hardwoods can be achieved. In order to achieve this, forest managers will use this system to improve the health of tolerant hardwood forest. With this system, sick and unhealthy trees are able to be individually removed, providing the space for future growth and increasing the health of the forest (SCIF, 2019). By not removing all of the growing stock from the start, this system works on a cutting cycle which allows the loggers to return to the same area every 15-25 years, depending on the forest. By leaving a residual forest behind, there is no need to replant this area since the conditions for the regeneration have been met. This has been done during the harvest providing the right amount of sunlight so that shade intolerant trees will not be able to grow. Since the system is used over many cycles on a forest, the condition of the forest is improved by removing all the unhealthy and diseased trees and leaving a healthy stock of trees (OTMG, 2004).

Figure 1 Illustrated example of a completed single tree selection harvest in a tolerant hardwood stand.

Figure 1 Single tree selection harvest (Illustration by Jodi Hall)

2.4 GROUP SELECTION

The group selection system is a method used to create larger openings in the crown for the regeneration of mid-tolerant species. This system is used alongside single tree selection in order to diversify the stand, creating an uneven stand with groups of evenly aged structure. This treatment focuses on emulating the effects of larger natural disturbances, such as small fires, large windfall, pest damage and disease. The size of the gap can vary since species have different conditions which need to be met. The gap sizes of mid-tolerant species are usually between 2 to 3 trees in length. These mid-tolerant species such as *Prunus serotina*, *Quercus rubra* and *Pinus strobus* require more exposure to sunlight in order to have successful regeneration (OTMG, 2004). If groups of these species are present in a stand, then this system can be used to increase the diversity of the forest.

Figure 2 Illustrated example of a completed group selection harvest in a mixed wood stand.

Figure 2 Group selection harvest (Illustration by Jodi Hall)

2.5 SHELTERWOOD

The shelterwood system entails the harvesting of mature trees over a series of cuts to ensure a good seed course and an even age of growth. This system is used on *Pinus strobus* and *Quercus rubra* in Southern Ontario since it provides the conditions needed for healthy regeneration to occur. The system usually requires two cuts to occur in order to complete the treatment (GOVBC, n.d.). The first cut is called a seed cut and forests which are 60 to 80 years old are selected where the forest is thinned. Mature and seed-trees are left behind. This ensures that there is natural regeneration occurring and no need for replantating. Once the regeneration has grown and does not require the mature trees, the forest is thinned as a mature commercial cut. This allows the new, immature trees the space needed to grow. Finally, the last harvest is completed when the regeneration has reached an age of 80 to 120 years where the process of this system can start over (Landowner Resource Center, n.d.).

Figure 3 Illustrated example of a completed shelterwood harvest in a white pine stand with scattered hardwood.

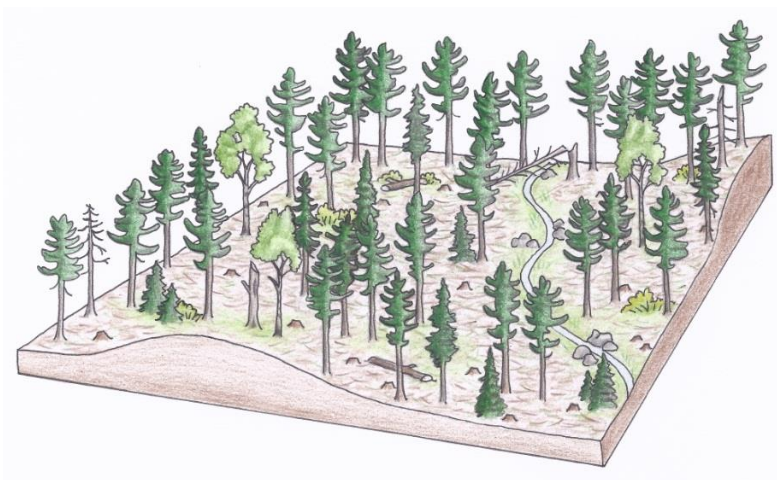

Figure 3 Shelterwood harvest (Illustration by Jodi Hall)

2.6 INDICATORS

Forestry indicators are tools used by the industry in order to see if the goals of the management plan are achieved. These indicators have different purposes when looking at the management plan and the results to see if the goal was achieved or failed. There are many aspects of indicators which focus on certain parts of the forestry industry. Indicators can be based on a fine filter approach or a coarse filter approach. Fine filter approach will base indicators appropriate for specific conditions. These indicators are tailored for specific species which are endangered, have destroyed habitats, or if the course fitler does not accommodate its requirements. A coarse filter approach focuses on a larger aspect of the ecosystem requirements. Coarse filters will manage for conditions which if achieved, will provide the circumstances for many other species and habitat requirements (Unit, 2007). This is because the requirements of a certain course filter will benefit many other species and conditions which would not have to be met in a fine filter. Indicators will look at many aspects of forestry to determine if targets are achieved. Indicators can look at biodiversity, forest production, soil and water, economic and social benefits, global contribution, and sustainable forestry. All of these indicators are used to determine present and future benefits of forestry management practices. Indicators for diversity will focus on the habitats for individual species and ecosystems. Indicators will focus on genetic diversity and ecosystem composition structures. Biodiversity indicators are important because it ensures that the management plan is creating high biodiversity. Forest productivity indicators monitor the growing stock of the forest and harvest area. This ensures that proper regeneration is occurring on previous harvest operations and that woody structures are present in a stand. Soil and water indicators ensure that the protection of forest soil is occurring and that watersheds are not being depleted. Motoring of harvest operations ensures that rutting and equipment damage is not occurring during harvest operations. Protecting water resources are important for fish habitats and wetland land ecosystems. Finally, social and economic indicators show the amount of land which can be harvested per year and the products which come from these harvests. Forestry plays a big role in many communities in Ontario and can be the only employer (Forest sustainability, n.d.). Understanding the economy of forestry and future forest capacity ensures a financially stable future.

Indicators don't only have to be used on crown land, but private woodlot owners can create indicators in order to see how a property is doing. These indicators can focus on forest health and future production of the stand. Indicators can focus on the objectives of the landowner and how these goals will be affected by the harvest. These goals can be based on the type of species which can be retained in a forest, the creation of habits for certain species, an elimination of invasive species, and a future productive forest. These indicators can be implicated in a management plan giving the landowner a tool to measure how successful a management plan and harvest are. Knowing this information, future management plans can be altered to achieve the goals of the landowner.

