THE EFFECTS OF MECHANICAL SITE PREPARATION, UNSCARIFIED AND REFILL LAND TYPES ON THE GROWTH AND ESTABLISHMENT OF PLANTED SEEDLINGS.

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ABSTRACT

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Keywords: density, mechanical site preparation, root collar diameter, seedling, seedling growth, silviculture, soil

structure, unscarified.

This study examines the effects of different site types of tree planting blocks on the growth and establishment of planted seedlings within the Black Spruce Forest, north of Thunder Bay, Ontario. Measurements of planted seedlings' root collar diameter (mm) and height (cm) from planted blocks spanning from the years in which planted from 2019 to 2022. Including different analyses of the data helps depict which site type provides the improved site conditions for seedling growth. The different block types included in this study were MSP trenching and mounding, un-scarified, refill and slash pile burns. Overall, un-scarified planted seedlings provided on par if not better results than the competing block types within the Black Spruce Forest. This data will help provide insight on planning for foresters of the Black Spruce Forest, whether to MSP or leave un-scarified. Un-scarified is preferred by planters, also is economically and environmentally beneficial and helps save time on implementing the tree plant for intended blocks.

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ACKNOWLEDGEMENTS

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INTRODUCTION

Site preparation, both mechanical and chemical, have been a very useful and popular choice by Foresters to improve the growth and establishment of planted seedlings. There are two other silviculture land types that are present within the Black Spruce Forest including unscarified and refill block types. These methods all serve a different purpose depending on the location of the block, the future goals for the intended block and other environmental and economic aspects that influence the decision-making for the cut block.

There are several different silvicultural site preparation systems and techniques. They are described as an anthropogenic disturbance of the top layers of the forest floor, releasing and exposing mineral soil, designed to improve the regeneration of future crops of their growth and establishment (Cardoso 2020). There is a combination of silvicultural site preparation techniques used within the Black Spruce Forest, although for this study two forms of mechanical site preparation, MSP, will be examined. The two methods are disc trenching and mounding both leading to similar outcomes resulting in the top vegetation and humus being flipped exposing the underlying mineral soil.

The majority of the cut blocks being examined followed the clearcut harvesting method, paired with either method of MSP followed by tree planting. This series of silvicultural events are very successful in terms of survivability along with the growth and establishment of seedlings, providing economic, social, and environmental benefits. Although this is a costly method for the licence holder which is Resolute Forest Products. This paper examines the growth and establishment of seedlings with an emphasis on measurements in the MSP blocks while also comparing the results with unscarified blocks to evaluate whether there is enough evidence of more growth to justify implementing more unscarified blocks to save resources and time leading to saving more money.

The data collected and processed will hopefully lead to other findings which will help with the efficiency of operations for silviculture methods. This study will provide up-to-date data on trees planted within the last four years, along with consistent measurements, valuable data on species competition; both interspecific and intraspecific, soil structures of examined cut blocks, and the amount of natural regeneration present within each plot.

OBJECTIVE

The outcome and goals of initiating mechanical site preparation are to provide an improved and more suitable microsite for planted seedlings. Providing a microsite with less competition while exposing mineral soil. Measuring seedlings' root collar diameter and total height from different silvicultural block types including two methods of mechanical site preparation; disc trenching and mounding. Along with unscarified and refill block types which have all been planted from 2019 to 2022 within the Black Spruce Forest. Analyzing different factors such as tree species, species competition, tree density, and soil structure will help evaluate which silvicultural block type is best suited for seedling growth and establishment within the Black Spruce Forest, BSF. Processing the data collected through different methods to examine the seedlings planted will help depict which silviculture method has the most influence on the growth and establishment. The species of trees will also have an impact on growth depending on the site and soil structure present, which is also taken into consideration. The methods used to find different forms of the mean and express the median and relationships of the seedling measurements. Also includes calculations of standard deviation, standard error, and the coefficient of variation.

The calculations will examine and show the data in a clear and concise manner which will hopefully lead to helping in decision-making for using a more related and accurate silviculture method based on calculated data results and forest stand goals. The objective of the study is to determine which mechanical site preparation provides the most suitable growing conditions based on the data collected and processed. Also comparing the processed data of the unscarified blocks to depict whether they compare enough to the prepped blocks would in the end save a lot of money and time.

HYPOTHESIS

Mechanical site preparation in theory should lead to improved growth and establishment, compared to a site that has not undergone site preparation. Furthermore, comparing the effects of the mechanical site methods of trenching and mounding. Mounding should be the method that provides the best microsite.

LITERATURE REVIEW

Differing silviculture practices inevitably have lasting impacts on the success of planted cut blocks, the main form of silviculture taking place in the Black Spruce Forest, BSF, is clear-cut, MSP then tree plant. There are many factors which encourage the growth and establishment success rates of planted seedlings within the BSF. Exploring and reviewing the specific species that are planted within the BSF will provide their site preferences, ranges, growth requirements and their main uses post-felling. With insight into plantations as well as how they grow from natural regeneration.

The overall factors which discern tree planting will be explored, such as success rates, tree density and other aspects which have implications for the planted seedlings. The success rates at which planting occurs will be discussed, as whether the general rates will apply here in the BSF and what factors differed in areas with lower success rates. As well as the density to which the cut-blocks are subscribed has impacts on the growth and establishment of the seedlings.

Mechanical site preparation is commonly used within the BSF and throughout Canada, this process influences seedling growth drastically by providing microsites with exposed mineral soils and drainage systems which encourage the growth and establishment of planted seedlings. The two main methods of MSP used within the BSF are trenching and mounding. They are similar approaches, while also differing in many ways which will be discussed.

There are other land types that are silvicultural prescribed within the BSF, each one is implemented for different reasons usually impacted most by the location and terrain of the cut-block. The three other land types that are applied in the BSF consist of unscarified, refill, slash pile burns, and roads.

PLANTED TREE SPECIES IN THE BLACK SPRUCE FOREST

An important aspect of silviculture and regeneration, artificial or natural, of harvested forest stands is ensuring that the stand regeneration emulates natural historical forest conditions and species compositions. Historical forest condition data is critical to understand to ensure best management practices are implemented to encourage the natural dynamics of the area, including natural disturbances and current forest conditions (MNRF 2020). Anthropogenic activities such as fire suppression, forest harvesting and the expansion of population have altered natural forest conditions including, forest succession, species composition, landscape structures and age-class distributions (Shinneman et al. 2010). Ontario's Boreal Forest relies on natural disturbances to maintain healthy and prospering forest stands, with the implementation of sustainable forest management planning within Ontario, set new legislations and guides to ensure the best management practices are implemented. This brought new silvicultural practices to light, focusing more on the ecosystems and environment where management takes place, emulating the natural dynamics of disturbance regimes and regeneration tactics (Fenton 2009). These sustainable forest management practices ensure that Ontario's Boreal tree species continue to thrive within their natural ranges.

Ontario's Boreal Forest is a vibrant and bountiful ecosystem, with a vast variety of floral species. This study focuses primarily on the conifer species within the Boreal Forest, specifically in the BSF. The main tree species within this range are Black spruce, *Picea mariana*, White spruce, *Picea glauca*, Jack pine, *Pinus banksiana*, Balsam fir, *Abies balsamea*, and Tamarack, *Larix laricina*. In the southern reaches of this region, there are also Eastern White pine, *Pinus strobus* and Red pine, *Pinus resinosa*. The regeneration through tree planting in the BSF focuses on Black and White spruce, Jack pine and White and Red pine, although there were no White pine trees measured within this study. There are many factors which influence planted seedlings' growth and establishment which can be explored at different scales such as climatic at the regional scale, edaphic at the stand scale and the local conditions, and the microsite scale (Henneb et al. 2020). This study investigates the stand and microsite scales, taking into consideration what method of site preparation, if present, affects the planted seedlings. Each species has its preferred ecotypes where they grow and establish to the best of their capabilities, to follow describes each species' habitat, site preferences, natural ranges, and growth requirements within the BSF.

Black Spruce – *Picea mariana* (Mill.) BSP

Black spruce in Ontario is one of the most economically valued and commercially used species specifically for its lumber and wood fibre to produce a variety of forest products (Henneb et al. 2020). In 2004, this species represented a total of 64% of Ontario's growing stock, and a total of 80% of the annual allowable cut (Zhang et al. 2004). In 2006 Black spruce represented a total of 37.4%, approximately 2.7 billion cubic meters, of Ontario's total available growing stock (Subedi and Sharma 2011). More recently, in 2021 Black spruce accounted for about 33% of Ontario's growing stock, of approximately 1.7 billion cubic meters within crown forests and a total of 2.1 billion cubic meters (MNRF 2021). Changes to the annual growing stock come from a variety of factors such as natural disturbances, annual allowable cut changes, the average annual growth, and the average annual harvest volumes.

Black spruce is a hearty, slow-growing, and long-lived conifer tree species, and are able to grow in a wide variety of habitats spanning Canada's Boreal Forest regions. These regions include wetlands, lowlands, and uplands forests, and thrive in disturbed sites both natural and anthropogenic (Farrar 2018). Within the BSF, there is also a variety of land types where Black spruce are found in abundance. This species does prefer wet and poorly drained sites to moist organic soils (Farrar 2018). Black spruce is usually found in extensive pure stands, while also consisting of mixed stands with other Boreal species both conifer and broadleaf, this species is also moderately shade-tolerant (Farrar 2018). Black spruce trees typically grow to be about 15-20 meters tall and have a conical shape. They have short needles that are dark green to blue-green in colour and are very stiff and sharp to the touch. The cones of black spruce trees are small and cylindrical, measuring only about 2-4 cm in length (Farrar 2018).

Black spruce forests are important ecosystems in Ontario, providing habitat for a variety of wildlife, such as moose, black bears, and songbirds. These forests also play a crucial role in the carbon cycle, storing large amounts of carbon in their biomass and in the soil (Nakane et al. 1997). In recent years, black spruce forests in Ontario and other parts of the boreal forest have been affected by climate change, with warmer temperatures and changes in precipitation patterns leading to increased wildfires and insect outbreaks. These changes have important implications for the ecology and management of these forests.

Black spruce plantations are an important tree species in Ontario for a variety of reasons including carbon sequestration, Black spruce trees are highly effective at sequestering carbon, making them an important tool in the fight against climate change. Biodiversity, Black spruce plantations can provide a habitat for a variety of wildlife, including birds, small mammals, and insects. Timber production, Black spruce is an important source of timber in Ontario, and plantations can be managed to provide a sustainable supply of wood. Soil stabilization, Black spruce trees have deep roots that help stabilize soil, reducing erosion and improving water quality. Economic benefits, Black spruce plantations can provide economic benefits to local communities through the creation of jobs in forestry and related industries (McKenney et al. 1992). Cultural significance, Black spruce trees have cultural significance to many Indigenous communities in Ontario, and the management of plantations can provide opportunities for traditional land use practices.

White Spruce – *Picea glauca* (Moench) Voss

White spruce is a coniferous tree species that are native to the boreal forest region of North America, including Ontario (Farrar 2018). White spruce trees are well-adapted to cold and harsh environments and have several ecological adaptations that help them survive in these conditions. The soil and nutrient requirements of White spruce trees are described as growing best in well-drained soils with high organic content. They have a shallow root system that can spread over a wide area to extract nutrients from the soil (Thompson et al. 2002). Reproduction of White spruce occurs through both sexual and asexual means. Sexual reproduction occurs through the production of cones that release seeds, which can be dispersed by wind or animals. Asexual reproduction occurs through the growth of lateral shoots, which can develop into new trees (O'Connell et al. 2006).

The growth and development of White spruce trees include reaching heights of up to 30 meters tall and can live for several hundred years. They are slow-growing trees, and their growth rate is influenced by several factors, including soil moisture, temperature, and light availability (Farrar 2018). Their role in ecosystems plays an important role in the boreal forest ecosystem, providing habitat for a variety of wildlife species, such as birds, small mammals, and insects. They also help regulate the local climate by storing carbon and releasing oxygen through photosynthesis (Farrar 2018). White spruce has several adaptations to winter that help them survive the harsh winter conditions in Ontario, including a thick layer of needles that helps retain moisture, flexible branches that can withstand heavy snow loads, and a cone shape that allows snow to slide off the branches (O'Connell et al. 2006). The ecology of white spruce trees is characterized by their adaptations to cold and harsh environments, their role in the boreal forest ecosystem, and their importance as a source of timber and other products.

White spruce is an important tree species in Ontario for various reasons including, timber production, White spruce is a valuable source of timber in Ontario, and it is commonly used for construction lumber, pulpwood, and paper (Hassegawa et al. 2019). Within Ontario and all land types, the estimated gross total volume of White spruce in 2021 is 157,682,144 , while within crown land the gross total volume is estimated to be 103,401,880 (MNRF 2021). There are many ecological benefits of White spruce such as soil stabilization, erosion control, and carbon sequestration. This flows into more benefits concerning wildlife habitat, White spruce forests provide a habitat for a variety of wildlife species, including birds, small mammals, and insects (Nienstaedt 1957). They pose Climate resilience, White spruce is a hardy species that are well-adapted to Ontario's climate, and it can help increase the resilience of forests to climate change. White spruce forests are popular destinations for recreational activities, such as hiking, camping, and hunting. White spruce trees have cultural significance to many Indigenous communities in Ontario, and they have been used for traditional purposes, such as making canoes, baskets, and snowshoes (Whitney 1993).

