

FOREST RESEARCH REPORT



Nova Scotia Department of Natural Resources
Forest Management Planning

Table of Contents

Introduction	1
Objective	2
Stock Types	2
Site Descriptions	3
Methods	5
Experimental Design	5
Assessment Procedures	5
Results	6
Summary	17
Discussion	18
Conclusions	19
Acknowledgements	20
References	20
Appendix 1	21

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The survival and growth of larger seedlings compared to regular seedlings planted on various sites in Nova Scotia.

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Introduction

Herbicides are used to control competing vegetation in regenerating areas so that desirable tree species can become established. There is increasing public pressure to reduce the use of herbicides in forest practices. This has lead forest managers to seek alternatives. Larger planting stock is being explored as a possible alternative. It is hypothesized that larger seedlings would be better equipped to survive and grow under heavy competition thereby reducing the use of herbicides.

Also, larger seedlings are more likely to survive feeding by the seedling debarking weevil (*Hylobius congener*), hereafter referred to as Hylobius. Hylobius can cause high levels of mortality in plantations established on recent harvest sites in Nova Scotia.

The adults feed on the bark of young softwood seedlings often girdling the trees. This damage is usually at the root collar. Hylobius is attracted by the scent given off from freshly cut stumps (Pendrel 1987, Quinn *et al* 1989). After a few years the hylobius threat is greatly reduced. The recommended control in Nova Scotia is to delay planting for two growing seasons. However by this time, the competing vegetation is often well established necessitating the use of herbicides. It is hypothesized that larger seedlings, which have more substantial root collars, would be better able to survive hylobius feeding and therefore could be planted immediately after harvest thus providing a head start on the competition. A previous survey suggests that seedlings with larger root collars are at a reduced risk for hylobius induced mortality (NSDLF 1988).

Objective

The objective of this study is to compare the survival and growth of three different types of black spruce (*Picea mariana*) larger stock seedlings to regular stock seedlings under different growing conditions.

Stock Types

The different stock types used in this trial are described in Table 1. The larger seedlings were shipped from Quebec. Stock of this sort was unavailable in Nova Scotia at the time. The bareroot stock was the largest of the four and had a substantially larger root collar diameter than the others. The other two large stock types (styro and square) were similar in root collar diameter, height, plug volume, and age. They were approximately double the size of the regular stock in both root collar diameter and height. Styro large stock seedlings were grown in styrofoam containers with a plug volume of 340 cubic centimetres. Square large stock seedlings were grown in hard wall plastic containers with square cavities. Slits ran down the walls of the cavities to help air prune the roots. The plug volume of square seedlings was 350 cubic centimetres. Multipot 67's (regular stock) seedlings were used as the control. They were grown in hard wall plastic containers with 67 cavities per tray and a plug volume of 60 cubic centimetres. Multipots were the most commonly used stock type in the province at the time.

Table 1. Comparison of the different stock types.								
Stock Size	Nursery	Stock Type	Container	Species	Age	Plug Volume (cc)	Root Collar Diameter (mm)	Height (cm)
Large	Quebec	Bareroot	No	*bS	4	**na	7.7	45
		Styro	Yes	bS	2	340	4.7	38
		Square	Yes	bS	2	350	4.5	39
Regular	Nova Scotia	Multipot 67's	Yes	bS	1	60	2.2	18

*bS = black spruce

**na = not applicable

Site Descriptions

Ten sites were chosen, seven in Antigonish county and three in Guysborough county (Figure 1). The different sites were chosen to represent situations where establishing plantations would be difficult due to severe competition, *Hylobius* risk, or both (Table 2). The Mayfield sites were old field white spruce stands that after harvest came back mainly to couch grass (*Elymus repens*). Grass can be a serious competitor, but in the case of the Mayfield sites this particular species due to its structure and height did not pose a serious threat. The main threat to seedling survival on these sites was *Hylobius* because they were softwood sites that were hot planted¹ (Pendrel 1987, Pendrel 1990), except Mayfield 2 which had been harvested 15 years earlier. There was severe herbaceous competition on Dunmaglass 1, Dunmaglass 2, and Springfield. *Hylobius* was not expected to be a threat on these sites because they had been harvested 5-7 years prior to establishment of this trial. The main challenge at Sunnybrae 1, Sunnybrae 2, and McKeen's Road was the regeneration of severe hardwood competition after harvest, these sites were also hot planted.