2.7 WILDLIFE MANAGEMENT

Forested areas are an important part of wildlife habitats and in North America they provide various natural environments for species. Although forestry is reasonable for harvest and the production of many wood products it also creates the habitats and conditions for these species. Within the management planning there is an aspect of wildlife management which creates conditions to meet the objectives for wildlife. Harvesting allows the creation of specific forest conditions and alters the succession of the forest. Forest compositions will determine the harvesting method which will be used and levels of succession will be created. These harvesting methods will replicate natural disturbance which will create stand initiation, stem exclusion, understory retention and old growth conditions. Adequate percentages of these forest conditions are required in order to meet the wildlife objectives. Each of these forest types create a specific condition for the species and their habitat needs. Course indicators can be used to achieve habitat conditions which meet the requirement for a variety of species. This on the other hand does not achieve the conditions needed for species which require specific habitat conditions. These species are usually endangered because of the loss of their habits. Within management plans these habitat conditions can be achieved using a fine coarse filter creating the conditions needed for the species. During the planning process the objectives for wildlife will be discussed with indicators developed to increase the species habitat though logging (NRCS. 2002).

In Southern Ontario there is a vast amount of variation throughout the tree species found in this area, creating complex ecosystems. The majority of these forests are hardwood forest or mixed wood forest which require more advanced management plans to achieve proper regeneration and the protection of habitats. In these forest conditions, tree markers are used to identify the tree which will be harvested and the ones which will be protected as wildlife trees. During the creation of the management plan, goals of the foresters will be set and provincial regulation will be followed in order to comply with the law. These regulations are set to maintain and protect sensitive habitats and ensure that wildlife habitats are being created. In the protection of habitats areas of concern, (AOC) are created to restrict the logging operation in these areas. This retains the sensitive areas which are crucial for the environment and wildlife. The creation of more habitats is done by developing the necessary forest conditions and preserving trees which have wildlife significance. Tree markers are the ones responsible for leaving these significant wildlife trees within the forests. Examples of these trees may be mast bearing trees, cavity trees, and dead trees. These trees are selected in order to maintain habitats and main food sources for the local wildlife (Landriault, 2015).

Private woodlot owners should also manage wildlife on their properties and can include it to their MFTIP plan. This will include the protection of important sites, and following the wildlife guides lines presented by the province during any logging operation. Landowners may have a preference on the wildlife which they would like to introduce. This can mean that specific techniques and procedures are done in order to achieve their goals. Examples of these projects can be developing food plots, planting grassland, planting specific trees, creating wildlife trees, and cutting deer bedding sites. These are just a few examples on how landowners can achieve their wildlife goals on their properties.

2.8 EMERALD ASH BORER

The Emerald Ash Borer (EAB), *Agrilus planipennis* is a small green beetle which infects the North American trees of *Fraxinus americana* (Parsons, 2008). This beetle is not native to North America and was brought from Asian countries during the shipping of goods. These beetles were first identified in the year 2002 near the cities of Windsor, Canada and Detroit, US. It is believed that the pest first entered America around 1990 in wooden shipping pallets. Because of human movement and the spread of logs and firewood, the beetle was able to migrate within this wood to new parts of North America and wreak havoc (Poland, and Chen, 2014). Throughout the years, EAB has spread through North America, affecting the majority of the growing area of the

Fraxinus trees. Over the past decade, the EAB has wiped out the whole growing stock of ash trees in the USA and Canada. Small patches of ash are found where the beetle has not accessed them. Patches are also found further north in Canada, where the cold climate reduces the beetle population (Fountain & Crocker, 2016). The EAB has killed millions of trees within forest stands and urban landscape. An estimated 20 percent of all urban trees are part of the *Fraxinus* family and would be impacted by the EAB. The estimated removal and replacement of these trees has been estimated in the billions of dollars. Finally, *Fraxinus americana* was a valuable forest product and a justice of the biodiversity of northern hardwood forests, the loss of this species will heavily impact the ecosystems of the area (Herms & et al, 2013).

2.9 GYSPY MOTH

European Gypsy Moth (EGM) *Lymantria dispar,* is an invasive species of North America which was accidentally introduced near Boston Massachusetts in 1869. The species has continuously spread throughout Eastern North America even with the extensive management programs. The species causes large scale defoliation over consecutive years in a stand and occasionally high mortality among conifer and deciduous trees are reported. The pattern of the invasive species fluctuates within a 10 to 20 year period where population size explodes (Johnson, Liebhold, Tobin & Bjørnstad, 2006). In North America, the adult female EGM are not capable of flight, so the eggs are spread within a close proximity. The species spread occurs in the larva stage and repels down a silk thread and is carried by the wind to an adjacent host (Weseloh, 1997). The spread of the species throughout Canada and the USA has mostly been through the interaction of humans. The EGM will lay their eggs on a suitable host which provides the most protection for the eggs. This sometimes results in laying eggs on other objects which can be spread by humans. These objects can be furniture, firewood, logs, and on vehicles. Once these objects are moved, the EGM eggs are moved as well and distributed unknowingly to new locations (Lyons & Liebhold, 1992). Over the past few decades, there have been several large EGM defloration events within Ontario. The areas impacted have been spread throughout Southern Ontario impacting large tracts of forest with hardwood composition (MNRF, 2014) The trees which are affected by EGM the most are the *Quercus* and *Populus* species. These species are not the only one as they can affect other species as well. The defloration of the trees occurs while the EGM is in the life cycle of a caterpillar and feeds off the leaves and needles. The rate and intensity of the defloration which occurs is in response to the population size of EGM. Usually large deflation occurs in the third year of EGM when the population has risen (DNR, n.d.) Once populations have reached a tipping point, EGM develops a virus which kills off the species to maintain population health. The virus digests the EGM from the inside out, killing the pest and releasing the virus to other moths. The EGM is killed at the top of the tree allowing the virus to be carried by the wind over large distances to other moths (Sweetlove, 2011). This completes the cycle, and the species population grows until the next outbreak.

3.0 METHODS & MATERIALS

3.1 STUDY AREA

The location of the property is 45 mins West of Barrie, Ontario. The property is within Tiny township and located on 876 Concession Road 17 West. The woodlot belongs to the Hojniak family. The woodlot consists of approximately 36 hectares of mixed hardwood stands minus one hectare cleared for a dwelling.

Using a geographic information system (ArcGIS), the property was divided into 4 harvestable forest stands, one recreational stand and finally a protected rigid stand. The stands were divided by using the winter imagery and stands were drawn where there was a clear contrast between deciduous and coniferous trees. The 4 forest stands have a total area of around 28 hectares, and this is where the timber inventory will take place. These stands will start with stand one, which has a total area of approximately 6 hectares and located to the left of the property. Stand two is 6 hectares in size and located on the right side of the property. Stand three is located at the bottom of the woodlot and has a size of around 5 hectares. Finally, stand four which is the largest in size with 11 hectares is located towards the back of the woodlot.

Figure 4 shows the map of the bird's eye view of the property. Within this map the 4 survey stands can be seen additional all of the survey points. Finally, all of the know trails are listed, the area of protection and finally the area of recreation.