<u>Jack Pine – *Pinus banksiana* Lamb.</u>

In Ontario, Jack pine is an important species for the forest industry, and understanding its silvics is crucial for its successful management. The range and distribution of Jack pine are within the northern and eastern parts of North America, including the boreal forests of Ontario. In Ontario, it grows in the northern half of the province, from Lake Superior to the Quebec border (Farrar 2018). The habitat in which Jack pine is adapted is harsh, dry, and nutrient-poor sites. It can grow on a variety of soils, including sandy, rocky, and clay soils, but it prefers well-drained sites. It is commonly found on sand plains, rocky ridges, and in post-fire environments (Desponts and Payette 1992).

The growth and development of Jack pine is a relatively short-lived tree, with a lifespan of 80-120 years (Farrar 2018). It is a pioneer species, meaning it is one of the first to establish on disturbed sites such as clear-cuts or burned areas. It is also a serotinous species, which means that its cones are held closed by a resinous bond until they are exposed to heat from a fire, at which point they open and release their seeds (Zhang et al. 2002). Silvicultural considerations for Jack pine are, it’s an important commercial species in Ontario, and primary uses for its timber and fibres are pulpwood, lumber and roundwood. Jack pine also make up about 10.9 % or 785 million cubic meters of the total growing stock in Ontario in 2006 (Subedi and Sharma 2011). While in 2021 the total gross volume for growing stock within Ontario was 759,876,866 , although within crown land Jack pine made up 13.3%, or 587,979,621 , of the total gross volume for growing stock (MNRF 2021). It is typically managed through even-aged silviculture, where stands are harvested at regular intervals to maintain a relatively uniform age structure. Natural disturbances such as fire can also be used to regenerate

Jack pine stands (Subedi and Sharma 2011).

The ecological relationships of Jack pine are an important component of the boreal forest ecosystem in Ontario. It provides a habitat for a variety of wildlife, including birds, mammals, and insects. It is also an important food source for wildlife, as its seeds are a preferred food for many small mammals and birds. In addition, Jack pine forests play a key role in the global carbon cycle, sequestering carbon from the atmosphere and storing it in their biomass and soils (Kenkel 1986).

Red Pine – *Pinus resinosa* Ait.

Red pine is another important tree species that are planted in abundance within Ontario's forests and understanding its silvics and ecology is necessary for successful management and silvicultural implications. Here are some key points about the silvics and ecology of Red pine in Ontario, the range and distribution of Red pine are common tree species in the Great Lakes-St. Lawrence forest region in Ontario, and it is also found in other parts of North America, including the northeastern United States. In Ontario, it is found primarily in the central and southern parts of the province (Farrar 2018). Their habitat consists of a variety of soils, including sandy, loamy, and gravelly soils, but it prefers well-drained soils. It is commonly found on sandy plains and ridges, and it is often associated with other conifer species such as Jack pine and white pine (Anand et al. 2013).

The growth and development of Red pine are a long-lived species, with a lifespan of up to 400 years. It is a relatively slow-growing tree, with an average growth rate of about 10-20 cm per year. Red pine is a shade-intolerant species, meaning it requires full sunlight to grow and does not tolerate shade (Farrar 2018). Silvicultural considerations for Red pine are an important commercial species in Ontario, primarily used for lumber and pulpwood. In 2021 the growing stock estimated total gross volume for Red pine was 80,906,115 within all land types in Ontario (MNRF 2021). While within crown land the growing stock of Red pine was 1.04% of the total estimated gross volume, accounting for 46,143,995 (MNRF 2021). It is typically managed through even-aged silviculture, where stands are harvested at regular intervals to maintain a relatively uniform age structure. Natural disturbances such as fire can also be used to regenerate Red pine stands (Drever et al. 2010). The ecological relationships of Red pine forests provide a habitat for a variety of wildlife, including birds, mammals, and insects. It is an important food source for wildlife, as its seeds are a preferred food for many small mammals and birds. In addition, Red pine forests play a key role in the global carbon cycle, just as many other species do within the Boreal in Ontario sequestering carbon from the atmosphere and storing it in their biomass and soils is another key feature of the species (Wetzel and Burgess 1994). Overall, understanding the silvics of Red pine is important for managing this valuable tree species in Ontario's forests.

TREE PLANTING

Tree planting is an important silvicultural activity in Ontario's forests, specifically within the BSF, and serves several significant purposes. The reforestation of harvested stands is one of the main purposes of tree planting in Ontario. Plantings' goal is to restore forests to their historical species compositions from which they have been degraded or destroyed by natural or anthropogenic causes, such as wildfire, or urbanization but mainly after harvesting (MNRF 2020). The renewal of forested stands helps to maintain the ecological functions and values of the forest, such as carbon sequestration, biodiversity, and watershed protection. While ensuring that there will be available harvests in the future for economic values. Future timber production is another purpose of tree planting in Ontario, which will produce timber for the forest industry for generations to come. Many tree species in Ontario, such as spruce, pine, and fir, are grown for their wood, which is used for building materials, paper products, and other industrial applications. Tree planting ensures a sustainable supply of wood for future generations.

Tree planting encourages improved wildlife habitat after harvesting, tree planting also provides new habitat for wildlife species within Ontario, specifically the BSF. Many tree species, such as oak and maple, provide food, shelter, and nesting sites for a variety of birds, mammals, and insects. By planting trees, wildlife habitat can be enhanced or restored, contributing to the conservation of biodiversity in the province (Weber et al. 2002).

Tree planting also plays a major role in soil conservation, as trees play an important role in preventing erosion, reducing runoff, and improving soil structure and fertility. Tree planting can help to stabilize soils, particularly on steep slopes or degraded lands, and reduce the impact of soil erosion on water quality and aquatic ecosystems (Holl and Brancalion 2020). Climate change mitigation is another important factor in tree planting, as climate change is an ever-growing topic of interest throughout the world. Trees are important carbon sinks, meaning they absorb carbon dioxide from the atmosphere and store it in their biomass and soils. Tree planting can help to mitigate the effects of climate change by increasing the amount of carbon stored in forests, reducing greenhouse gas emissions, and contributing to the transition to a low-carbon economy (Hulvey et al. 2013).

Overall, tree planting in Ontario serves multiple purposes, from restoring degraded forests and producing timber to providing wildlife habitat, conserving soils, and mitigating climate change.

<u>Success Rates</u>

Tree planting success rates in Ontario can vary depending on several factors, including the species of tree being planted, the site conditions, and the planting techniques used. Generally, tree planting success rates in Ontario are influenced by the following factors, such as species selection. The choice of tree species plays a crucial role in determining the success of tree planting efforts (Brancalion and Holl 2020). Some tree species are better adapted to Ontario's climate and soil conditions than others. For example, the species that are planted the most within the BSF are Black and White spruce, Jack pine, and White and Red pine, which are known to have higher success rates in Ontario due to their ability to tolerate the region's climate and soil conditions.

The site conditions both at temporal and spatial scales, considering both block types and microsites are also key factors in planting success within the BSF. Site conditions such as soil type, moisture availability, and sunlight exposure can significantly impact tree planting success (Duguma et al. 2020). Trees require suitable soil conditions for root growth and establishment, adequate moisture for survival, and proper sunlight exposure for photosynthesis. If the site conditions are not conducive to the tree species being planted, it can reduce the success rate of tree-planting efforts (Preece et al. 2023).

Proper planting techniques are critical for tree survival and establishment. Factors such as planting depth, root orientation, and soil compaction can all affect the success of tree planting efforts. If trees are not planted at the appropriate depth, with their roots properly oriented, or if the soil is too compacted or poorly prepared, it can negatively impact their survival and establishment rates (Harris and Bassuk 1993). In turn, this leads to post-planting maintenance and care and also plays a significant role in tree-planting success, mainly with efforts towards the use of the chemical spray.

It's important to note that tree planting success rates can vary widely depending on the specific circumstances and practices employed. However, with proper species selection, suitable site conditions, appropriate planting techniques, and diligent post-planting maintenance and care, tree planting efforts in Ontario and the BSF can have higher success rates, resulting in healthy and established trees that contribute to the region's environmental and ecological benefits. Consulting with local forestry experts or arborists can provide further guidance on best practices for successful tree planting in Ontario.

Overall, ensuring that all the key factors are taken into consideration and proper care is provided can increase the chances of success for tree planting efforts in Ontario. So, it is important to plan and implement tree planting projects carefully to promote successful tree establishment and growth in the region. Remembering local regulations and guidelines may also play a role in tree planting success, so it's important to be aware of and adhere to any applicable rules and regulations when planting trees in Ontario. Proper planning, site preparation, planting techniques, and post-planting care are all essential components of successful tree-planting efforts in Ontario or any other region. Working with local forestry experts, arborists, or other knowledgeable professionals can help ensure the best chance of success for tree planting projects. Overall, successful tree planting in Ontario depends on careful planning, appropriate species selection, suitable site conditions, proper planting techniques, and diligent post-planting maintenance and care. With these factors in mind, tree planting efforts in Ontario can contribute to the conservation and sustainability of the region's forests, urban greening, and environmental health.

Density Quality

Tree planting density and quality are important factors that can significantly impact the success of tree planting efforts. Density refers to the number of trees planted per unit area, while quality refers to the health, size, and condition of the trees being planted.

Tree density is an important factor when considering quality, the appropriate planting density depends on several factors, including the tree species, site conditions, and management objectives. Planting trees too densely can result in competition for resources, such as sunlight, water, and nutrients, which can negatively impact tree growth and survival (Grilo et al. 2021). On the other hand, planting trees too sparsely can result in reduced tree cover and lower ecological benefits. It's important to consider the specific species and their growth characteristics when determining the appropriate planting density (Forrester et al. 2013). The tree planting contractor has specific densities to meet set out by the client, for the BSF the contractor is Outland and the Client making the calls is Resolute.

The quality of trees being planted is also crucial for their success. Healthy, well-formed trees with a well-developed root system have a better chance of survival and establishment compared to weak, diseased, or poorly formed trees. It's important to source trees from reputable nurseries that follow best practices for tree production, including appropriate tree spacing, pruning, and root development techniques (Isaac-Renton et al. 2020). Inspecting the quality of trees before planting, such as checking for signs of disease, pest infestation, or root damage, can help ensure that only healthy trees are planted.

Both tree planting density and quality are important factors that can influence the success of tree planting efforts. It's important to carefully consider the appropriate planting density for the tree species and site conditions, source high-quality trees, use proper planting techniques, and provide post-planting care to ensure the best chance of success for tree establishment and growth. Consulting with local forestry experts, arborists, or other knowledgeable professionals can provide guidance on optimal tree-planting practices for specific areas and management objectives. Overall, ensuring proper tree planting density and quality is essential for successful tree establishment and the long-term benefits of trees, including environmental, ecological, and social benefits.

OTHER LAND TYPES

After harvesting, silvicultural land types can vary depending on the specific management practices and goals of the forest. Regeneration Stands are areas where new trees are actively being regenerated after harvesting. They may be established through natural regeneration, where new trees grow from seeds or sprouts left behind after harvesting, or through artificial regeneration, where new trees are planted or seeded by humans. Regeneration stands may have varying tree densities, species composition, and age classes, depending on the silvicultural methods used. The land types other than MSP within the BSF are un-scarified blocks, refill blocks, slash pile burns and decommissioned roads.

It's important to note that the specific silvicultural land types that occur after harvesting will depend on the silvicultural practices used, the ecological characteristics of the site, and the management objectives of the forest or woodland. Silviculture is a complex and dynamic field, and the specific land types may change over time as the forest or woodland progresses through different stages of succession and management. The exact silvicultural land types that occur after harvesting can vary widely depending on local conditions and management practices. The choice of a regeneration system depends on various factors, including the species being managed, site conditions, ecological considerations, and management objectives. It is important to carefully plan and implement regeneration silviculture systems to ensure sustainable forest management and the long-term health and productivity of forest ecosystems.

Unscarified

After harvesting, unscarified land refers to a type of site preparation where the forest floor is left undisturbed or minimally disturbed before tree planting. This approach is commonly used in certain silvicultural systems, such as natural regeneration or direct seeding, where the objective is to establish new trees without disturbing the forest floor. This method is also used in certain situations where the goal is to establish new trees without any additional site preparation or disturbance to the forest floor (Sheppard et al. 2006). The use of unscarified land for tree planting in forestry can have several advantages. It can reduce the cost and effort associated with site preparation, and it can minimize soil disturbance and erosion, which can help maintain soil productivity and protect water quality. Additionally, natural regeneration or direct seeding can result in a more diverse and resilient forest ecosystem, as it allows for the natural selection and adaptation of tree species to the site conditions.

Although, there are also challenges associated with unscarified land types for tree planting in forestry. The success of tree establishment depends on various factors, including the availability of viable seeds, favourable environmental conditions, competition from other vegetation, and potential impacts from pests and diseases

Refill

Refill blocks are a rarely used block type within tree planting, as it requires a few different instances to occur before it needs to be implemented. Only a small percentage of the total tree planting blocks are categorized as refill blocks within the BSF. For a block to be categorized as a refill block this means that either the block has been planted before, and the trees did not take as well as the forester had intended. The success rates were not satisfactory and implementing another plant to fill in the holes where no survival helps to reach the intended goals of the once forested area.

Slash Pile Burning

Slash pile burning is a common practice in forestry that involves burning accumulated debris, also known as slash, left behind after harvesting activities. This debris includes tree limbs, branches, and other woody material that is typically not used for timber or other purposes. Slash pile burning is often done as part of site preparation for tree planting, as it helps to clear the land and create favourable conditions for the establishment of new trees.