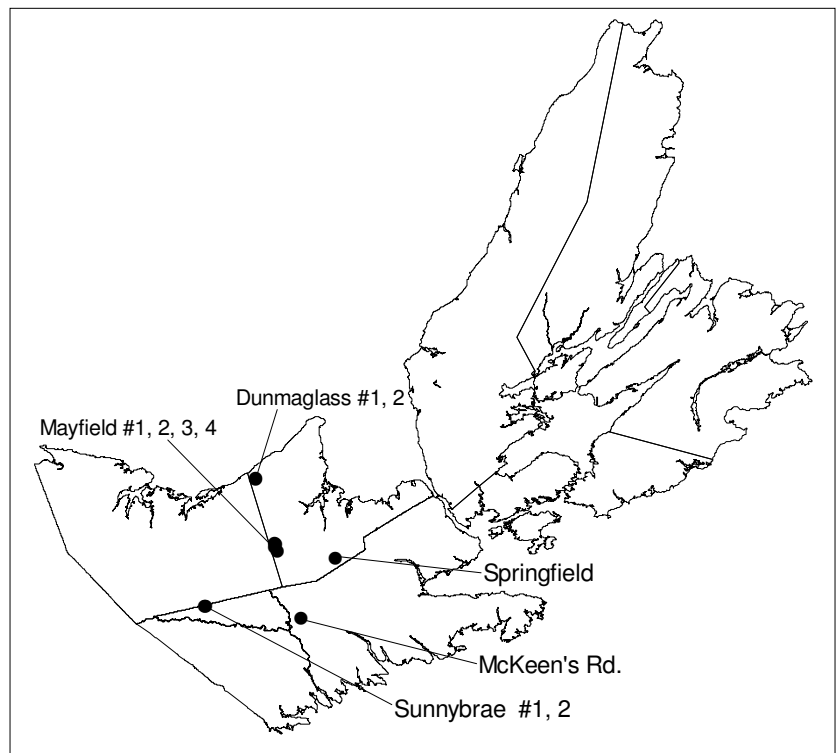


Figure 1. The locations of the sites in Nova Scotia.

¹ Hot planted: planted within the first two growing seasons after harvest.

Table 2. Site Descriptions

Sites	*Pre-harvest stand type	Competition			Hylobius Risk Factors and Rating			Description
		Severity	Type	Main Species	Hot Planted	Yrs between Harvest & Planting of Trial	**Hazard Rating	
Mayfield 1	Old field white spruce	Light	Grass	couch grass	Yes	0	High	An old field white spruce stand that was clearcut and hot planted.
Mayfield 2	Old field white spruce	Light	Grass	couch grass	No	15	Low	An old field white spruce stand that was clearcut 15 years earlier. There were two plantation failures in the 80's.
Mayfield 3	Old field white spruce	Light	Grass	couch grass	Yes	0	High	An old field white spruce stand that was clearcut and hot planted.
Mayfield 4	Old field white spruce	Light	Grass	couch grass	Yes	0	High	An old field white spruce stand that was clearcut and hot planted.
Dunmaglass 1	Sw	Severe	Herbaceous	fireweed aster	No	5	Low	A replant in heavy herbaceous competition 5 years after harvest. A previous plantation of white spruce failed.
Dunmaglass 2	Sw	Severe	Herbaceous	aster fireweed	No	5	Low	A replant in heavy herbaceous competition 5 years after harvest. A previous plantation of white spruce failed.
Springfield	Sw	Severe	Herbaceous	raspberry blackberry grass	No	7	Low	A replant in heavy herbaceous competition 7 years after harvest. A previous plantation of Norway spruce was thought to have failed, however portions recovered. Now it is a mixed Norway spruce/black spruce plantation.
Sunnybrae 1	Mw	Severe	Hardwood	pin cherry	Yes	1	Low-Moderate	A Mw stand that was partially cut and hot planted. After harvest it came back heavily to pin cherry.
Sunnybrae 2	Mw	Severe	Hardwood	red maple white birch	Yes	1	Low-Moderate	A Mw stand that was clearcut and hot planted. After harvest it came back heavily to red maple and white birch.
McKeen's Rd	Mw	Severe	Hardwood	white birch	Yes	1	Low-Moderate	A Mw stand that was clearcut and hot planted. After harvest it came back heavily to white birch.