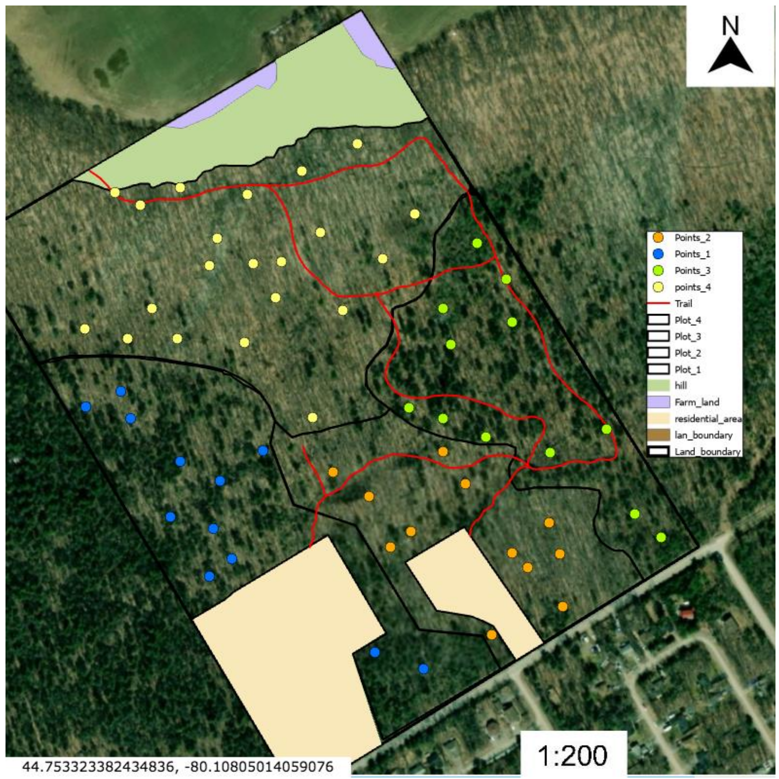

Figure 4: Map of private property and forest stands

3.2 SURVEY DESIGN

The survey of the property consisted of a timber inventory using fixed plot survey within the stands to determine the volume, species and distribution in diameter. In order to have an accurate survey of the timber inventory, five to six percent of the stand will be surveyed using the fixed plots. The radius of the fixed plot is 9.77 meters with an area of 0.03 hectares per plot (The Art of Timber Cruising Part II, 2001). Stands

1-3 will have 10 plots while stand 4 has 18 plots surveyed. The plots will be randomly generated using ArcGIS programming so that there is no human impact on the survey. Using ArcGIS, each stand was selected, the total area was determined, and the number of plots was calculated. The random plot generator was used inputting the number of plots needed per stand to have the spacing between plots be no greater than 20 meters and have no overlapping plots. In total, 48 plots were surveyed throughout the woodlot achieving a high and unbiased survey. Finally, a tally sheet was created in order to collect the information gathered. The tally sheet would have the date, stand number, plot number and the tree tally. The tally included the room for six tree species on the top and on the left would have the diameter of tree in centimeters starting from 10 and increasing by two until reaching 50.

Figure 5 shows an example of a survey sheet used.

Date :

Stand Number :

Plot Number :

DBH						
10						
12						
14						
16						
18						
20						
22						
24						
26						
28						
30						
32						
34						
36						
38						
40						
42						
44						
46						
48						
50						
Total						

Figure 5: Example of tally sheet

3.3 DATA COLLECTION

The data collection of the timber inventory was completed during a two month period on the weekends in the months of December 2019 and January 2020. Data collection started by downloading the plots from ArcGIS to a mobile app called Avenza maps. Avenza maps is a phone-based GPS and would give direction to every plot where a survey would take place. At the location of the plot, a stake was placed in the ground with the rope tied to it, tracing out the circle for each plot. Once the plot was determined, the tree's diameter was measured, and the species were recorded on the tally. This procedure was the same for each plot using Avenza maps for direction to the next plot, filling out another tally sheet.

3.4 DATA ANALYSIS

Once the data is collected, it will be analyzed to get the results of the timber inventory for each stand. Microsoft Excel creates tables and figures of the information so that it can be presented visually. A chart is created in Excel and all the trees from the survey are moved to the document. A chart was made for each stand which will provide the information for the forest condition. Once the chart is filled, the total trees per species were calculated to acquire the forest composition of the stand. For each diameter, the totals were tallied up in order to find the distribution of trees by size. These calculations were changed to trees/hectare in order to get a clearer representation. This was done by multiplying the stand 1-3 results by 3.33 and stand 4 results by 1.85. Finally, the basal area (Ba) was determined so that it could be easier to interpret the data and develop accurate management plans. To determine the Ba of each of the stands, a formula was used to determine the Ba in meters squared (Luckai, & Gooding, 1991).

This area is meters squared of the tree at breast height (BDH) (Luckai & Gooding, 1991). Finally,9 the total Ba was determined per hectare and stand to determine the amount of wood which needs to be harvested.

3.5 LANDOWNER OBJECTIVE

The purpose of this management plan is to improve the health of a degraded forest which has seen a logging operation high grading the forest in the seventies. The compositions of the forest change throughout each stand and different objectives and goals will be set for each one in order to get the best outcome for the forest. Over the past year the forest has been impacted with a couple invasive species which are killing off a few of the trees. These species are Emerald Ash Borer and Gypsy Moth. The Emerald Ash Borer is in its fourth year as no previous signs were seen until this year as the Ash trees are starting to die. Next is the Gypsy Moth which is in its third year of its cycle and expected to be the most damaging year. Finally, beech bark disease is present in the forest and has decimated the Beech population. In the management plan the goal will be to focus as much of the harvest on the species being impacted by these factors as they will not likely survive until the next harvest. Other objectives are to retain large conifers trees within the stands to provide habitat for animals and as a seed course. Majority of the stand will be planned using a selection cut system as this is mostly tolerant hardwood. There will be a location where group and shelterwood can be used to diversify the forest with Prunus serotina, Quercus rubra and Pinus strobus. Result of the property being logged improperly in the past, there are locations with high composition of trembling poplar. These trees are in their maturing stage and will be affected by the Gypsy Moth in these locations, priority will be for the regeneration of white pine.

Finally, the management of the property must ensure the protection and creation of new wildlife habitats throughout the stands.

3.6 INDICATORS

Table 1 shows the indicators of sustainability used in this management plan.