The process of slash pile burning usually involves gathering the slash into piles or windrows, typically using heavy machinery such as bulldozers or loaders. These piles are then ignited and burned under controlled conditions to reduce the volume of debris and create open spaces for tree planting. The burn is carefully managed to ensure that it is done safely and with minimal impact on the surrounding environment.

There are several purposes of slash pile burning for tree planting such as it's a different form of site preparation. Slash pile burning helps to clear the land of accumulated debris, creating open spaces for tree planting. By burning the slash, the debris is reduced to ash, which can be more easily incorporated into the soil or removed, providing a clean planting surface for tree seedlings (Thorpe and Timmer 2005). Burning the slash piles can help control competing vegetation that may compete with the newly planted tree seedlings for nutrients, water, and sunlight. The heat from the burn can also help to reduce the viability of weed seeds, reducing the overall weed pressure in the area.

Nutrient cycling is another important aspect, as the ash left behind after slash pile burning contains valuable nutrients, such as potassium, phosphorus, and calcium, which can be returned to the soil. These nutrients can help replenish the nutrient levels in the soil and provide essential elements for the growth of the newly planted trees (Thorpe and Timmer 2005). Slash pile burning also acts as a fire hazard reduction tactic, accumulated slash can increase the risk of wildfires, especially in areas with dry and hot conditions. Burning the slash piles can reduce the fuel load and help mitigate the risk of uncontrolled wildfires, contributing to overall forest fire management (Patterson and Clarke 2006).

It's important to note that slash pile burning is typically conducted following strict guidelines and regulations, including obtaining necessary permits, adhering to local air quality regulations, and following safe burning practices to minimize the potential negative impacts on air quality, wildlife habitat, and water quality. Proper planning, training, and supervision are essential to ensure that slash pile burning is conducted safely and effectively. Slash pile burning is a common practice in forestry used for site preparation, competition control, nutrient cycling, and fire hazard reduction purposes in preparation for tree planting. When done in accordance with regulations and best management practices, slash pile burning can be an effective tool for promoting successful tree planting and sustainable forest management

MECHANICAL SITE PREPARATION

Mechanical site preparation, MSP, is a forestry management technique used to prepare a site for tree planting by removing unwanted vegetation and debris from the area. This is typically done using heavy machinery such as bulldozers, excavators, and skidders. In the case of the BSF, MSP involves several steps. The top layer of soil is disturbed and debris such as branches and rocks are removed. After the initial clearing, the site is usually left to dry out for several weeks or months. This helps to reduce soil compaction and increase the effectiveness of the planting operation.

There are many reasons to implement MSP such as improving soil quality by breaking up compacted soil and creating a better seedbed for tree growth. This can increase water retention, reduce soil erosion, and improve nutrient availability for tree roots (Newmaster et al. 2007). Enhanced tree growth is another benefit, by providing a better seedbed, trees are able to establish and grow more quickly and efficiently. This can lead to improved survival rates, higher growth rates, and overall better health of the planted trees (Zhao et al. 2009). MSP can help to prepare a large area for planting quickly and efficiently, increasing the tree plant efficiency. This can reduce the time and cost associated with preparing a planting site by hand and allow for more trees to be planted in a shorter amount of time (Buitrago et al. 2015).

Reduced Competition through MSP can help to reduce competition from competing vegetation, such as woody shrubs inhibiting nutrients or other faster-growing tree species. This can improve the chances of planted trees surviving and growing successfully. Greater Diversity is another benefit, as MSP can be used to create a range of planting conditions, from highly disturbed sites to more natural settings. This can allow for a greater diversity of tree species to be planted and can help to create a more resilient forest ecosystem over time (Raulund-Rasmussen et al. 2012).

Overall, using MSP for tree planting in Ontario can offer several benefits for forest health and productivity, while also providing cost and time savings for forest managers. Mechanical site preparation is an important part of forestry management in the BSF because it helps to create the conditions necessary for healthy tree growth. By removing unwanted vegetation and debris, the seedlings have access to more nutrients and light, allowing them to grow more quickly and successfully.

Trenching

MSP through disc trenching is a process used to prepare the soil for planting trees by creating trenches or furrows in the ground. This process involves the use of heavy machinery, such as a backhoe or trencher, to create a narrow trench or furrow in the soil. The depth and width of the trench will depend on the size of the trees being planted and the soil conditions (Cardoso 2020).

The disc trenching process serves several purposes such as improving soil drainage, the trenches allow excess water to drain away from the tree roots, preventing waterlogging. Reducing soil compaction, the process of trenching helps loosen the soil, making it easier for roots to penetrate and grow (Sikström et al. 2020). Creating an enhanced microsite for planted seedlings, the trenching process creates a planting bed where the trees can be placed, ensuring that they are surrounded by loose, aerated soil (Cardoso et al. 2020). This promotes better root growth and helps the trees establish themselves more quickly. Disc trenching also increases soil aeration, allowing air to circulate around the roots and promoting the growth of beneficial microorganisms that help to break down organic matter in the soil, allowing for enhancing soil fertility (McLaughlin et al. 2000).

The trenching process should be done in the fall or winter before the tree planting season. This allows the soil to settle and the organic matter to decompose before the trees are planted in the spring. Once the trenches have been dug, the soil should be left to settle for several weeks before planting. Overall, MSP disc trenching is an effective way to improve soil conditions for tree planting and can help ensure the long-term health and success of trees in a planting site.

Mounding

MSP by mounding, which is very similar to disc trenching, is a process used to prepare the soil for planting trees by creating raised planting beds or mounds. This process involves the use of heavy machinery, such as a bulldozer, excavator and a more specific machine called Brackie, to create mounds of soil that are raised above the surrounding ground. The size and shape of the mounds will depend on the soil conditions and the size of the trees being planted (Cardoso 2020).

The process of mechanical site preparation mounding serves several purposes which are very similar to disc trenching, improving soil drainage, mounding raises the soil above the surrounding ground, allowing excess water to drain away from the tree roots and preventing waterlogging and root rot. Keeping the seedlings raised above pooling water. Reducing soil compaction: Mounding helps to loosen compacted soil, making it easier for roots to penetrate and grow (Londo and Mroz 2001). Creating a beneficial microsite produces an improved planting bed. Mounding creates a planting bed where the trees can be placed, ensuring that they are surrounded by loose, aerated soil. Mounding also enhances soil fertility, incorporating organic matter, such as compost or mulch, into the soil. This helps to improve soil fertility and provide nutrients that the trees will need to grow (Thiffault et al. 2020).

The mounding process should be done in the fall or winter, just like for disc trenching, before tree planting season. This allows the soil to settle and the organic matter to decompose before the trees are planted in the spring. Once the mounds have been created, the soil should be left to settle for several weeks before planting. Overall, MSP mounding is an effective way to improve soil conditions for tree planting and can help ensure the long-term health and success of trees in a planting site.

METHODS AND MATERIALS

STUDY AREA

The BSF is an expansive managed forest, with a total size of 1,369,973 hectares, of those, 1,201,325 hectares is crown-managed land located just north of the city of Thunder Bay, Ontario (MNRF 2020). The blocks that were included were scattered throughout the BSF, with plenty being along Highway 527 which splits the forest longitudinally. All the cut blocks that were included in this study were submitted for either MSP trenching or mounding by Brackie, unscarified, refill, slash pile burns, or decommissioned roads proceeded by planting. The blocks that were included in the study consisted of the planted tree species Black spruce, White spruce, Jack pine and Red pine. Data collection took place during the months of October and November in 2022. In total 22 planted blocks were examined within the BSF, all being planted between the years 2019 to 2022.

DATA COLLECTION

At each of the 22 planted blocks that were observed five plots were thrown, using a standard plot cord with a length of 3.99 m which was wrapped around a planting shovel marking the centre of the plot. The location of the plots thrown within each cut block was entirely random, trying to promote a good representation of what was in each cut block.

Each planted tree was measured for total height and its root collar diameter. The height of each planted seedling was measured with a standard retractable measuring tape, measuring the total height to the closest

0.5 cm. The planted seedlings' root collar diameter was measured with a Samona 6” fractional digital caliper, measuring the root collar diameter to the closest 0.01 mm.

The total number of plots thrown was a total of 116 plots, 110 of those consisting of MSP, unscarified, refill and road plots, while the remaining 6 plots were from burn piles within those 22 blocks. In total 1,192 planted seedlings were measured, with an average of 10.42 seedlings per plot. Each plot consisted of a mixture of tree species, as each cut block required a mixed species composition while planting.

STATISTICAL ANALYSES

All statistical analysis was conducted using Microsoft Excel, calculating different approaches of average growth for height and root collar diameter of planted seedlings within different land types. The overall averages were calculated for both total seedling height and root collar diameter for each year, within each land type, and for each species in each land type. The use of box and whisker graphs used made for an easy-to-understand visual representation of the data collected. They provide the mean, median, maximum, minimum values, and outliers, while also presenting where most of the data points are found within the lower and upper quartiles.

Standard error was also used, to help differentiate the population mean from the sample mean. The standard error is a valuable tool for assessing the precision of sample statistics and making inferences about population parameters, and its use can improve the validity and reliability of statistical analyses. This helps to represent the whole population data as a whole compared to the sample data, helping to describe how dispersed the data is to the actual mean. Data with a lower standard error depicts that there is a more uniform approach in the growth of planted seedlings, providing a good representation of the whole population and vice versa with a higher standard error.

The standard deviation of the data is very similar to the standard error but represents the data as a descriptive statistic whereas the standard error is an inferential statistic. The standard deviation is a useful measure of variability that can provide insights into the consistency, precision, and quality of data, and can inform decisions in a wide range of applications from research to industry.

The coefficient of variation is also used, it is a valuable statistical measure that can provide insights into the variability and risk of datasets. This powerful tool can be used to make informed decisions and improve processes in how we manage our forests and match silviculture practices with certain variables to provide the best possible outcome for planted seedlings.

RESULTS

The results calculated for each year varied from each other, as each year produced a different best land type for both seedling total height and root collar diameter. Table 1 breaks down the block count by year, showing how many blocks from each block type were examined, and from which year they were planted. In total 22 planted cut blocks were examined, the most blocks examined were from the years 2020 and 2022 with seven blocks. MSP specifically trenching was the most blocks examined within the different block types.

Table 1. Block count for each land type for each year planted from 2019 to 2022.

	Block Type					
Year Planted	MSP - Trench	MSP - Brackie	Un-scarified	Refill	Road /Burn	Total Blocks
2019	2		1			3
2020	4		2	1		7

2021	3			1	1	5
2022	2	3	2			7
Total Blocks	11	3	5	2	1	22

As each plot thrown consisted of different amounts of planted seedlings, the number of trees in each block type varied a lot. Table 2 outlines the amount of measured planted seedlings within each block type from each year that it was planted. The total amount of planted trees was 1,192, while the year 2022 was the year with the greatest number of trees planted with 429 trees measured. Also, the block type with the greatest number of trees measured was MSP – trench.

Table 2. Total planted seedlings measured for height (cm) and root collar diameter (mm) for each year and block type.

Year Planted	MSP - Trench	MSP - Brackie	Un-scarified	Refill	Burns	Road	Total Trees
2019	99		50				149
2020	169		94	45	7		315
2021	164			58	39	38	299
2022	98	162	114		55		429
Total Trees	530	162	258	103	101	38	1192

BLOCKS PLANTED IN 2019

The blocks that were planted in 2019 and examined for this study consisted of seedlings that have had three and a half growing seasons since being planted between the months of May and June of 2019. Strictly based on the greatest height and root collar diameter the block type producing the greatest values was the un-scarified blocks. As can be observed in figure 1, the maximum, minimum, and average height values were greater in un-scarified blocks compared to MSP trench blocks. The values for un-scarified compared to MSP trench in that order are 146 cm and 135 cm, 38 cm and 29 cm, and 83.9 cm and 76.9 cm respectively. As figure 1 depicts, the values in both block types tend to vary a lot, as can be seen from evaluating the maximum and minimum values.

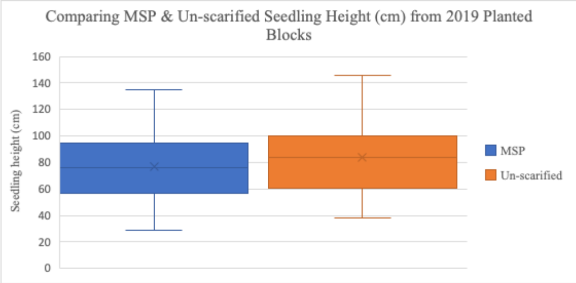

Figure 1. Box and whisker analysis on planted seedlings' height (cm), including all tree species, comparing MSP to Un-scarified measurements, planted in 2019.

The root collar diameter, CD, data for 2019 provided similar results with the average CD being greater in the un-scarified blocks compared to MSP blocks, 19.36 mm, and 12.55 mm (Figure 2). Although, MSP did contain the highest maximum value measured for diameter at 42.65 mm compared to the un-scarified blocks' greatest value of 41.74 mm. The minimum values measured for un-scarified, and MSP were 7.98 mm and 3.92 mm respectively (Figure 2).

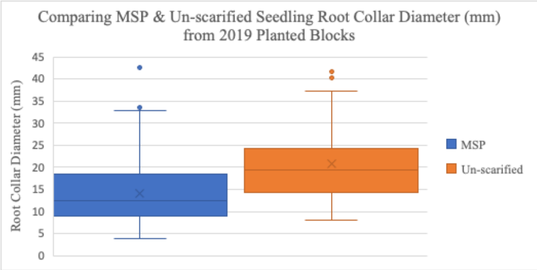

Figure 2. Box and whisker analysis on planted seedlings' root collar diameter (mm), including all tree species, comparing MSP to Un-scarified measurements, planted in 2019.