*Pre-harvest stand type: Sw = Softwood, Mw = Mixedwood. Scientific names: couch grass (*Elymus repens*), fireweed (*Epilobium angustifolium*), aster (*Aster* species), raspberry (*Rubus idaeus*), blackberry (*Rubus allegheniensis*), pin cherry (*Prunus pensylvanica*), red maple (*Acer rubrum*), white birch (*Betula papyrifera*), Norway spruce (*Picea abies*), white spruce (*Picea glauca*).

**Hazard Rating: Based on Pendrel 1987 and Pendrel 1990.

Methods

The ten sites were planted at a spacing of 1.8m x 1.8m between May 23-29, 1996. Spades were used to plant the bareroot stock, large dibbles for the square and styro stock, and hoe pipes for the multipot stock.

Experimental Design

A completely randomized block design was used with three replicates of the four stock types at each site. Blocks were 24m x 24m, except at Mayfield 1, 3 and 4 where the locations of the brushpiles necessitated the use of rectangular blocks.

Assessment Procedures

The sites were assessed at years two, five, and ten. A sampling intensity of approximately 1/3 of the trees was used. Within each block, 15 plots were systematically laid out in a uniform grid pattern providing full coverage of the block (Figure 2). Each plot consisted of four quadrants with the first clockwise to the direction of travel. Full stocking was achieved when all quadrants were occupied by a planted tree.

Each quadrant was assessed for the presence of a planted tree which was classified as either healthy, unhealthy, dead or missing. Any damages were recorded and root collars were examined for hylobius damage at year two. The height and leader of every fifth tree was measured.

The severity of competition around each planted tree was assessed as nil, light, moderate or severe. Also, the abundance and height of the major competitive species per block was recorded.

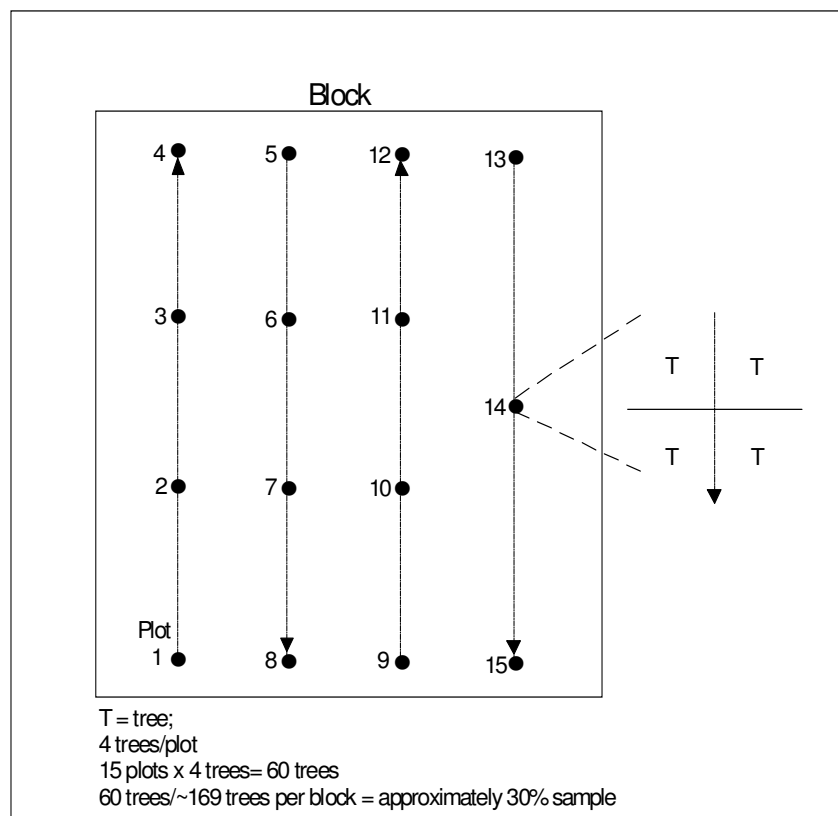


Figure 2. Assessment Procedures.