Indicator	Target
Wildlife trees	The retention of at least 5 wildlife trees per hectare throughout the whole property.
Scattered Conifers	Retain at least 10 large conifers per hectare when managing for a tolerant forest and where conditions are possible. Conifers of 25+ cm in size.
Super Canopy Trees	Trees larger than 60 cm will be retained. One per hectare if possible.
Shelterwood Harvest	Shelterwood harvest will retain at least 10 m2/ha after a harvest is complete.
Selection Harvest	Selection wood harvest will retain at least 20 m2/ha after a harvest is complete.
Selection Harvest Amount	During a selection harvest no more than 1/3 of the total base area may be removed.
Genetic Conservation of Native Trees	During the harvest operation first the UGS trees need to be removed in order to improve genetic quality of the trees
Removal of Invasive Species	Trees which are infected or have reduced production due to invasive species will be harvested first.
Selection Harvest Regeneration	The targeted regeneration for the selection harvest will be tolerant hardwood majority being sugar maple.
Shelter Wood Regeneration	The targeted regeneration for shelterwood operation are conifer trees white pine and white spruce.
Logging Damage	Mechanical damage to trees during logging operation must maintain under 7 percent of the remaining trees

Table 1 List of indicators and the targets for each one

4.0 RESULTS

4.1 FOREST CONDITION

4.1.1 STAND 1 FOREST COMPOSITION

Stand one is located on the left side of the property and has a size of approximately six hectares. Looking at a winter earth image of the stand, it can be seen as having a mixed wood composition because of the coniferous and deciduous trees present. This stand had a total of 10 survey plots conducted within the stand totaling 0.3 hectares tallied. Stand one after analyzing the data shows a basal area of 33.5m^2/ha. The forest composition of the stand is Mh 4, Sw 3, Aw 2, Or 1 which is calculated from the basal per hectare of the stand. The size distribution of the stand is polewood at 13.6 m^2/ha, small sawlogs at 14.2 m^2/ha and finally large sawlogs at 5.7 m^2/ha. When looking at the composition of the stand, the two dominant species are the *Acer saccharum* and the *Picea glauca* as they make up the majority of the stand. The *Picea glauca* in the stand are most abundant near the property line on the left because the neighbouring property has a high composition of spruce. The seeds from this property have been distributed in the stand since the last harvest in the seventies which created a mixed wood stand. As you get closer to the stand borders, the composition of the stand starts to convert into more tolerant hardwoods such as *Acer saccharum* and *Quercus rubra* and *Fraxinus americana*. Throughout the stand, mature trees of *Picea glauca* are scattered within the forest but are usually found in clusters ranging between three to six trees.

Figure 6 shows the distribution of species within stand 1. The distribution uses the Ba/Ha of each species and is expressed as a percentage.

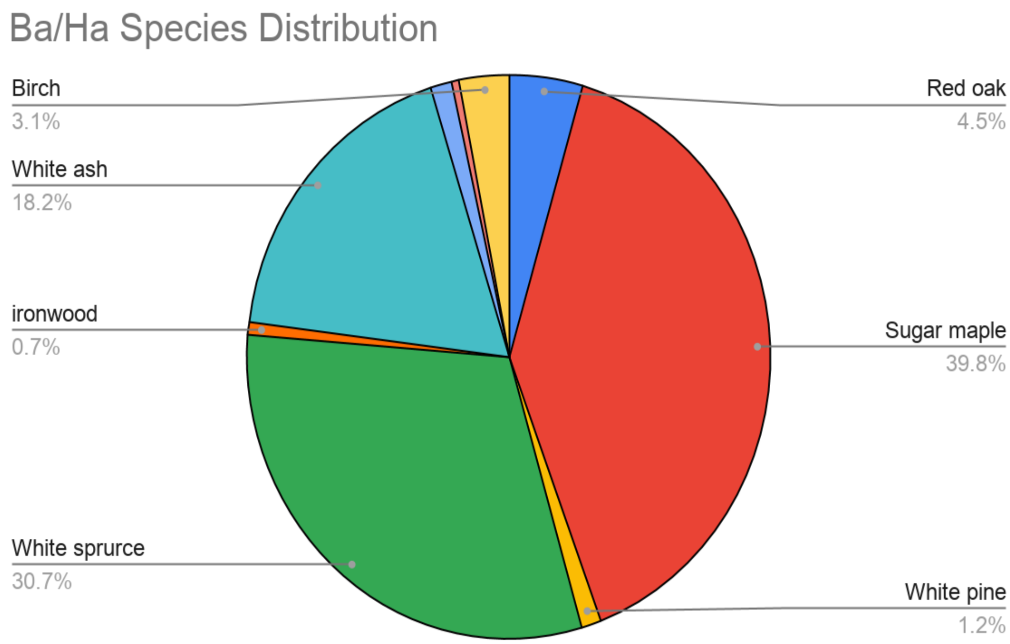

Figure 6 Species distribution of stand 1.

The distribution of diameter sizes in stand 1 is shown in Figure 7. The distribution is in three classifications which are polewood sizes 10-24 cm, small sawlogs 26-36cm and finally large sawlogs greater than 38 cm. The value is shown in the basal area/ha.

Figure 7: Diameter distribution of stand 1

4.1.2 STAND 2 FOREST COMPOSITION

Stand 2 is located at the bottom of the property and has an area of five hectares. The forest is composed with deciduous trees with a few large conifers spread throughout the stand. The stand had 10 plots surveyed totaling an area of 0.3 hectares. Once the data from the tally sheet was calculated the Ba of the stand was 35.5 m^2 per hectare. The forest composition of the stand consists of At 4, Mh 3, Aw 2, Or 1. The distribution of the size class in the stand is polewood 15.25 m^2/ha, small sawlogs at 18.06 m^2/ha and finally large sawlogs have 2.14 m^2/ha. The forest composition of the forest shows that *Populus grandidentata* is the most dominant species followed by *Acer saccharum* and *Fraxinus americana. Populus grandidentata* being the most dominant species in the stand is not evenly distributed. There are pockets within the stand where the *Populus* *grandidentata* makes up 90 percent of a plot. *Acer saccharum* and *Quercus rubra* are more dominant around the border between stand 3 and 4. The age of the stand is very young and *Populus grandidentata* is the species which dominates the polewood diameter class. The small sawlogs are when the tolerant hardwood is seen in the stand. The large sawlogs make up a very little portion of the stand being composed of *Populus grandidentata* and *Acer saccharum*.

Figure 8 shows the distribution of species within stand 2. The distribution uses the Ba/Ha of each species and is expressed as a percentage.

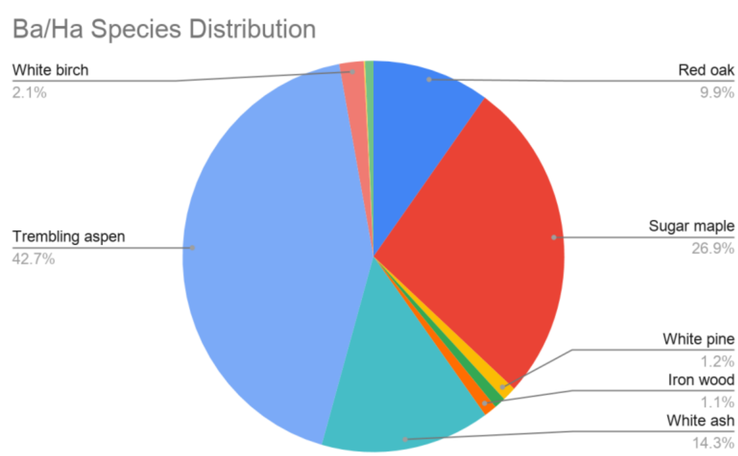

Figure 8 Species distribution of stand 2

The distribution of diameter size in stand 2 is shown in Figure 9. The distribution is classified into three classifications which are polewood sizes 10-24 cm, small sawlogs 26-36cm and finally large sawlogs greater than 38 cm. The value is shown in Ba/Ha.