Comparing the standard deviation, SD, and calculations between MSP and un-scarified blocks proved that the un-scarified blocks tend to have more dispersion of measurements for both heights and root collar diameter. Calculations for the SD (Table 3) for height in un-scarified and MSP blocks are 26.156 and 25.738 respectively. For root collar diameter in un-scarified and MSP blocks the SDs were 8.723 and 7.223 respectively. As for the calculations for standard error, SE, the smaller the value the better which MSP comes out on top for both height and CD measurements, the values being 2.587 and 0.726 respectively for MSP and 3.699 and 1.234 for un-scarified blocks. The calculations produced for the coefficient of variation, CV, (Table 3) proved that un-scarified has a superior return on the growth of planted trees compared to MSP blocks. After three and a half growing seasons for these planted trees, the un-scarified blocks consisted of a lower level of dispersion from the mean providing less variability of growth meaning more consistent growth for the trees planted. The values for CD and height in the un-scarified blocks (Table 3) were 0.419 and 0.312 respectively. The calculated CV within MSP blocks for CD and height were 0.512 and 0.335 respectively.

Table 3. Summary of calculated analysis for both root collar diameter, CD, (mm) and height, Ht, (cm) comparisons between MSP and Un-scarified blocks, for all species planted in 2019.

Block Type	SD-CD	SE-CD	SD-Ht	SE-Ht	CV-CD	CV-Ht
Un-scarified	8.723	1.234	26.156	3.699	0.419	0.312
MSP	7.223	0.726	25.738	2.587	0.512	0.335

Across the board, the species with the highest values in all calculations (Table 4) was Pj within un-scarified blocks, all except for maximum CD, which was still Pj just within an MSP block. After three and a half growing seasons Sb and Sw produced similar growth habits for both measurements of CD and height. With more variation of their growth within un-scarified blocks compared to their growth within MSP blocks (Table 4). The maximum height measured in 2019 was a Pj at 146 cm within an un-scarified block, and the maximum CD measured was also Pj at 42.65 mm within an MSP block (Table 4). While the lowest value measured for CD in 2019 was a Sb at 3.92 mm within an MSP block, and the lowest height value measured was a Sb at 29 cm within an MSP block (Table 4).

Table 4. Summary of calculated analysis for both root

collar diameter, CD, (mm) and height, Ht, (cm) depicting each species in each block type, planted in 2019.

Block Type	Species	Ave. CD	Ave. Ht	Median CD	Median Ht	Max CD	Min CD	Max Ht	Min Ht
MSP	Pj	22.94	98.70	20.84	96	42.65	12.42	135	61
	Sb	10.51	69.61	10.94	71.5	18.76	3.92	121	29
	Sw	12.12	69.38	11.19	67.5	22.34	5.23	131	37
Un-scarified	Pj	33.71	109.75	33.84	104.5	41.74	20.86	146	82
	Sb	13.11	87	13.11	87	14.79	11.43	90.5	83.5
	Sw	16.96	75.09	18.055	76	25.29	7.98	119	38

BLOCKS PLANTED IN 2020

After two and a half growing seasons, the trees planted in 2020 expressed similar growth and establishment values between MSP, un-scarified, and refill blocks. While burn blocks varied more and produced lower measurements across the board (Figure 3). Including all the tree species, the block type that produced the greatest height among planted trees was from an MSP block measuring 109.5 cm (Figure 3). The block type that has the lowest measured height was from an un-scarified block, measuring 12.5 cm (Figure 3). As for average height between the blocks, from greatest to least was MSP, refill, un-scarified then burn blocks with 55.57 cm, 53.19 cm, 51.73 cm, and 30.43 cm respectively (Figure 3).

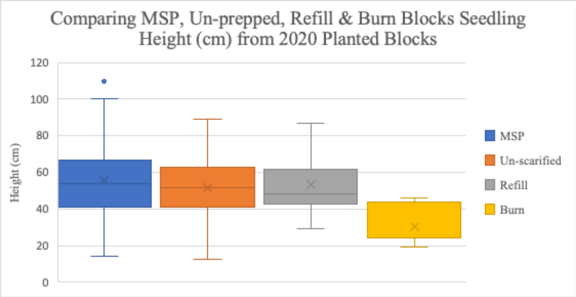

Figure 3. Box and whisker analysis on planted seedlings' height (cm), including all tree species, comparing MSP, Un-scarified, Refill, and Burn blocks, planted in 2020.

The CD measurements (Figure 4) produced even closer averages compared to the height measurements from trees planted in 2020. From greatest to least calculated average for CD in 2020 block types for all species of planted trees was MSP, un-scarified, refill then burn blocks with values of 10.67 mm, 9.98 mm, 9.55 mm, and 5.68 mm respectively. After two and a half growing seasons the block type that produced the greatest CD was within an un-scarified block measuring 27.03 mm while the lowest measured CD was also in an un-scarified block measuring 2.8 mm (Figure 4).

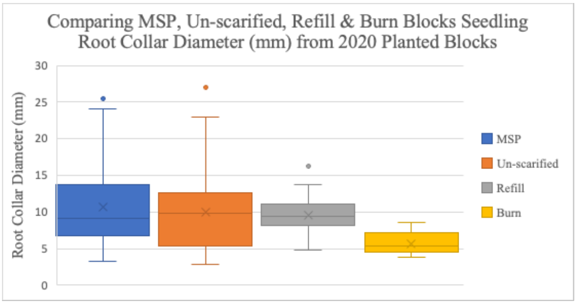

Figure 4. Box and whisker analysis on planted seedlings' root collar diameter (mm), including all tree species, comparing MSP, Un-scarified, Refill, and Burn blocks, planted in 2020.

The blocks that provided the most consistent to least measurements based on SD calculations for CD were burn, refill, un-scarified and MSP blocks with values of 1.50, 2.45, 5.14 and 5.24 respectively (Table 5). The trees planted within burn piles were very consistent, with most of the values being very close to the average. While the MSP blocks varied a lot more, mostly due to many more samples being recorded. The calculations produced for SD for height were the same pattern as the CD block types with the burn blocks yielding the most consistent measurements and then refill, un-scarified and MSP having the least consistent measurements with values of 9.88, 14.01, 16.75 and 19.65 respectively (Table 5). The numbers calculated for SE within the different block types varied a lot comparing the results for CD and height. For CD the block delivering the least discrepancy for SE was refill blocks, then MSP, un-scarified and burn piles with values of 0.37, 0.40, 0.53, and 0.57 respectively (Table 5).

While the lowest SE for height was within MSP blocks, then un-scarified, refill and burns were the greatest with values of 1.51, 1.73, 2.09 and 3.74 respectively (Table 5). In terms of the calculated CV for CD, the block type that produced the better return values was refill blocks with a value of 0.257 (Table 5). While un-scarified blocks had the greatest level of dispersion with a value of 0.515 (Table 5). As for the CV calculated for height it produced the same results with refill being the better return at a value of 0.263 and MSP having the highest value of 0.354 (Table 5).

Table 5. Summary of calculated analysis including standard deviation, SD, standard error, SE, and coefficient of variation, CV, for both root collar diameter, CD, (mm) and height, Ht, (cm) comparisons between MSP, Un-scarified, Refill and Burn Blocks, planted in 2020.

Block Type	SD-CD	SE-CD	SD-Ht	SE-Ht	CV-CD	CV-Ht
MSP	5.24	0.40	19.65	1.51	0.491	0.354
Un-scarified	5.14	0.53	16.75	1.73	0.515	0.324
Refill	2.45	0.37	14.01	2.09	0.257	0.263
Burn	1.50	0.57	9.88	3.74	0.265	0.325

Breaking down the data even more (Table 6) provides insight into how different species react to different block types which were planted in 2020. After two and a half growing seasons the species with the highest average CD was Pj within MSP blocks with a value of 16.40 mm, while the lowest average CD was also Pj but within burn piles with a value of 5.68 mm (Table 6). As for the averages for height, they produced the same results as the CD averages. Pj produced the highest average height within MSP blocks with a value of 68.43 cm and the lowest average height was also Pj within burns at 30.43 cm (Table 6).

Table 6. Summary of calculated analysis for both root collar diameter, CD, (mm) and height, Ht, (cm) depicting each species in each block type, planted in 2020.

Block Type	Species	Ave. CD	Ave. Ht	Median CD	Median Ht	Max CD	Min CD	Max Ht	Min Ht
MSP	Pj	16.40	68.43	16.31	65.5	25.43	5.97	109.5	30.5
	Sb	8.49	53.12	8.225	51.25	14.41	4.51	100.5	19
	Sw	8.56	49.34	8.18	47	16.79	3.31	92	14
Un-scarified	Pj	15.62	62.00	13.98	61.5	27.03	5.23	83	38
	Sb	8.08	47.65	6.68	47.5	18.07	2.8	89	12.5
	Sw	10.96	55.38	11.13	56	19.73	3.92	80.5	32
Refill	Pj	11.15	54.30	10.55	54.75	16.23	8.03	87	29.5
	Sw	9.10	52.87	9.12	48.5	13.74	4.81	83	38.5
Burn	Pj	5.68	30.43	5.32	24	8.52	3.82	46	19

BLOCKS PLANTED IN 2021

The average height among planted trees varied greatly within planted 2021 blocks compared to other years. After one and a half growing seasons, the greatest to the least average height between the different block types were burns, MSP, refill, and roads with values of 57.17 cm, 42.65 cm, 33.94 cm, and 30.84 cm respectively (Figure 5). As for the greatest measured height the tree was measured in an MSP block totalling 89.5 cm, while the lowest total height was also in an MSP block measuring 8 cm (Figure 5).

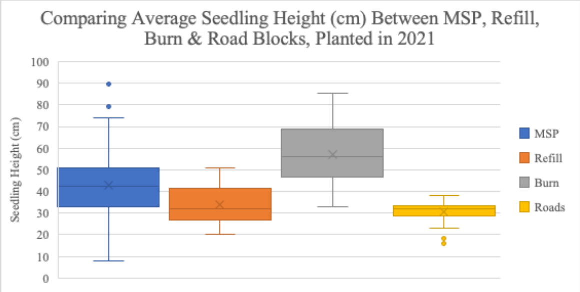

Figure 5. Box and whisker analysis on planted seedlings' height (cm), including
all tree species, comparing MSP, Refill, Burn and Road blocks, planted in 2021.

The CD measured from trees planted in 2021 produced fairly consistent averages among the different block types with the exception of burn piles. From greatest to least calculated average for root collar diameter after one and a half growing seasons was burns, MSP, roads, and refill with values of 14.76 mm, 5.71 mm, 5.43 mm, and 4.18 mm respectively (Figure 6). Burns consisted of the greatest CD at 27.4 mm, much higher than the next block type which was MSP with a maximum CD of 12.36 mm (Figure 6). In 2021 the lowest-recorded CD was within a refill block measuring 2.1 mm (Figure 6).

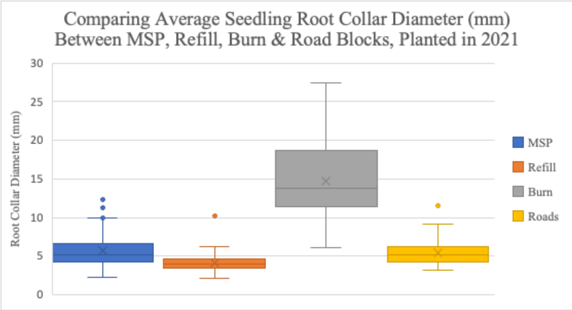

Figure 6. Box and whisker analysis on planted seedlings' root collar diameter (mm), including all tree species, comparing MSP, Refill, Burn and Road blocks, planted in 2021.

The block type that produced values that were closer to the mean based on SD calculations for CD from trees planted in 2021 was refill at 1.161 while burn piles produced values that were more dispersed from the mean with a calculated SD of 4.574 (Table 7). SD calculations for height within the different blocks produced varied results, with roads having less dispersal from the mean with a value of 4.466, while MSP produced the most dispersed height measurements at 14.439 (Table 7). The discrepancy that can be expected within the different blocks provided somewhat similar results for SE and CD measurements, with refill producing the lowest value of 0.152 which better represents its recorded data (Table 7). While the block type with the most discrepancy based on SE calculations for CD was from burn piles consisting of a value of 0.732 (Table 7). The calculations for SE within the different block types for height were higher compared to CD measurements, with 0.725 being the lowest SE from road blocks and the highest being from burn piles with a value of 2.179 (Table 7). The calculations produced for the CV were consistent for CD within the different block types with refill blocks producing the better return with a value of 0.278 (Table 7). While for the CV for height within the different blocks, roads produced a calculated value of 0.145 (Table 7).

Table 7. Summary of calculated analysis including standard deviation, SD, standard error, SE, and coefficient of variation, CV, for both root collar diameter, CD, (mm) and height, Ht, (cm) comparisons between MSP, Refill, Burn and Road blocks, planted in 2021.

Block Type	SD-CD	SE-CD	SD-Ht	SE-Ht	CV-CD	CV-Ht
MSP	2.102	0.164	14.439	1.128	0.368	0.339
Refill	1.161	0.152	8.570	1.125	0.278	0.253
Burn	4.574	0.732	13.608	2.179	0.310	0.238
Road	1.723	0.279	4.466	0.725	0.317	0.145

After one and a half growing seasons the tree species that had the greatest average CD and height were Pj's within burn piles with an average of 14.76 mm, and 57.17 cm respectively (Table 8). The tree species with the lowest average CD and height were Sb's within refill blocks with an average of 3.31 mm and 23.75 cm respectively (Table 8).