Results

The results comparing the different stock types on the various sites are displayed in Figures 3-10. Sites with similar Hylobius levels, competition, origins, and results were combined for ease of viewing the results. Mayfield 1 and 3 were combined and Dunmaglass 1 and 2 were combined. One-way anovas and Fisher's LSD tests were used to detect significant differences ($p < 0.05$) between stock types in terms of survival, height, and hylobius induced mortality. For ease of reading the results, the statistics have been restricted to the figures (Figures 3-10). The statistical significance of the hylobius induced mortality for Mayfield 2 and Sunnybrae 2 could not be performed because the data did not meet the testing criteria.

Old Field Softwood Sites

All four Mayfield sites were originally old field white spruce stands. These types of sites in Nova Scotia typically lack an abundance of natural tree regeneration and often require planting (Wall 1975, Jablanczy 1979). The most abundant competition on these sites was couch grass. A short feathery-like grass that produced minimal competition for the planted stock. These conditions are particular to this site; other old field sites can have severe competition. With competition not playing a major role the effects of Hylobius were prominent.

Larger diameter seedlings showed better survival in the presence of Hylobius. The Mayfield 4 site had the most severe Hylobius presence and the bareroot stock survival (73%) was far superior to the others (Figure 3ab). This stock type had a much larger root collar diameter than the others (Table 1). The survival of the square (45%) and styro (34%) large stock types was better than the regular stock (23%) but results were still unsatisfactory. On Mayfield 1/3, which had a moderate hylobius presence, the bareroot stock survival was 81%, square 72%, styro 62%, and regular 47% (Figure 4ab)

It would appear that smaller seedlings in this trial are more palatable to Hylobius as a greater portion were targeted in most cases (Figure 3b, 4b, 8b, 9b, 10b). In addition, of the seedlings that were damaged by Hylobius, a greater proportion of the smaller stock types died as a result of their injuries. On the Mayfield 4 site, 96% of the regular stock (mp 67) seedlings that were fed upon died, 83% of the styro, 78% of the square, and 44% of the bareroot (Figure 3b). On Mayfield 1/3, which had a moderate Hylobius presence, there was a similar trend where 79% of the regular stock (mp 67) seedlings that were fed upon died, 65% of the square, 59% of the styro, and 34% of the bareroot (Figure 4b).

Mayfield 2 was chosen as a control to the other Mayfield sites, because it was harvested and left for 15 years prior to trial establishment so Hylobius damage should not be a factor. Under these conditions, there was little difference in survival between the various stock types (Figure 5a). Bareroot survival was 84%, square was 81%, styro was 78%, and regular stock was 72%.

There is little difference between the 10 year average heights of the various stock types on Mayfield 4 and Mayfield 1/3 (Figures 3f, 4f). Either the height advantage of the larger stock types was not maintained over the long term or the height growth of the large stock was affected by the hylobius damage. On the larger stock types Hylobius tended to climb up the stem to feed, unlike on the regular stock where the feeding was concentrated at ground level. This feeding higher up the stem often produced top kill in the large stock seedlings which likely affected the height results. Despite the damage, ten years later there appears to be no lasting

effects in terms of multiple leaders or multiple stems. On Mayfield 2, the average height of the different stock types are quite variable with the regular stock (mp67) the shortest (Figure 5f).

Severe Herbaceous Competition

The Dunmaglass 1/2 and Springfield sites had severe herbaceous competition of aster, fireweed, raspberry and blackberry at the time of plantation establishment (Figures 6c, 7c). These sites were failed plantations that were replanted 5-7 years after harvest, so there was a low threat of Hylobius damage (Figures 6b,7b). In this environment of severe herbaceous competition there appears to be an advantage in using large stock. The survival of the square (82%, 93%) and styro (86%, 87%) large stock types was superior to the regular stock (mp 67) (54%, 50%) on Dunmaglass 1/2 and Springfield respectively (Figures 6a, 7a). The square and styro large stock types were also significantly taller than the regular stock 10 years after planting (Figure 6f,7f). Dunmaglass 1 and Dunmaglass 2 were manually weeded at 9 years after plantation establishment as is shown by the reduction in competition in the 10 year re-measurement (Figure 6c). In the beginning, herbaceous species were the main competition, however, over time hardwoods started to dominate.