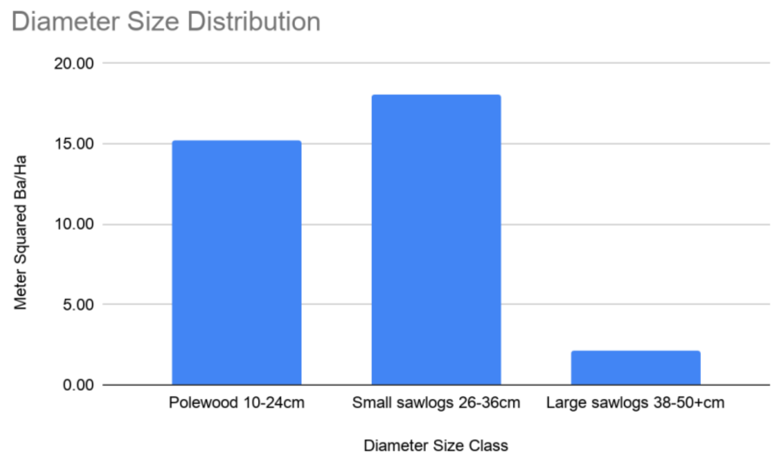

Figure 9 Diameter distribution of stand 2

4.1.3 STAND 3 FOREST COMPOSITION

The next stand is located on the right side of the property and is labelled stand 3. This stand has an area of six hectares and consists of a mixed wood forest. The stand had 10 plots surveyed totaling an area of 0.3 hectares. The composition of the forest is red oak 4, Mh 2, Sw 2, Aw 2. After analyzing the tally sheets, the total Ba of stand 3 is 25.65 m^2/ha. The size distribution of the stand is polewood at 16.61 m^2/ha, small sawlogs at 4.56 m^2/ha and finally large sawlogs at 4.49 m^2/ha. In this stand, the most dominant species is the *Quercus rubra* which makes up more than 40 percent of the stand. The *Quercus rubra* found in the stand is near the border of stand 2 and 4. The mixed wood and *Picea glauca* can be found near the property line to the adjacent property to the right. The Ba of the stand is very low as it only makes up 25.65 m^2/ha which is why the stand is very patchy. When *Quercus rubra* is found, there are clusters of two to three trees growing together and most neighboring trees are *Quercus rubra.* The *Picea glauca* in the stand are all grouped together. There are a few conifer species which lie around the stand which are large diameter trees and can be considered super canopy trees. Finally, the stand is littered with small trees and the regeneration layer will be *Quercus rubra,* as it is the most abundant species.

Figure 10 shows the distribution of species within stand 3. The distribution uses the Ba/Ha of each species and is expressed as a percentage.

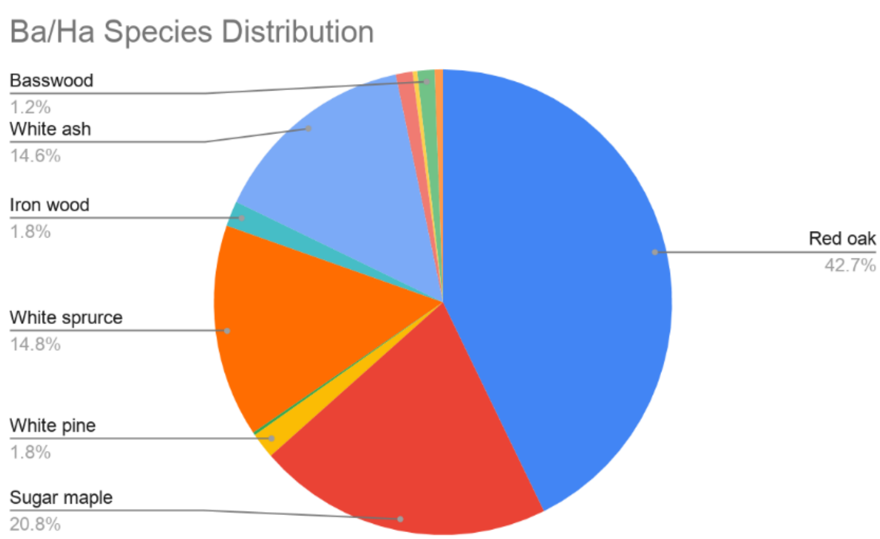

Figure 10: Species distribution of stand 3.

The distribution of diameter size in stand 2 is shown in Figure 11. The distribution is classified into three classifications which are polewood sizes 10-24 cm, small sawlogs 26-36cm and finally large sawlogs greater than 38 cm. The value is shown in Ba/Ha.

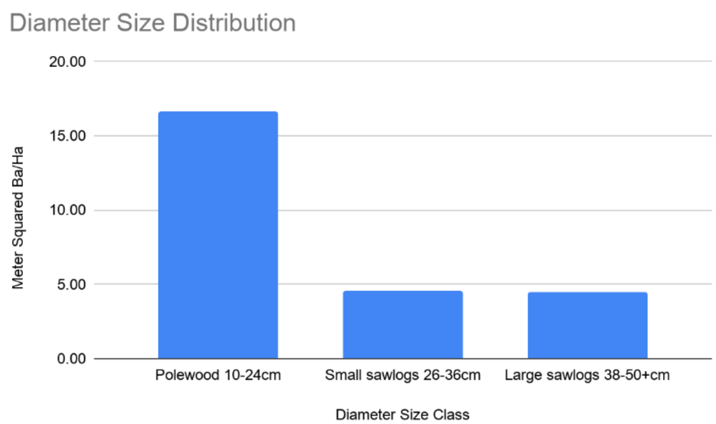

Figure 11: Diameter distribution of stand 3.

4.1.4 STAND 4 FOREST COMPOSITION

Stand 4 is located at the back of the property and is 11 hectares in size. This stand from earth images appears to be a full deciduous forest. There are no mixed wood portions in the stand but singular *Pinus strobus* is present in the stand. This stand has a total of 18 survey plots conducted within the stand totaling 0.54 hectares tallied. After analyzing the data from these tallies, the total Ba is 21.87m^2/ha. The forest composition of the forest is Mh 4, Aw 2, Al 2, Or 1, Be 1. The size distribution of the stand is polewood at 10.74 m^2/ha, small sawlogs at 7.70 m^2/ha and finally, large sawlogs at 3.43 m^2/ha. The most dominant species is *Acer saccharum* in the stand but will vary throughout the forest. The tallies show that stand 4 has different forest conditions throughout. The left side of the stand is where the *Acer saccharum* is dominant and consists of a tolerant hardwood forest. The center of the plot is where the large *Populus* *grandidentata* trees are present which is consistent with stand 2. Finally, the right of the plot has very few mature trees and has a very low size distribution. Therefore, the total Ba of the stand is low, considering the fact that the distribution of trees throughout the stand is not the same. The stand should be split into three parts so that a better representation of forest distribution could be made.