Table 8. Summary of calculated analysis for both root collar diameter, CD, (mm) and height, Ht, (cm) depicting each species in each block type, planted in 2021.

Block Type	Species	Ave. CD	Ave. Ht	Median CD	Median Ht	Max CD	Min CD	Max Ht	Min Ht
MSP	Pj	8.78	55.27	9.05	59	12.36	6.18	74	23.5
	Sb	5.17	40.65	4.71	41	12.6	2.25	79.5	8

	Sw	6.21	44.10	5.995	41.25	11.77	2.95	89.5	17
Refill	Pj	6.91	33.17	5.94	30	10.2	4.59	43	26.5
	Sb	3.31	23.75	3.45	22.75	4.23	2.1	27	22.5
	Sw	4.08	34.78	4	33	6.2	2.73	51	20
Burn	Pj	14.76	57.17	13.84	56	27.4	6.09	85.5	33
Road	Pj	6.09	30.69	5.645	32.25	11.53	3.96	38	16
	Sw	4.01	31.17	3.815	30	5.25	3.16	37.5	27.5

BLOCKS PLANTED IN 2022

The trees planted in 2022 only had about 5 to 6 months of growth from being planted to being measured and adding a new type of site preparation which is MSP Brackie. From highest to the lowest height averages from the different block types in 2022 was MSP Brackie, MSP trench, un-scarified and burns with values of 31.35 cm, 25.29 cm, 23.10 cm, 19.54 cm respectively (Figure 7). MSP Brackie provided the greatest height measured from trees planted in 2022 measuring 56.5 cm, while the lowest recorded height was within un-scarified blocks measuring 7 cm (Figure 7).

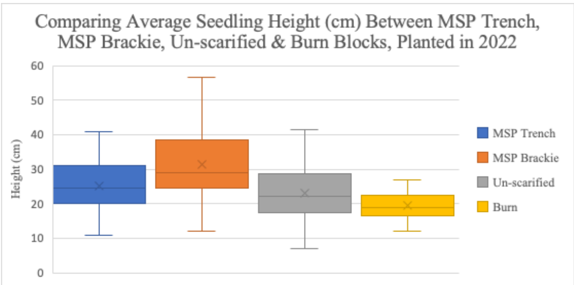

Figure 7. Box and whisker analysis on planted seedlings' height (cm), including

all tree species, comparing MSP Trench, MSP

Brackie, Un-scarified and Burn blocks, planted in 2022.

Trees planted in the spring of 2022 have very consistent average CDs between the different block types, from greatest to the least average CD it was MSP Brackie, un-scarified, MSP trench and burns with values of 4.19 mm, 3.80 mm, 3.63 mm, and 3.40 mm respectively (Figure 8). Although the block type with the highest and the lowest measured CD from planted trees in 2022 was within un-scarified blocks with values of 7.29 mm and 1.37 mm respectively (Figure 8).

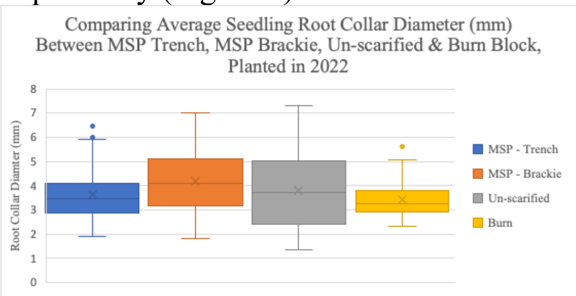

Figure 8. Box and whisker analysis on planted seedlings' root collar diameter (mm), including all tree species, comparing MSP Trench, MSP Brackie, Un-scarified and Burn blocks, planted in 2022.

Out of the four block types examined from planted blocks in 2022, the block type with the most consistent data providing the lowest SD for the measured CD was within burn piles with a value of 0.708 (Table 9). While the block type that has the most dispersed data from 2022 planted blocks was within un-scarified blocks with a value of 1.424 (Table 9). After 5 to 6 months of growth, the data collected for height showed that the block type with the most consistent data based on SD calculations was also within burns with a value of 3.673 (Table 9). While the block type with the most dispersed data based on SD calculations for height within planted 2022 blocks was MSP Brackie with a value of 9.144 (Table 9). Out of the block types examined that were planted in 2022, the blocks that were the most discrepant in terms of SE for the measured CD were un-scarified blocks with a value of 0.133 (Table 9). While the block type that most accurately represented the distribution of the sample for CD in terms of SE was MSP Brackie with a value of 0.092 (Table 9). While the block type that displayed the greatest calculated SE for CD was un-scarified blocks with a value of 0.133 (Table 9). As for the calculated SE for height from blocks planted in 2022, they were very similar while the greatest SE was within the MSP trench blocks with a value of 0.719 (Table 9). Whereas the blocks that displayed the lowest calculated SE were within burn piles with a value of 0.495 (Table 9). Another comparison of the mean depicting the difference of data between block types was the calculation on the CV, as for the measurement of the CD the greatest CV was within un-scarified blocks with a value of 0.374 (Table 9). Whereas the lowest calculated CV for CD amongst planted 2022 blocks was within burns with a value of 0.208 (Table 9). As for the calculated CV for height within the different blocks of 2022, the greatest value was within un-scarified blocks with a value of 0.325 (Table 9). Comparing to the lowest value calculated for CV and height was 0.188 within burns (Table 9).

Table 9. Summary of calculated analysis including standard deviation, SD, standard error, SE, and coefficient of variation, CV, for both root collar diameter, CD, (mm) and height, Ht, (cm) comparisons

between MSP Trench, MSP Brackie, Un-scarified and Burn blocks, planted in 2022.

Block Type	SD-CD	SE-CD	SD-Ht	SE-Ht	CV-CD	CV-Ht
MSP Trench	0.954	0.096	7.117	0.719	0.263	0.281
MSP Brackie	1.169	0.092	9.144	0.718	0.279	0.292
Un-scarified	1.424	0.133	7.501	0.703	0.374	0.325
Burn	0.708	0.095	3.673	0.495	0.208	0.188

Further comparing the difference of growth between different block types although by depicting the differences in species as well. The highest average CD among tree species was Sw within MSP Brackie blocks with an average of 4.93 mm, while the lowest average CD among species was Sb within un-scarified blocks with an average of 2.43 mm (Table 10). The tree species planted in 2022 that has the highest average height was Sw within MSP Brackie blocks with an average of 37.42 cm, and the lowest average tree species was Pj within un-scarified blocks with an average of 17.34 cm (Table 10).

Table 10. Summary of calculated analysis for both root collar diameter, CD, (mm) and height, Ht, (cm) depicting each species in each block type, planted in 2022.

Block Type	Species	Ave. CD	Ave. Ht	Median CD	Median Ht	Max CD	Min CD	Max Ht	Min Ht
MSP Trench	Pj	3.19	19.75	3.045	20	5.91	1.89	27	11
	Sb	3.45	30.14	3.3	31	5.4	2.11	41	17.5
	Pr	4.64	22.36	4.48	23	6.47	3.48	31	11.5
MSP Brackie	Pj	3.52	20.59	3.52	19.1	4.69	2.62	30.5	16.5
	Sb	3.44	26.43	3.395	26	5.44	1.84	38	12
	Sw	4.93	37.42	4.85	38.5	7.01	2.73	56.5	23
Un-scarified	Pj	2.73	17.34	2.88	18.5	3.84	1.37	23	7
	Sb	2.43	19.00	2.14	18.5	4.56	1.85	24	13.5

	Sw	4.54	26.41	4.93	26.75	7.29	1.63	41.5	13
Burn	Pj	3.32	19.33	3.185	19	5.63	2.31	27	12
	Pr	3.81	20.61	3.89	19.5	4.74	3.05	25	17.5

DISCUSSION

Tree planting in Ontario is an important topic with environmental, economic, and sociological implications. As a densely populated province with a significant amount of land under agricultural production, the need for reforestation and afforestation is becoming increasingly important. The focus on tree planting has become more pressing as a response to the impacts of climate change, as trees act as carbon sinks and can help mitigate the effects of greenhouse gas emissions.

However, there are several factors to consider when discussing the effectiveness of tree-planting initiatives in Ontario. This includes the type of trees planted, the location of planting sites, and the methods used to ensure the long-term survival and growth of the trees. Additionally, there are social and economic considerations, such as the involvement of local communities and the potential for job creation.

This discussion aims to explore the various factors that contribute to the success or failure of tree-planting initiatives in the BSF and to analyze the potential benefits and challenges associated with such initiatives. By examining the current state of tree planting in the BSF and considering different perspectives, a better understanding of the role that tree planting can play in achieving environmental and economic sustainability in the province.

2019

The blocks examined that were planted in 2019 went against the original hypothesis, which could be induced by a number of reasons and variables. The only block types that were surveyed from 2019 planted blocks were MSP disc trenching and un-scarified. Although the averages, along with other calculations show different aspects of the data, were greater within the un-scarified blocks for both height and CD measurements. The maximum CD recorded was from an MSP block, this could have been encouraged for a number of reasons, including a larger seed lot while planting. During the planting season, each block has different seed lots prescribed to meet the species allocation set by the managing forester. These seed lots come in different species, ages and sizes depending on many factors. Grading and matching of species for certain areas is what helps make tree planting more successful, by matching specific species with a certain area and grading the nursery stock encourages improved growth and establishment when the seedlings are first planted (Sutton 1979). Since first being a part of the tree plant within the BSF, many more seed lots have been prescribed each year.

Although, in regard to the further calculations of SD, and SE the more favourable numbers were produced from MSP blocks. This would be expected from blocks that were prepped, as all the seedlings planted likely had very similar microsites to grow from, providing them with similar growing conditions. Compared to un-scarified planted seedlings, each microsite could be very different on a number of factors including, soil conditions and structure, slope, and competition. While MSP may have these same influential factors, one of the main reasons for MSP is to limit the effects of said factors (Morris and Lowery 1988). When considering the results for calculated CV, the un-scarified blocks were more favourable, which would be expected as with un-scarified there is more risk involved for the growth and establishment of seedlings, but the reward and return are greater.

Some shortcomings of the 2019 data include, not having more block types and more blocks to include that the information was not available, meaning no overview maps of the 2019 plant were available to help make more blocks accessible. These blocks were accessed solely based on the memory of where they were, and what site preparation occurred if any did. When more data is obtainable it has a great impact on results, as it better represents what is within these types of blocks within the BSF. As no refill blocks were included in the 2019 results, this did not allow for comparison to the other tree plant years that did have refill blocks included. Other details that could have been involved, possibly for further studies, could include the influence of natural trees within the recorded plots. This would display different approaches in terms of competition with the planted seedlings and what is already present.

Overall, the tree plant year of 2019 produced results that were not expected. The implications that this data can have can mean a variety of things in terms of regeneration and the silviculture methods surrounding it. Although these blocks were harvested, prepped or not, and planted some time ago now, provide light on how Black and White spruce and Jack pine respond to different land types. Also, 2019 planted trees being the oldest that was recorded for this study, shows the lasting effects and comparisons between both MSP and un-scarified. This data could help impact future best management practices within the BSF, by showing the measured trees observed in 2019, the un-scarified blocks were more successful in terms of growth for both height and root collar diameter.

2020

After two and a half growing seasons, the seedlings planted in 2020 produced results that were aligned with the hypothesis. While for all the different years of planting, the results were expected to be fairly close in their respective years. As it's still the same species and most of the time the same seed lot is being panted between the blocks, the growth rate would be very similar to each other. This is another reason why this study can have great implications for regeneration silviculture practices, by having recently compiled data comparing the growth rates between different silvicultural methods after harvesting. Throughout the BSF, the management tactics are very similar, as the landscape responds well to these methods, and is suitable for this area. Exploring deeper into the relationships between silviculture and planted seedlings will have beneficial outcomes on all aspects of the environmental, economic, and sociological factors of the BSF.

In the data gathered for the 2020 blocks, MSP disc trenching was the most favourable treatment for the planted seedlings. After two and a half growing seasons both the maximum height and greatest average height were within MSP blocks along with the greater average of CD. While the maximum CD was recorded within an un-scarified block. The averages calculated for both height and CD were very similar between MSP, un-scarified and refill, while burn piles seemed to be much lower which was surprising. Although, the placement of this specific burn pile, as there was only one recorded from the 2020 plant, seemed to be in an area of constant flooding. Especially with only Jack pine being planted within burn piles, for the majority, this is a species that does not respond well to over-saturation. This would lead to the lower observation of height and CD recorded from these specific Jack pines in this burn pile from 2020.

In regard to the other calculations of SD, SE and CV, the burn pile was more favourable in some respects mainly due to the much smaller sample size. As for the others, the results varied between which was the most favourable between the different block types. These close results are to be expected, as previously explained why, but looking closer at the values helps depict which method works better with improving either height or the CD. Varied sample sizes as well sway the results slightly, although the general idea can be inferred, as the SD of CD and height and SE of CD were more favourable within refill blocks compared to the MSP and un-scarified blocks which contain higher sample sizes. While comparing just the results from both MSP and un-scarified they are very similar. The un-scarified blocks retained improved outcomes in all aspects but two which were the SE for CD and CV for CD. These results again go against the original hypothesis of this study, proving once again that un-scarified blocks may be the better management decision to make when applying silviculture prescriptions within the BSF.