On Springfield, McKeen's Road, Sunnybrae1, Sunnybrae 2, and especially on Dunmaglass1/2 the bareroot stock performed poorly (Figures 6,7,8,9,10). Given this stock types greater root collar diameter, height, and root system it should have performed the best. The reason for its poor performance is largely unknown. Possible explanations could include poor handling at the time of shipping and planting. The exposed roots makes this stock type prone to drying out. Another possible explanation is that some of the sites were not suitable for planting bareroot stock. Excessive rock, vegetation or lack of site preparation can make planting bareroot stock difficult. This stock type performed the best on the old field Mayfield sites, which were likely easier to plant (Figures 3,4,5).

Hardwood Competition

McKeen's Road, Sunnybrae1, and Sunnybrae2 were mixedwood sites that were hot planted. The idea being that the jump on the competition provided by hot planting in conjunction with using large stock would put the seedlings in a better position to compete and stay ahead of the hardwoods without the use of herbicides.

The Hylobius threat is not as great on these sites because of their mixedwood origins. Hylobius is normally attracted to softwood sites (Pendrel 1987). For this reason the Hylobius presence is relatively low even though they are recent cuts (Figure 8b, 9b, 10b). Despite the overall Hylobius damage being low, the square and styro large stock types performed better than the regular stock during the first few years primarily due to less hylobius induced mortality (Figures 8ab, 9ab, 10ab).

After 10 years, the square and styro large stock types showed better survival. The survival for square, styro, and regular stock at McKeen's Road was 87%, 86%, and 82%; at Sunnybrae1 62%, 71%, and 45%; and at Sunnybrae 2 90%, 90%, and 64%. The 10-year survival levels for some of the stock types appear satisfactory at present, but this is deceiving as many of these trees are overtopped by a thick canopy of hardwoods (Figures 8ce, 9ce, 10ce). In the next few years there is likely to be a drop in survival in all stock types as they succumb to suppression.

At McKeen's Road, one block out of each stock type was manually weeded at 7 years of age. At year 10, these blocks are still relatively free of competition (Figure 8c). At present there is very little difference in survival between stock types whether weeded or not, therefore results for weeded blocks are not shown separately. This is likely to change as the overtopped seedlings in non-weeded blocks succumb to suppression.

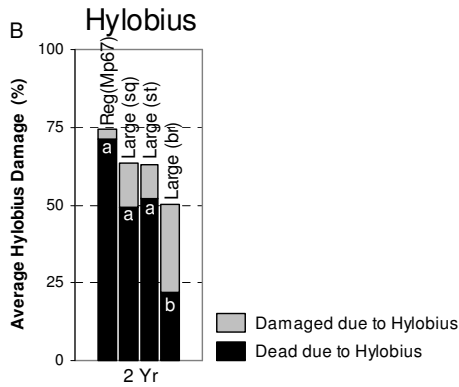
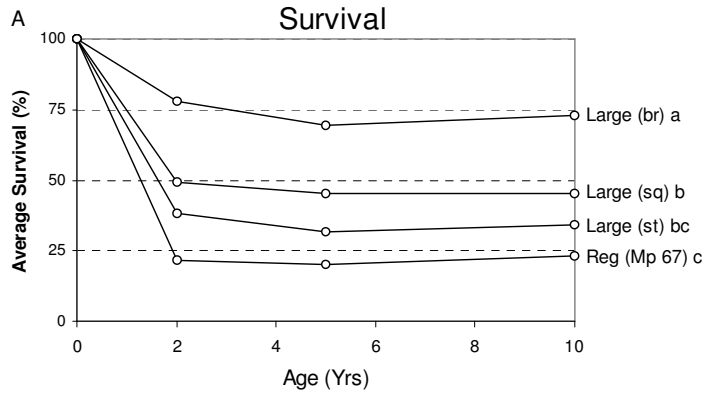
On McKeen's Road, the square and styro large stock types are taller than the regular and bareroot stock (Figure 8f). On both Sunnybrae sites there is little difference in height between the various stock types, except the bareroot on Sunnybrae 2 (Figures 9f, 10f).