Figure 12 shows the distribution of species within stand 4. The distribution uses the Ba/Ha of each species and is expressed as a percentage.

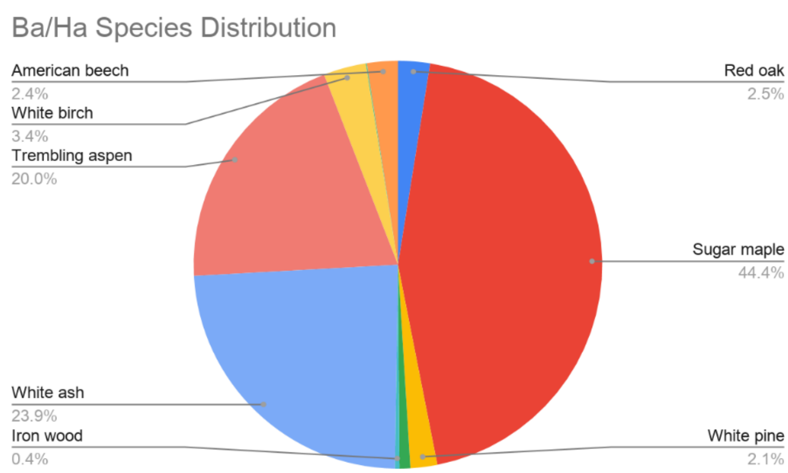

Figure 12: Species distribution of stand 4.

Figure 13 shows the distribution of diameter size in stand 2. The distribution is classified into three classifications which are polewood sizes 10-24 cm, small sawlogs 26-36cm and finally large sawlogs greater than 38 cm. The value is shown in Ba/Ha.

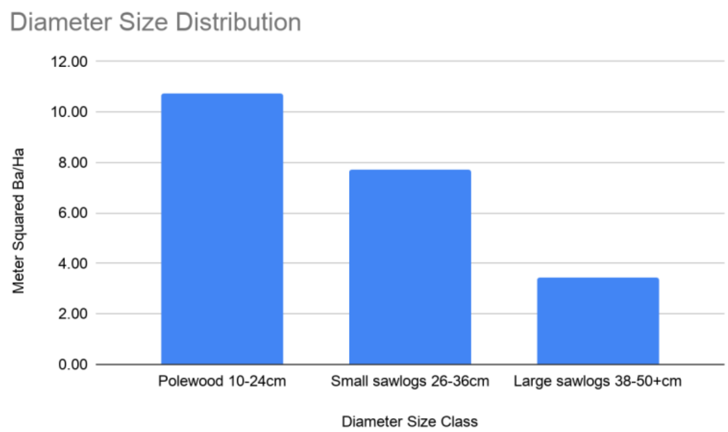

Figure 13: Diameter distribution of stand 4.

4.2 SILVICULTURE TREATMENT AND HARVEST

4.2.1 STAND 1

4.2.1.1 Silviculture treatment

Stand one has a composition of a mixed wood forest, the two dominant species being *Acer saccharum* and *Picea glauca*. In the management of this stand, *Acer saccharum* will be the targeted species of the treatment. The silviculture strategy which will take place on stand one is a single tree selection system. This system will benefit the tolerant *Acer saccharum* which makes up a large portion of the regeneration in the stand. The stand age distribution shows that the majority of the Ba is based in smaller diameter classes. Management of the *Picea glauca* includes leaving large individual trees for habitats and clusters of three or more for wildlife habitats. Larger group cuts will provide the condition of the regeneration of *Picea glauca* to increase the biodiversity in the stand (MNRF, 2015).

4.2.1.2 Harvest

The harvest on stand one will see the removal of one third of the basal area reducing the Ba from 33.5 m^2 to 22 m^2. This means the harvest will remove around 11 m^2 per hectare on stand one. To achieve this harvested volume, *Fraxinus americana* will be the majority of the harvest because of the EAB infestation of the stand. The volume of *Fraxinus americana* being removed will be around 6 m^2/ha which will leave a Ba of around 5 m^2 to be removed from other species. The remainder of wood will focus on low value species and the removal of sick or diseased trees. Finally, to develop an uneven stand, the majority of the wood will be removed for smaller diameter classes to have a good distribution in age.

4.2.2 STAND 2

4.2.2.1 Silviculture treatment

The silviculture treatment which will be used on the stand is a uniform shelterwood. This is because of the low quality of the stand and the high composition of *Populus grandidentata*. In order to restore the maple in the stand, a more drastic treatment is needed. The harvest will consist of two cuts being the regeneration cut and the final removal. The regeneration cut will consist of opening the crown to 50-60% in order to release the *Acer saccharum* seedlings. In order to achieve this opening, the Ba need to be around 14-16 m^2/ha. The stand is overgrown and has too high of a Ba, so achieving this opening will allow intolerant species to grow. A Ba of 20 m^2/ha will be left instead to remove most of the wood in the regeneration cut and *Acer saccharum* regeneration to grow. Trees which should be left are all *Acer saccharum* trees in order to have a seed source and healthy trees. The final cut will be completed 5 to15 years after the regeneration cut when the *Acer saccharum* regeneration will be more than a meter high (MNRF, 2015). This is when the *Acer saccharum* has the capacity to overtake other species and become the dominant tree. Tending of the *Populus grandidentata* may need to take place in order to reduce the new regulation so it does not compete with *Acer saccharum.*

4.2.2.2 Harvest

The harvest of stand 2 will be done in two stages, removing a large quantity of wood in order to get the right conditions. In the regeneration cut the harvest of 15 m^2/ha of wood will be required to open the crown to 60 percent. *Fraxinus americana* will be harvested in this cut as it is infested with EAB and will not survive to the next harvest. This will remove around 5 m^2/ha of wood and 10 m^2/ha will need to be replaced by other species. The remaining wood will be harvested from *Populus grandidentata* as this species will be eliminated in the future stand. The total Ba of *Populus grandidentata* is 15 m^2/ha of wood so all of the trees will not be harvested at once. The *Populus grandidentata* which will be harvested are the largest and lowest quality trees. This will ensure that all the sick and diseased trees are removed and only the *Populus grandidentata* which will survive until the next harvest will remain. This allows there to be a canopy cover of 60% to achieve regeneration goals. The final removal is when the remaining *Populus grandidentata* will be harvested and the other diseased trees. This is done to give the new regeneration the room to grow.