Overall, the differences in growth of both CD and height mainly between the MSP and un-scarified blocks are minimal. Leading to the question once again, is it worth applying MSP to so many blocks within the BSF when the growth rates of planted seedlings after two and a half years are this similar? Also including the other two block types of refill and burns, it is still reasonable to apply these methods as refills are prescribed when needed due to other factors. As for burn piles, they mitigate the leftover slash produced from the harvest, making a valuable microsite for planting species such as Jack pine. The recorded 2020 planted trees provided more promising and convincing values towards un-scarified blocks, as this is the land type that most planters actually prefer as well, as this land type pays more money per tree compared to what MSP blocks pay within the BSF.

2021

The planted seedlings from 2021 produced different outcomes than the others, by having more variation and having burn piles as the favourable land type based on the observed calculations. Throughout the previous years that were examined, Jack pine has been the species that have consistently shown greater growth in both CD and height compared to the other species measured. After one and a half growing seasons, this is no different, as once again Jack pine has been the superior species and may shed light on how the burn piles produced the greatest results based on figures 5 and 6 for 2021. The only species recorded within burns in 2021 were Jack pine, which is usually the case for any year as they are the preferred species planted within burns prescribed by the forester. This influenced the results to show that burn piles produced the greatest results, while still having smaller sample sizes compared to MSP and refill in 2021 in the BSF.

The block type with the greatest recorded height was MSP, although the average height within MSP blocks was considerably lower than the average produced within burn pile heights. Also comparing the results based on the calculated SD and SE, the most favourable block type was found on roads, as it showed more consistent growth around the mean height within refill blocks. As the heights recorded from roads, they were much less than what was found in the other blocks along with a smaller sample size. Although comparing the results between MSP and refill, the refill blocks produced more encouraging results as all

SD, SE and CV calculations were in favour of refill blocks. Once again showing that no site preparation produced better growth and establishment results. The planted trees recorded within MSP blocks produced data that was much more distributed with plenty of variances, this level of dispersion shows inconsistency for planted trees that have been planted in areas that have undergone site preparation.

As for the different results for the measured CD of planted seedlings from 2021, it produced similar results that of the recorded height. Burn piles have a much greater average than the rest of the block types. While burn piles have the greatest average, they also had the greatest variance of the block types based on the CD, and SE calculations. This level of dispersion is surprising as the only species planted within burns in 2021 was Jack pine, usually more dispersion would be met with multiple species as they have different growing standards. The blocks with the greater CV were found within MSP blocks, while they also included the second-highest maximum and average CD recorded. The refill blocks that were examined from 2021 produced the most promising outcomes for all three calculations of SD, SE and CV. Showing that refill blocks in this instance have a lower rate of dispersion around the mean, which include having the lowest variance of all the block types measured in 2021. Having a greater average height is one thing, although the most valuable trees are the ones with the most amount of fibre and saw log potential. This mainly comes with an increase in diameter, which is the refill blocks in this case, making refill blocks the most valuable of the block types measured in 2021. This means that for the trees planted in 2021 refill blocks have a greater level of reward over risk in terms of having an improved return rate over the other block types.

One disadvantage of the data collected from planted blocks of 2021 is that there were no un-scarified blocks included. This was mainly due to the fact that their location was difficult to reach. Although, the closest land type to un-scarified is refill blocks. At the time of planting, there is no scarification present, and there is more competition on average in refill blocks. These blocks can be compared to un-scarified blocks as they would likely produce results that are similar to the results produced from the refill blocks that were examined in 2021.

2022

The 2022 data saw the introduction of MSP Brackie, as this type of scarification was not planted in the years prior to 2022. Included in the original hypothesis, MSP Brackie was estimated to produce the ideal microsite for planted seedlings and result in improved growth for both height and CD. This method of scarification provides a supreme planting microsite for a single tree, which greatly helps limit the effects of competition from other planted seedlings and other vegetation. The trees measured were planted only five to six months after being planted, the recorded measurements provide an inside look at how the different land types impact the growth of planted seedlings within a year of being planted. This is valuable information as it provides depth into how seedlings respond in different land types shortly after being planted. Taking into consideration the different species planted, different seed lots used and the density of the planted blocks. The other blocks included from the 2022 plant were MSP trenching, un-scarified and burn piles. Also documented within the 2022 data, Red pine trees were measured for the first time, and this species was planted within both burn piles and the MSP trench. This species was amongst the highest-measured CD and height, with the greater average for the species being within MSP trench blocks for both CD and height (Table 10).

The block type with the highest average height for planted seedlings in 2022 was within MSP Brackie blocks, this could have happened for a number of reasons. The most likely reason is that within the Brackie blocks a larger seed lot of White spruce was prescribed as this species had the greatest average CD and height measured from 2022 planted seedlings, within the MSP Brackie blocks (Table 10). Overall, the MSP Brackie blocks consisted of the greatest average and maximum height recorded within 2022 data recorded. Comparing the MSP trench and un-scarified blocks for measured height, they produced very similar results across the board. This means that only five to six months after being planted, there is no immediate difference or advantage of MSP trenching over un-scarified planted seedlings consisting of a variety of species. The block that contained the lowest calculated SD and CV for height was within burn piles, (Table 9) these burn pile seedlings had the most consistent measurements which would likely be due to most of the trees being one species, Jack pine, with only a few measured Red pine as well. Having fewer species in a block helps reduce the variance as they likely will have similar growing habits and rates, which will help the future growing stock to be more consistent and produce more reliant growth and yield projections for the specific block.

As for the results of the measured CD, the MSP Brackie also consisted of the highest average CD although the greatest CD recorded from the 2022 plant was found within an un-scarified block. The un-scarified blocks produced results that were very comparable to MSP Brackie, as there was plenty of White spruce planted within the un-scarified blocks as well. This data once again shows that the un-scarified seedlings can compete just as well in terms of growth for CD and height against the planted seedlings of both the MSP trench and Brackie. As for the calculations of the lowest SD and CV, it was once again within burn piles for CD, while the lowest SE was produced in MSP Brackie blocks.

One shortcoming of this data from 2022, is having measurements of seedlings before being planted for a reference for how much they have grown exactly in those five to six months. This would have assisted greatly in demonstrating the actual growth between species and the different block types. The next study should include measurements of each species and seed lot before being planted, to help determine the exact growth rates between the species and their respective block types.

CONCLUSION

The main purpose of this study was to examine the growth and establishment differences of planted seedlings within the BSF. Evaluating the growth of planted trees during the 2019 to 2022 seasons between different block types, to observe which land type provides the best growth of seedlings from four and a half growing seasons to five to six months of growth. With the inclusion of the original hypothesis which was that MSP trenching would provide the best growing conditions, and for the 2022 measurements that MSP Brackie would be the best. With the data collected and compiled for this study, the results were different than what was expected. The overall results provided insight that un-scarified planted seedlings were growing at rates very similar to those planted in MSP blocks, and in some saw improved results over MSP blocks.

These results proved the hypothesis to be incorrect, which is seen as a success, as un-scarified blocks are favoured for both the forester and planters alike. This information would help the process of best management practices towards tree planting blocks, helping to decide if MSP is necessary for different tree species and the overall goals of the intended planted area. Not having to implement MSP is beneficial for economic and environmental aspects, and it saves time.

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APPENDIX I

Un-scarified		Un-scarified	MSP		MSP
Species	CD (mm)	Ht (cm)	Species	P-CD(mm)	Ht (cm)
Pj	25.22	82	Pj	21.75	93
Pj	33.27	95	Pj	14.99	69
Pj	34.41	142	Pj	23	133.5
Pj	40.22	128	Pj	21.14	102.5
Pj	31.33	116	Pj	19.45	119

Pj	34.56	84	Pj	20.84	88.5
Pj	20.86	105	Pj	22.49	104
Pj	37.21	88.5	Pj	19.31	96
Pj	32.29	104	Pj	18.69	87.5
Pj	33.16	89.5	Pj	19.41	109
Pj	41.74	137	Pj	20.29	95
Pj	40.29	146	Pj	12.42	81
Sb	14.79	90.5	Pj	15.57	87
Sb	11.43	83.5	Pj	20.65	87
Sw	19.12	95	Pj	15.74	62
Sw	21.31	99.5	Pj	18.47	72.5
Sw	21.06	88.5	Pj	14.31	61
Sw	15.16	80	Pj	33.49	135
Sw	16.91	68	Pj	42.65	120
Sw	7.98	48.5	Pj	33.53	121
Sw	20.6	79	Pj	30.07	84
Sw	19.87	97	Pj	31.01	127
Sw	19.84	72.5	Pj	25.27	104.5
Sw	18.8	78.5	Pj	32.82	103
Sw	20.15	87.5	Pj	26.17	125.5
Sw	19.96	62	Sb	10	59
Sw	18.72	61	Sb	5.65	58.5
Sw	14.26	53	Sb	8.89	53.5
Sw	17.64	57.5	Sb	12.92	73.5
Sw	14.05	52.5	Sb	7.35	56.5
Sw	11.07	38	Sb	7.47	37
Sw	18.3	89	Sb	7.15	52
Sw	18.61	56	Sb	4.62	41.5
Sw	19.61	82.5	Sb	6.5	46
Sw	21.26	90.5	Sb	7.38	52
Sw	11.01	54.5	Sb	12.32	78.5
Sw	11.93	55	Sb	5.81	42
Sw	12.33	52.5	Sb	12.17	73
Sw	8.69	41.2	Sb	7.98	45
Sw	12.91	42	Sb	10.53	81
Sw	21.84	119	Sb	10.49	50
Sw	24	108	Sb	10.13	60.5
Sw	16.26	95	Sb	3.92	29
Sw	14.39	75.5	Sb	5.94	47
Sw	21.03	102	Sb	6.93	46.5
Sw	16.03	102	Sb	11.33	64
Sw	25.29	112.5	Sb	13.17	63

Sw	17.81	76.5	Sb	7.72	76
Sw	13.39	72.5	Sb	6.98	56
Sw	9.47	59	Sb	11.5	75.5
			Sb	12.34	69
			Sb	10.04	71.5
			Sb	12.24	83.5
			Sb	15.88	113
			Sb	12.91	117.5
			Sb	12.69	93
			Sb	15.12	106
			Sb	13.24	72
			Sb	8.3	36.5
			Sb	15.01	72.5
			Sb	6.3	41
			Sb	15.18	79
			Sb	18.76	121
			Sb	13.66	88
			Sb	10.94	90.5
			Sb	11.01	82.5
			Sb	14.66	73
			Sb	13.99	98.5
			Sb	13.88	105
			Sb	11.98	103
			Sw	6.35	40
			Sw	13.47	79.5
			Sw	12.83	102
			Sw	12.55	83.5
			Sw	8.79	63.5
			Sw	9.94	46
			Sw	6.72	44.5
			Sw	6.81	45
			Sw	20.68	58.5
			Sw	17.08	81
			Sw	20.4	63
			Sw	18.42	37
			Sw	22.34	92
			Sw	5.23	44
			Sw	9.48	67.5
			Sw	11.19	84
			Sw	13.12	78
			Sw	20.97	131
			Sw	14.22	95.5

			Sw	11.23	64
			Sw	13.94	96
			Sw	8.22	58
			Sw	6.63	38.5
			Sw	7.37	49
			Sw	10.88	79
			Sw	12.34	84.5
			Sw	9.33	57
			Sw	11.18	80
			Sw	9.74	70.5

APPENDIX II

2020 MSP			2020 un-scarified			2020 refill			2020 Burns		
Species	CD (mm) P	Ht (cm) P	Species	CD (mm) U	Ht (cm) U	Species	CD (mm) R	Ht (cm) R	Species	CD (mm)	Ht (cm)
Pj	14.44	55.5	Pj	11.84	57	Pj	16.23	87	Pj	7.14	44
Pj	13.52	64	Pj	10.11	63	Pj	13.54	73	Pj	3.82	19
Pj	18.12	72	Pj	13.07	73.5	Pj	13.68	75.5	Pj	5.55	24
Pj	16.22	63	Pj	5.23	38	Pj	11.08	62	Pj	8.52	46
Pj	14.99	63.5	Pj	12.48	56	Pj	9.73	40	Pj	4.51	24
Pj	23.1	58.5	Pj	11.36	62	Pj	8.03	32	Pj	4.87	32
Pj	10.85	59	Pj	27.03	83	Pj	10.97	61.5	Pj	5.32	24
Pj	15.25	67	Pj	18.09	76	Pj	10.13	34.5			
Pj	8.65	52.5	Pj	15.72	60	Pj	9.45	29.5			
Pj	8.19	41	Pj	23.02	68.5	Pj	8.67	48			
Pj	7.2	33.5	Pj	23.01	78.5	Sw	13.21	51			
Pj	14.07	57.5	Pj	17.27	67	Sw	11.55	60			
Pj	20.69	65.5	Pj	22.66	61	Sw	6.39	39			
Pj	21.75	77	Pj	11.58	55	Sw	9.12	61.5			
Pj	21.44	74.5	Pj	12.58	52	Sw	9.41	45			

Pj	11.41	64	Pj	14.88	41.5	Sw	8.34	53.5			
Pj	11.7	56.5	Sb	5.35	29.5	Sw	10.49	70.5			
Pj	8.04	38.5	Sb	11.58	52.5	Sw	12.26	83			
Pj	5.97	30.5	Sb	5.2	41	Sw	13.74	76			
Pj	14.4	61	Sb	7.46	41	Sw	8.64	52			
Pj	18.62	62	Sb	5.2	49	Sw	10.45	47			
Pj	21.12	80	Sb	4.95	19.5	Sw	11.44	53.5			
Pj	14.71	65.5	Sb	4.27	46.5	Sw	10.73	43.5			
Pj	25.43	97	Sb	5.72	47	Sw	10.07	46.5			
Pj	9.12	38.5	Sb	5.15	51.5	Sw	8.53	47			
Pj	23.92	95	Sb	5.22	45.5	Sw	6.21	46			
Pj	19.9	84	Sb	5.85	56	Sw	6.73	40			
Pj	23.57	98	Sb	3.87	39.5	Sw	9.5	41			
Pj	20.98	96	Sb	5.74	24	Sw	8.4	53.5			
Pj	10.1	58.5	Sb	6.61	48	Sw	9.52	43.5			
Pj	10.38	56	Sb	5.74	22.5	Sw	10.11	56			
Pj	21.45	47	Sb	4.19	14.5	Sw	10.18	71			
Pj	22.47	86	Sb	12.07	79	Sw	6.1	56.5			
Pj	21.63	87	Sb	9.04	49	Sw	5.46	48.5			
Pj	22.39	69	Sb	6.74	44	Sw	7.58	48			
Pj	20.11	89.5	Sb	4.09	30.5	Sw	6.92	49.5			
Pj	17.03	75	Sb	4.5	36.5	Sw	7.75	71			
Pj	16.4	67.5	Sb	5.51	56	Sw	12.03	71.5			
Pj	18.67	94	Sb	6.41	39	Sw	4.81	46			
Pj	24.02	91.5	Sb	2.8	29	Sw	9.47	74.5			
Pj	21.45	109.5	Sb	4.44	56.5	Sw	8.27	41.5			
Pj	21.35	92	Sb	4.14	30	Sw	12.63	42			
Pj	11.01	46	Sb	3.48	12.5	Sw	5.58	43			
Pj	7.07	31	Sb	3.81	14	Sw	8.15	38.5			
Pj	15.84	87	Sb	4.94	23.5	Sw	8.56	40			
Pj	15.43	91	Sb	11.01	55						
Sb	6.63	46.5	Sb	6.98	43						
Sb	8.46	35.5	Sb	5.04	30.5						
Sb	7.7	54	Sb	5.92	43.5						
Sb	9.19	46	Sb	7.62	45						
Sb	11.02	69	Sb	6.23	34						
Sb	6.71	42.5	Sb	10.23	75						
Sb	9.33	61	Sb	4.88	43						
Sb	6.53	50.5	Sb	10.35	63						
Sb	5.92	49	Sb	9.92	58						
Sb	4.51	44	Sb	10.27	57.5						
Sb	8.31	50.5	Sb	9.23	65						

Sb	10.23	49.5	Sb	9.18	39.5						
Sb	10.98	61.5	Sb	12.58	65.5						
Sb	5.65	40	Sb	9.87	51.5						
Sb	7.07	37	Sb	9.73	48						
Sb	10.07	61	Sb	11.27	50.5						
Sb	11.96	51.5	Sb	10.13	59.5						
Sb	8.14	53	Sb	7.04	42						
Sb	13.03	55	Sb	5.01	45						
Sb	8.78	51.5	Sb	14.01	72						
Sb	6.71	42	Sb	15.62	89						
Sb	10.27	54.5	Sb	13.46	76						
Sb	7.08	33.5	Sb	12.25	71.5						
Sb	9.73	68	Sb	16	65.5						
Sb	9.87	52.5	Sb	16.02	51.5						
Sb	6.3	38.5	Sb	18.07	85						
Sb	13.36	64.5	Sb	14.77	61.5						
Sb	13.7	100.5	Sb	12.01	50.5						
Sb	5.33	36	Sw	5.99	36.5						
Sb	13.45	92	Sw	10.71	44						
Sb	11.4	50.5	Sw	10.25	54.5						
Sb	14.41	94	Sw	7.57	54.5						
Sb	9.04	51	Sw	4.49	37.5						
Sb	7.22	58.5	Sw	7.36	45						
Sb	6.83	33	Sw	7.07	57.5						
Sb	4.51	33	Sw	12.41	80.5						
Sb	7.07	38	Sw	3.92	32						
Sb	6.75	74	Sw	4.5	32						
Sb	5.31	19	Sw	16.19	73.5						
Sb	4.63	45.5	Sw	12.11	69						
Sb	9.3	70.5	Sw	12.43	54.5						
Sb	6.05	59.5	Sw	11.03	63.5						
Sb	4.92	46	Sw	11.22	51						
Sb	8.83	60	Sw	14.77	59						
Sb	12.66	65	Sw	16.34	59						
Sb	5.5	55.5	Sw	13.82	59.5						
Sw	7.22	36	Sw	19.73	67						
Sw	3.56	15.5	Sw	17.34	77.5						
Sw	4.95	38.5									
Sw	4.97	30.5									
Sw	7.41	54.5									
Sw	8.18	50									
Sw	7.81	61.5									

Sw	6.79	14										
Sw	8.88	27.5										
Sw	7.8	41.5										
Sw	6.19	41.5										
Sw	15.19	69.5										
Sw	10.21	47										
Sw	5.44	31.5										
Sw	10.97	46.5										
Sw	12.24	74.5										
Sw	5.7	46										
Sw	4.74	34										
Sw	5.16	41										
Sw	5.86	32.5										
Sw	8.76	41.5										
Sw	5.01	37										
Sw	3.31	14										
Sw	5.6	36										
Sw	4.13	25.5										
Sw	4.83	23										
Sw	6.27	39.5										
Sw	6.83	53										
Sw	9.89	56.5										
Sw	8.28	42.5										
Sw	9.52	50										
Sw	7.04	46										
Sw	4.35	31										
Sw	4.39	30.5										
Sw	4.14	41										
Sw	5.87	41.5										
Sw	9.57	55										
Sw	4.46	34.5										
Sw	8.19	48										
Sw	5.58	38.5										
Sw	6.64	40.5										
Sw	6.5	32										
Sw	5.56	25										
Sw	11.6	48										
Sw	10.59	52.5										
Sw	15.98	82.5										
Sw	14.32	71										
Sw	8.84	64										
Sw	15.02	72										

Sw	12.84	59									
Sw	13.87	72									
Sw	10.04	57.5									
Sw	10.05	90.5									
Sw	11.7	67									
Sw	13.98	60.5									
Sw	16.79	75									
Sw	7.04	33.5									
Sw	8.94	61									
Sw	8.74	57									
Sw	9.69	59									
Sw	9.56	52									
Sw	4.78	27									
Sw	15.71	92									
Sw	15.7	87									
Sw	13.52	85.5									
Sw	6.52	37									
Sw	11.23	50.5									
Sw	7.08	45.5									
Sw	7.28	55.5									
Sw	8.91	54.5									
Sw	11.1	66									
Sw	7.79	45.5									
Sw	8.55	62.5									
Sw	7.35	45									
Sw	8.82	59.5									
Sw	8.31	49									
Sw	13.17	87.5									

APPENDIX III

2021 MSP			2021 Refill			2021 Burns			2021 Road		
Species	CD(mm)	Ht(cm)	Species	CD (mm)	Ht (cm)	Species	CD (mm)	Ht (cm)	Species	CD (mm)	Ht (cm)
Pj	10.14	74	Pj	5.94	30	Pj	15.06	57	Pj	5.65	16
Pj	6.18	66	Pj	4.59	26.5	Pj	12.75	53.5	Pj	3.96	35
Pj	7.41	38	Pj	10.2	43	Pj	18.73	56	Pj	4.12	23
Pj	8.8	57	Sb	2.1	27	Pj	11.75	46	Pj	4.97	31.5
Pj	9.05	48	Sb	4.23	23	Pj	18.88	69	Pj	5.17	18.5
Pj	7.15	52	Sb	2.8	22.5	Pj	19.03	80.5	Pj	4.3	33.5
Pj	9.27	69	Sb	4.1	22.5	Pj	19.54	85.5	Pj	5.64	33.5
Pj	9.92	36	Sw	6.2	47	Pj	11.23	46	Pj	5.11	33
Pj	9.44	62	Sw	5.95	46.5	Pj	11.42	46.5	Pj	11.53	32
Pj	6.31	23.5	Sw	4.52	41.5	Pj	6.38	33.5	Pj	4.22	26.5
Pj	9.99	65	Sw	4.1	47	Pj	19.52	63	Pj	7.16	33.5
Pj	8.15	59	Sw	4.03	36.5	Pj	10.05	44.5	Pj	5.04	29
Pj	12.36	69	Sw	3.5	38	Pj	7.42	35	Pj	5.3	28.5
Sb	4.34	35	Sw	3.87	41	Pj	13.84	72	Pj	6.69	28.5
Sb	6.69	55	Sw	4.68	47.5	Pj	11.36	69	Pj	5.54	32
Sb	5.3	32.5	Sw	5.5	26	Pj	14.66	76	Pj	8.45	32.5
Sb	5.62	39	Sw	3.6	30	Pj	13.12	70.5	Pj	9.2	35
Sb	4.36	39	Sw	3.49	23	Pj	6.09	33	Pj	6.08	33.5
Sb	5.95	39	Sw	3.56	20	Pj	12.35	57	Pj	7.08	31
Sb	4.83	12	Sw	3.52	22	Pj	14.45	73	Pj	7.26	33
Sb	5.93	50.5	Sw	4.09	32.5	Pj	9.57	51	Pj	6.82	38
Sb	9.23	47.5	Sw	3.28	34	Pj	10.59	51.5	Pj	6.57	29
Sb	12.6	53	Sw	4.28	22.5	Pj	27.4	51	Pj	5.76	34.5
Sb	7.77	51.5	Sw	3.91	43	Pj	18.5	61	Pj	5.13	29
Sb	6.57	34	Sw	3.37	31.5	Pj	19.65	61	Pj	5.56	33.5
Sb	8.21	50.5	Sw	4.8	47.5	Pj	12.9	48	Pj	6.05	35
Sb	3.84	21	Sw	2.75	31	Pj	11.16	49.5	Sw	3.49	29.5
Sb	9.96	51	Sw	3.22	39.5	Pj	18.37	64	Sw	3.16	28.5
Sb	8.95	55	Sw	4.67	42	Pj	19.06	82.5	Sw	3.26	28
Sb	8.93	43	Sw	3.84	37	Pj	14.86	42.5	Sw	5.05	36.5
Sb	4.45	48.5	Sw	3.16	35.5	Pj	13.04	68.5	Sw	3.19	29.5
Sb	4.61	39.5	Sw	3.91	39.5	Pj	13.2	39	Sw	5.25	37.5
Sb	5.69	43	Sw	4.39	44	Pj	12.92	46.5	Sw	4.69	33
Sb	5.45	48	Sw	3.74	43	Pj	12.23	38.5	Sw	3.77	30.5
Sb	4.35	37	Sw	5.57	48.5	Pj	18.2	67	Sw	4.33	32.5
Sb	5.5	31	Sw	3.87	31	Pj	23.6	60.5	Sw	3.86	27.5
Sb	5.47	50	Sw	2.79	20	Pj	21.33	70	Sw	3.67	29

Sb	4.46	33	Sw	4.96	29	Pj	15.75	55	Sw	4.36	32
Sb	3.76	22	Sw	4	27.5	Pj	15.75	56			
Sb	4.8	34.5	Sw	4.63	33						
Sb	6.12	46	Sw	4.82	35						
Sb	3.62	36	Sw	2.73	28						
Sb	5.26	47	Sw	3.92	29						
Sb	4.91	33	Sw	3.42	27						
Sb	4.31	32	Sw	4.14	32						
Sb	4.67	30.5	Sw	4.03	28.5						
Sb	6.12	42	Sw	3.3	29.5						
Sb	6.74	72.5	Sw	2.83	26						
Sb	4.81	37	Sw	3.35	22						
Sb	4.6	54	Sw	4.73	26.5						
Sb	6.27	79.5	Sw	5.23	51						
Sb	7.54	49	Sw	5.01	39.5						
Sb	7.01	70	Sw	4.2	33.5						
Sb	4.11	51	Sw	3.54	33						
Sb	3.53	41.5	Sw	4.56	45						
Sb	4.91	49	Sw	3.73	31						
Sb	4.6	46.5	Sw	4.47	49						
Sb	4.47	40	Sw	4.4	31						
Sb	5.26	53.5									
Sb	6.41	58									
Sb	4.02	43									
Sb	5.63	52									
Sb	9.83	35									
Sb	8.37	54									
Sb	8.29	47									
Sb	5.28	24.5									
Sb	7.69	69									
Sb	6.05	54									
Sb	2.95	24									
Sb	3.82	40									
Sb	5.8	52									
Sb	4.71	43									
Sb	6.72	46									
Sb	3.1	22.5									
Sb	3.2	28									
Sb	4.1	38									
Sb	4.31	46									
Sb	4.13	29									

Sb	3.88	35										
Sb	3.1	30										
Sb	3.67	44.5										
Sb	4.44	52.5										
Sb	5.13	47										
Sb	4.2	55										
Sb	2.8	33.5										
Sb	6.8	55.5										
Sb	5.4	44										
Sb	3.58	30										
Sb	3.37	24										
Sb	5	23.5										
Sb	4.53	49.5										
Sb	4.56	44.5										
Sb	4.9	41.5										
Sb	4.48	33										
Sb	5.86	50										
Sb	4.71	40.5										
Sb	4.54	48										
Sb	5.08	46.5										
Sb	5.25	44										
Sb	3.5	24										
Sb	5.12	45										
Sb	4.5	29										
Sb	3.87	19										
Sb	4.78	8										
Sb	4.62	39.5										
Sb	4.68	15.5										
Sb	4.26	16										
Sb	2.3	11.5										
Sb	5.06	33										
Sb	4.04	34										
Sb	4.39	40.5										
Sb	4.05	35										
Sb	3.72	31.5										
Sb	3.16	41										
Sb	2.25	25										
Sb	4.65	42.5										
Sb	5.89	44										
Sb	5.19	43.5										
Sb	3.54	36										
Sb	4.79	37.5										