4.2.3 STAND 3

4.2.3.1 Silviculture Treatment

The silviculture treatment of the stand will be a uniform shelter wood which will favor the *Quercus rubra.* The future goal of this stand is to create a Quercus *rubra* savanna to increase the biodiversity and species. The stand already has low density, and the harvest will not be removed much. The uniform shelterwood will be done in two stages consisting of regeneration cut and final removal. The regeneration cut will retain 20 m^2/ha to achieve regeneration goals. By leaving this Ba the *Quercus rubra* will be able to reseed the area and increase the regeneration of this species. The final removal will be performed when the regeneration of the species has reached a height of one meter (MNRF, 2015). This cut will focus in removing more wood out of the canopy, providing more room for the species to grow.

4.2.3.2 Harvest Removal

The harvest of stand 3 will be delayed for a few years considering low density and EGM. The EGM will stress *Quercus rubra* trees for a few more years and the trees will not be producing enough seeds for regeneration. By delaying the harvest, more wood will be grown for the harvest and the stand will be able to be naturally reseeded. The expected harvest is to be done in five years where the density of the wood will be greater. In this regeneration cut, roughly 5-10 m^2/ha will be harvested depending on the growth of the trees over the next 5 years. This harvest will remove the *Fraxinus americana* as they die over time. Once this harvest is completed *Quercus rubra* regeneration will take over the stand. The final removal will focus on sick and diseased trees so that more resilient trees will be left to provide healthier growing conditions and future seed sources.

4.2.4 STAND 4

4.2.4.1 Silviculture treatment

The silviculture treatment for stand 4 will vary depending on which part of the stand will be harvested. The left side of the property is more tolerant hardwood and already has a developed uneven age structure. Here, a single tree selection system will be used in order to improve the health of the forest. A Ba of 20m^2/ha will be retained to create conditions where intolerant species will not develop. The center of the stand has a two-age structure, old *Populus grandidentata* which are at the end of their life cycle and young *Acer saccharum* regeneration. *Acer saccharum* will be the favoured species and become the future of this stand. To achieve these goals, a uniform shelterwood will be performed in order to open the crown, allowing the regeneration to overtake the canopy. Two cuts will take place, first a retention cut to release the regeneration and a final cut to remove the remaining over story (MNRF, 2015). Finally, the young forest located to the right of the stand will have a single tree system performed. The Ba in this stand is very low and minimal harvesting will achieve a Ba of 20m^2/ha.

4.2.4.2 Harvest Removal

The harvest of stand 4 will focus on species which will not survive until the next harvest. Considering EAB and EGM, there will be species of trees which will be impacted by these pests and high mortality will be seen in the coming years. Depending on the treatment being performed in stand 4, various amounts of wood will be harvested. In the single tree selection, *Fraxinus americana* and diseased trees will be removed in order to create a healthier forest. The Ba of the forest after harvest couldn't be less than $20m^2$/ha to create these conditions. In the uniform shelterwood cut, the harvest will focus on old large *Populus grandidentata* which take up large portions of the canopy. By removing these trees, the maple in the regeneration will receive the conditions needed to grow faster. The Ba after the harvest of the shelterwood will be heavier and retain a Ba of $15m^2$/ha. This will allow more removal of unwanted species but provide the necessary conditions. *Populus grandidentata* which should remain after harvest should be the healthiest and be able to survive until the final removal.

4.3 Harvest Volume

Table 3 Shows the available growing stock in each stand by meters cubed and by cords. From the management plans for each stand an allocated harvest amount can be determined. The harvest amount is shown in cords and this is the amount of wood being harvested in the first cycle. Finally, the potential revenue is documented and calculated from the allocated harvest amount. The cost of a cord is based of the firewood log prices considering the low quality of wood in the stand.

Stand	Basel Area Per Hectare	Total m3	Total Cords	Harvest in Cords	Cost of One Cord $60
1	33.5m2	1463 m3	403 Cords	140 Cords	$8,400
2	35.45m2	1343 m3	370 Cords	210 Cords	$12,600
3	25.65m2	1081 m3	298 Cords	83 Cords	$4,980
4	21.87m2	1817 m3	501 Cords	50 Cords	$3,000
Total		5704 m3	1572 Cords	483 Cords	$28,980

Table 3 Harvest volume for each stand and the potential revenue.

4.4 HABITAT MANAGEMENT

The wildlife consideration which will take place during the management plan ensures to increase habitats. Larger diameter trees are important for species which create stick nests within the canopy of the trees. During the tree marking phase, larger trees which are spaced throughout the stand will be saved as habitat trees. Cavity trees are an important habitat structure within forest. Many species use these habitats, and these trees will need to be saved during logging. These trees are ones which have cavities in them and larger trees with these features should be marked for wildlife importance. The management plan will require the retention of three wildlife trees per hectare. In the forest there are portions which are mixed wood but are areas where individual conifer trees exist. These conifer trees are essential to the biodiversity of the forest and larger conifers provide habitats for a diverse number of species. During tree marking, conifers over 45 cm in diameter will be left as important wildlife trees.

4.5 LOGGING METHOD

The type of logging which will occur on the property is low intensity logging. The operation will use tree length extraction leaving the tops in the stands. The cutting process will be motor-manual, and the method of skidding is mechanical. Logging will occur during the winter months to have minimal impact on the soil and other species. The existing logging trails will be used to access the stands and a temporary skidding trail will be developed in order to move the wood. A stand will be logged starting from the furthest point in order to use marked trees as bumpers when pulling wood out of the stand. These trees will be harvested and will ensure low damage to the existing stand. The landing will be a two-acre cleared piece of land which is located off the road and labelled for recreation on the map. This is the location where the trees will be sorted and bucked for the appropriate market. Finally, a border of 10 meters from the property line and the protected ridge to prevent damage to neighboring properties (Byford, 2009).

4.6 RENEWAL AND TENDING

Future renewal and tending will depend on how the regeneration in the stands will act. Stands which had more *Populus grandidentata* might need to have regeneration removed after a few years because of coppice growth. Manual and chemical processes may be used in order to control the growth of *Populus grandidentata* to allow tolerant species to take over the stand. Conifers provide great biodiversity for forests so the implication of small-scale conifer planting will occur where the Ba density is low. Trees in this planting will come from the property and be replanted, ensuring that trees being planted have adjusted to the ecological zones.

5.0 DISCUSSION

5.1 RESULTS DISCUSSION

The goals and indicators of the property owner will be achieved by the management plan and the harvest operation mentioned earlier. The harvest operation will focus on improving the stand quality, as due to past logging operations the forest has been left in a state of low quality thus degrading the forest. The objective of the landowner is to increase the quality of wood which can be harvested in future operation. With these goals and indicators, a harvest prescription was developed in order to achieve the wildlife management and timber supply goals. During the forest harvest operation in each stand, the management plan will focus on removing the lower quality growing stock and the trees affected by the invasive species present on the property. The removal of these species will release the canopy of the existing trees and allow regeneration to occur. The harvest will also manage for the protection and creation of habitat for species. These harvests will follow the provincial regulation so that adequate procedures are done while developing AOC or by creating necessary habits in the stand. The management plan has provided the landowner with a guide on how they should harvest the property to achieve their goals. The harvest, logging, and trending plans will allow the landowner to schedule the necessary logging and monitor the future growth of the forest. Finally, the indicators identified in the management plan determine how well the goals and objectives have been completed. By following the harvest procedures the majority of the indicators will be achieved, indicators that have not been achieved can be reevaluated and completed in future harvest operations.

5.2 INDICATORS ACHIEVED

Indicator	Achieved
Wildlife trees	This indicator was achieved by retaining trees which have wildlife significance. These trees included mast bearing trees, c1 and c2 cavity trees, and dead trees which will provide for species.
Scattered Conifers	Throughout the property there can be seen many conifers which are scattered on the property. these trees will be protected. During logging due to the significance, it brings wildlife. Clusters of 3 conifers were especially saved and protected. This target could not be achieved throughout the whole stand as not every hectare would have 10 conifers.
Super Canopy Trees	This goal could not be achieved on every hectare because the forest is only around 60 years old. There are only a handful of trees on the property which go over the size of 60 cm and these trees will be protected because of their significance.
ShelterWood Harvest	This goal will be achieved so that the light requirements can be achieved in order to create the proper natural regeneration required for the stand.
Selection Harvest	Selection harvest needs to remain 20 m2/ha in order to achieve the proper light condition so that tolerant hardwoods can regenerate without any composition of other species.
Selection Harvest Amount	Removing more than one third of the Basel Area during selection cut will not occur to ensure good health and regeneration of the forest.
Genetic Conservation of Native Trees	During the harvest operation first trees which show the worst genetic quality or conditions will be removed in order to generate higher quality trees for future harvest. These trees will be ladled as UGS.
Removal of Invasive Species	Invasive species like emerald ash borer and gypsy moth will affect certain species. These species will be white ash and trembling aspen which will either be killed or have reduced growth. In the management plan these species will be targeted during the first harvest operation to allow other trees species to grow.
Selection Harvest Regeneration	In selection harvest area tolerant hardwoods are the goal with sugar maple being the dominant tree in the stand. After 5 years a survey will be completed which will determine the regeneration layer. If the stand is being infiltrated with shade intolerant species thinning will occur to allow the release of tolerant species.
Shelter Wood Regeneration	In shelter wood harvested area coniferous will the species of target. Once the natural vegetation is established it will be determined if planting is required to achieve the goals of the management plans. Thinning operations may be required to remove unwanted species.
Logging Damage	Logging damage will be reduced by using sacrificial trees as bumpers so that the damage is not done to the trees which will remain.

Table 3 List of the indicators and how or if the targets were achieved.

6.0 CONCLUSION

Private woodlot owners in Southern Ontario play a vital role in the conservation of forests resulting in high volume of private ownership. Developing forest management plans provides the landowner guidance for the goals set. These management plans allow the conservation of biodiversity and the retention of specific habitat. Finally, a plan like this brings value to a landowner as the wood can be harvested ethically and leaves a forest to increase in value supporting the investment of silviculture practices.

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8.0 APPENDIX

	red oak	sugar maple	white pine	cherry	sprurce	iron wood	white ash	poplar	birch	basswood	beech
10		18									
12	1	10			2	1				1	
14	1	14			3	1	4		2		
16	1	9			1	1					
18	3	10			4	1	3		3	1	
20	2	8			4		5		4		
22	1	11			3		4		2		
24	2	10			3		5			1	1
26		9			1		6			1	
28		3			2		4				
30	2	5			5		5				
32		2			1		3				
34		4			5						
36		1			2						
38					3						
40			1		1						
42		1			3						
44											
46											
48					1						
50		1			1						

Stand 1 tally results of ten plots

	red oak	sugar maple	white pine	cherry	sprurce	iron wood	white ash	poplar	birch	basswood	beech
10	1	23			1	3	6				
12	1	20				4	6			1	
14	1	12				3	5				
16	2	10					5	1	1		
18	1	3			1		2	2			
20	1	5			1		5	13			
22	5	11			1		3	5	2		2
24		8					2	15			
26	2	5					3	16	1		
28	1	6					2	5			
30	2	1					1	9	1		
32	1	2					2	3			
34	1	1					2	8			
36	1	1						2			
38								1			
40			1				1	1			
42											
44	1										
46											
48											
50											

Stand 2 tally results of ten plots

	red oak	sugar maple	white pine	cherry	sprurce	iron wood	white ash	poplar	birch	basswood	beech
10	5	15	0	0	3	5	2	0	0	0	0
12	8	7	0	0	5	4	3	0	0	1	0
14	8	15	0	1	5	2	5	0	0	0	0
16	7	9	0	0	3	1	4	0	0	0	0
18	8	6	0	0	9	0	3	0	1	2	0
20	6	7	0	0	3	0	5	0	0	1	0
22	14	10	0	0	3	0	6	1	0	0	0
24	4	3	0	0	2	0	5	0	0	0	1
26	3	2	0	0	2	0	3	1	0	0	0
28	4	0	0	0	2	0	0	0	0	0	0
30	1	0	0	0	0	0	1	0	0	0	0
32	1	0	0	0	0	0	0	0	0	0	0
34	1	0	0	0	0	0	0	0	0	0	0
36	1	0	0	0	0	0	0	0	0	0	0
38	7	0	0	0	0	0	0	0	0	0	0
40	2	0	0	0	0	0	0	0	0	0	0
42	0	0	1	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	1	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0

Stand 3 tally results of ten plots

	red oak	sugar maple	white pine	cherry	spruce	iron wood	white ash	poplar	birch	basswood	beech
10	0	56	0	0	0	1	5	0	1	0	1
12	0	19	0	0	0	3	6	0	4	1	0
14	0	28	0	0	0	0	5	0	2	0	1
16	2	15	0	0	0	0	8	1	3	0	0
18	1	21	0	0	0	0	7	2	3	0	1
20	0	8	0	2	0	0	8	5	2	0	0
22	1	13	0	1	0	0	10	1	3	0	3
24	0	13	0	0	0	0	4	3	0	0	0
26	1	7	0	0	0	0	3	1	0	0	0
28	1	5	0	0	0	0	3	2	0	0	0
30	0	9	0	0	0	0	4	1	0	0	0
32	1	4	0	0	0	0	5	1	0	0	0
34	0	0	0	0	0	0	1	3	0	0	0
36	0	2	0	0	0	0	2	2	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0
40	0	0	2	0	0	0	0	2	0	0	1
42	0	0	0	0	0	0	0	0	0	0	0
44	0	1	0	0	0	0	0	1	0	0	0
46	0	0	0	0	0	0	1	0	0	0	0
48	0	0	0	0	0	0	0	2	0	0	0
50	0	0	0	0	0	0	0	2	0	0	0

Stand 4 tally results of 18 plots