Sb	4.01	38									
Sb	8.03	72.5									
Sb	3.32	37									
Sb	3.88	31.5									
Sw	5.34	36									
Sw	5.81	51									
Sw	6.55	47									
Sw	10.1	63.5									
Sw	9.99	44.5									
Sw	7.15	48									
Sw	6.05	48									
Sw	5.11	37									
Sw	4.5	29									
Sw	6.12	31									
Sw	7.97	45									
Sw	6.09	48									
Sw	4.28	32									
Sw	7.11	58									
Sw	6.95	79									
Sw	5.23	68.5									
Sw	6.3	79									
Sw	9.27	63.5									
Sw	8.5	89.5									
Sw	6.39	51.5									
Sw	11.3	58									
Sw	10.48	55.5									
Sw	6.51	46									
Sw	11.77	58									
Sw	4.99	38.5									
Sw	5.11	30									
Sw	3.13	30									
Sw	3.29	30.5									
Sw	6.56	42.5									
Sw	5.92	40									
Sw	3.35	17									
Sw	5.39	34									
Sw	4.99	33									
Sw	2.95	31									
Sw	3.25	28									
Sw	6.25	38.5									
Sw	5.94	30.5									
Sw	4.22	25.5									

Sw	3.83	27									
Sw	4.51	21.5									

APPENDIX IV

2022 MSP Trench			2022 MSP Brackie			2022 Un-scarified			2022 Burns		
Species	CD (mm)	Ht (cm)	Species	CD (mm)	Ht (cm)	Species	CD (mm)	Ht (cm)	Species	CD (mm)	Ht (cm)
Pj	3.9	21.5	Pj	3.6	19.5	Pj	3.11	19.5	Pj	2.51	20.5
Pj	3.42	16.5	Pj	3.51	19	Pj	1.37	22.5	Pj	3.07	22.5
Pj	3.48	19	Pj	4.69	19.2	Pj	2.48	12	Pj	2.96	21.5
Pj	5.91	23	Pj	3.7	22.5	Pj	3.06	16	Pj	3.1	24
Pj	5.64	27	Pj	4.4	22	Pj	2.9	18.5	Pj	3.31	26.5
Pj	4.04	26	Pj	3.53	19	Pj	2.92	20.5	Pj	2.59	17
Pj	3.05	22	Pj	3.66	19	Pj	2.3	17.5	Pj	2.96	16.5
Pj	3.43	20.5	Pj	2.62	18	Pj	1.42	19.5	Pj	2.31	18
Pj	3.93	20	Pj	2.88	16.5	Pj	3.51	23	Pj	2.76	15
Pj	2.67	19	Pj	3.31	19	Pj	2.83	21.5	Pj	2.9	15
Pj	2.57	21	Pj	3.33	21.5	Pj	2.88	19.5	Pj	2.39	18.5
Pj	2.32	23	Pj	3.53	18	Pj	2.21	13	Pj	2.99	18
Pj	2.38	14.5	Pj	3.29	30.5	Pj	2.41	14.5	Pj	3.27	21.5
Pj	2.75	17	Pj	3.22	24.5	Pj	2.91	17	Pj	4.28	19
Pj	3.56	25	Sb	4.1	21	Pj	2.35	20.5	Pj	3.17	18.5

Pj	3.33	11	Sb	5.1	24.5	Pj	2.71	22	Pj	2.9	25
Pj	3.38	17.5	Sb	4.46	24.5	Pj	2.42	23	Pj	4.4	14
Pj	2.61	17	Sb	4.1	26.5	Pj	3.29	13	Pj	4.81	18.5
Pj	1.89	14	Sb	4.07	28	Pj	3	20	Pj	3.61	22
Pj	3.33	23	Sb	3.85	21	Pj	2.9	17.5	Pj	3.66	22.5
Pj	2.8	14.5	Sb	5.24	21	Pj	3.25	15.5	Pj	3.38	21
Pj	2.56	18.5	Sb	4.92	25.5	Pj	3.33	7.5	Pj	3.33	20
Pj	3.11	20	Sb	3.7	28.5	Pj	2.78	23	Pj	3.82	21.5
Pj	3.46	20	Sb	3.45	27.5	Pj	3.1	7	Pj	4.32	24
Pj	3.04	20	Sb	5.09	27	Pj	3.84	7.5	Pj	5.63	27
Pj	2.54	17	Sb	4.6	35	Pj	2.08	19	Pj	3.68	23
Pj	3.03	26.5	Sb	4.51	32	Pj	2.92	21	Pj	5.06	27
Pj	2.39	20.5	Sb	2.81	19	Pj	2.86	18.5	Pj	3.8	17.5
Pj	2.65	17	Sb	3.47	26	Pj	1.87	18	Pj	3.2	23.5
Pj	2.5	21	Sb	3.88	27	Pj	1.94	14.5	Pj	2.7	23.5
Sb	4.85	33	Sb	4.05	24.5	Pj	3.56	15.5	Pj	3.16	15.5
Sb	4.98	36	Sb	4.24	31	Sb	2.14	18.5	Pj	2.73	19.5
Sb	3.75	32	Sb	3.46	28	Sb	3.25	16	Pj	2.79	16
Sb	3.16	24.5	Sb	3.4	24.5	Sb	1.85	16	Pj	3.5	20.5
Sb	3.72	21	Sb	3.72	23.5	Sb	2.4	22.5	Pj	2.94	13.5
Sb	5.4	38.5	Sb	2.99	21.5	Sb	2.12	18	Pj	3.35	19
Sb	3.17	36.5	Sb	4.41	22	Sb	2.49	24	Pj	3.92	12
Sb	3.4	34	Sb	2.24	19	Sb	1.96	19.5	Pj	3.29	19
Sb	2.72	21.5	Sb	2.9	19.5	Sb	2.4	21	Pj	3.43	23
Sb	4.16	37.5	Sb	3.78	21	Sb	1.96	17.5	Pj	2.72	15.5
Sb	3.03	26	Sb	3.72	27.5	Sb	2.13	22.5	Pj	2.44	15.5
Sb	3.25	29.5	Sb	3.16	24	Sb	4.56	17	Pj	3.27	15.5
Sb	2.71	19	Sb	5.2	33	Sb	2.03	13.5	Pj	2.49	16
Sb	2.66	21	Sb	2.81	25.5	Sb	2.26	21	Pj	2.65	12.5
Sb	3.46	40	Sb	2.73	26	Sw	2.35	16	Pj	2.97	18
Sb	2.81	27	Sb	2.4	23.5	Sw	2.23	20	Pj	4.32	16
Sb	3.21	32	Sb	2.95	24	Sw	2.33	15.5	Pr	3.78	23.5
Sb	3.04	24	Sb	3.58	26	Sw	2.41	13	Pr	3.97	23.5
Sb	3.91	34.5	Sb	3.55	26.5	Sw	3.55	16	Pr	4.2	19
Sb	3.3	31	Sb	2.65	24	Sw	2.26	15.5	Pr	3.92	19
Sb	2.91	28	Sb	3.73	32	Sw	1.93	14.5	Pr	3.27	17.5
Sb	3.48	23	Sb	2.43	22	Sw	2.18	20.5	Pr	4.74	25
Sb	2.53	17.5	Sb	2.55	24	Sw	2.19	22.5	Pr	3.89	20.5
Sb	3.08	26.5	Sb	3.39	31	Sw	1.63	17	Pr	3.05	18
Sb	2.64	31	Sb	2.81	25	Sw	1.86	17.5	Pr	3.51	19.5
Sb	3.95	34	Sb	2.93	29.5	Sw	1.98	16			
Sb	4.89	37	Sb	3.56	25	Sw	4.41	37			
Sb	4.01	33.5	Sb	3.51	31	Sw	6.03	36.5			
Sb	2.11	25	Sb	2.92	33	Sw	4.73	32			
Sb	4.68	24.5	Sb	3.21	35	Sw	4.03	23			
Sb	3.65	31	Sb	2.71	16.5	Sw	5.53	33.5			
Sb	4.54	38.5	Sb	3.01	29	Sw	5.97	19			

Sb	3.79	35	Sb	1.84	12	Sw	5.43	33.5			
Sb	3.83	41	Sb	2.72	24	Sw	5.08	33			
Sb	4	40.5	Sb	3.13	33	Sw	4.92	28			
Sb	3.08	30	Sb	2.3	23.5	Sw	4.28	41.5			
Sb	2.91	36	Sb	2.42	29	Sw	4.5	33.5			
Sb	3.93	39	Sb	3.71	28	Sw	4.56	27			
Sb	3.74	34	Sb	2.47	26	Sw	5.18	20			
Sb	3.25	34	Sb	5.44	38	Sw	4.37	22			
Sb	2.75	23	Sb	2.84	22.5	Sw	5.55	37			
Sb	2.4	28.5	Sb	3.28	33.5	Sw	5.3	41.5			
Sb	3.33	27	Sb	3.63	24.5	Sw	5.02	33			
Sb	3.3	30.5	Sb	4.54	26	Sw	5.3	30.5			
Sb	3.9	27.5	Sb	3.02	30.5	Sw	5.66	27			
Sb	2.58	22	Sb	3.15	28.5	Sw	5.86	21.5			
Sb	2.18	20.5	Sb	3.07	28	Sw	5.8	22.5			
Pr	4.31	18	Sb	3.65	34	Sw	5.42	31.5			
Pr	3.48	18	Sb	3.03	26	Sw	5.12	31			
Pr	4.06	24.5	Sb	2.54	29	Sw	7.29	26.5			
Pr	5.67	28	Sb	2.53	30.5	Sw	5.57	29.5			
Pr	5.15	23	Sb	2.82	29.5	Sw	4.93	32.5			
Pr	3.79	20.5	Sw	5.42	48.5	Sw	5.97	28.5			
Pr	4.1	23	Sw	6.52	44	Sw	5.75	32.5			
Pr	4.52	21	Sw	4.77	48	Sw	5.74	32			
Pr	4.35	28	Sw	5.85	43.5	Sw	5.23	38.5			
Pr	5.41	31	Sw	4.16	31	Sw	5.69	24.5			
Pr	4.71	26.5	Sw	6.12	50	Sw	5.05	29.5			
Pr	6	25	Sw	5.07	34	Sw	4.64	22			
Pr	6.47	26	Sw	6.04	53	Sw	4.98	34.5			
Pr	4.76	25	Sw	5.68	47.5	Sw	5.01	31			
Pr	3.75	11.5	Sw	7.01	56.5	Sw	4.87	39			
Pr	4.48	13	Sw	6.04	49.5	Sw	4.55	13.5			
Pr	4.57	24.5	Sw	5.92	48.5	Sw	3.49	26			
Pr	4.42	22	Sw	5.8	37	Sw	4.42	35			
Pr	4.07	18	Sw	4.81	35	Sw	4.67	29.5			
Pr	5.14	19	Sw	6.37	44	Sw	4.1	16			
Pr	4.26	24	Sw	5.34	35	Sw	4.86	23.5			
			Sw	5.97	47	Sw	4.6	28			
			Sw	6.83	43	Sw	5.79	25			
			Sw	5.91	44	Sw	5.04	33			
			Sw	5.45	42.5	Sw	4.96	23			
			Sw	5.71	42	Sw	4.63	34			
			Sw	4.21	40	Sw	3.9	24.5			

			Sw	4.81	39.5	Sw	5.14	23			
			Sw	5.03	39.5	Sw	5.03	27.5			
			Sw	4.38	40	Sw	4.8	17.5			
			Sw	4.7	32	Sw	6.5	25			
			Sw	4.38	25.5	Sw	5.28	29			
			Sw	6.04	42	Sw	4.93	27.5			
			Sw	4.41	43	Sw	2.1	17			
			Sw	4.53	36	Sw	2.89	22.5			
			Sw	5.42	38.5	Sw	5.25	25.5			
			Sw	5.93	39.5	Sw	4.99	23.5			
			Sw	5.4	37.5						
			Sw	5.94	46						
			Sw	5.15	46.5						
			Sw	4.77	38.5						
			Sw	6.01	47						
			Sw	5.91	39.5						
			Sw	4.85	33						
			Sw	4.55	48.5						
			Sw	4.3	28						
			Sw	4.85	41						
			Sw	4.6	51.5						
			Sw	4.62	36						
			Sw	5.64	47						
			Sw	6.62	45						
			Sw	5.41	51						
			Sw	4.79	39						
			Sw	6.04	28.5						
			Sw	4.36	24						
			Sw	5.96	35						
			Sw	6.47	38.5						
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			Sw	4.51	25.5						
			Sw	3.61	27.5						
			Sw	4.8	36.5						
			Sw	3.03	23.5						
			Sw	3.22	23						
			Sw	4.23	34.5						

			Sw	3.93	32.5						
			Sw	3.01	23.5						
			Sw	3.14	32						
			Sw	3.2	30						
			Sw	3.45	25						
			Sw	2.98	26.5						
			Sw	2.73	29						
			Sw	3.09	23						
			Sw	3.25	31						
			Sw	2.9	29						
			Sw	5.25	45						
			Sw	4.95	40						
			Sw	5.15	41.5						
			Sw	5.1	43						
			Sw	4.29	27						
			Sw	3.99	25.5						