Old Field Site/ Light Competition/ Hot Planted

Location: Mayfield 4

History: Old field white spruce stand harvested and hot planted.

D 5 Years



E 10 Years

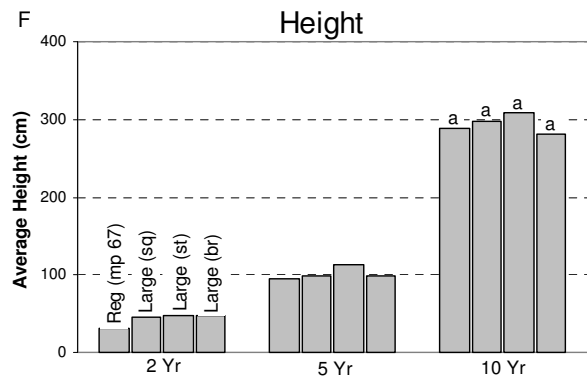
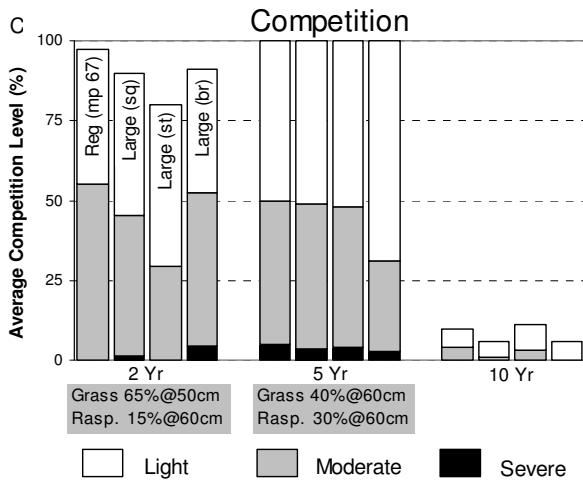
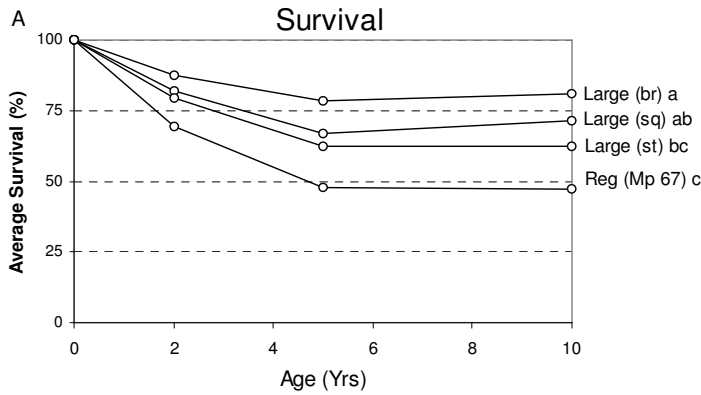


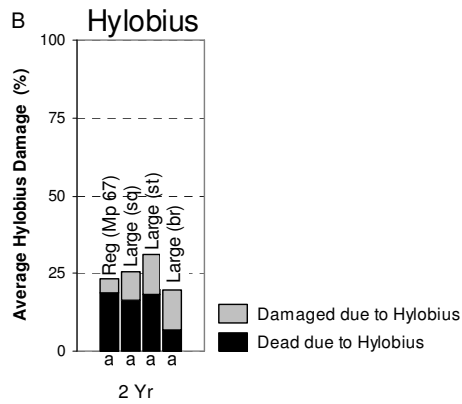
Figure 3. Mayfield 4 - A) survival, B) Hylobius, C) competition, D) 5 year photo shows a tree of average height, E) 10 year photo, F) height. Graphs A,B,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graph B: The statistics refers to the portion which is dead due to Hylobius. Graphs A,B,C,F: st=styro, sq=square, mp67=multiplot 67's, br=bareroot. Graph C: grass = couch grass (*Elymus repens*), rasp.= raspberry (*Rubus idaeus*).

Old Field Site/ Light Competition/ Hot Planted

Locations: Mayfield 1, Mayfield 3 (combined)
 History: Old field white spruce stand harvested and hot planted



D 5 Years



E 10 Years

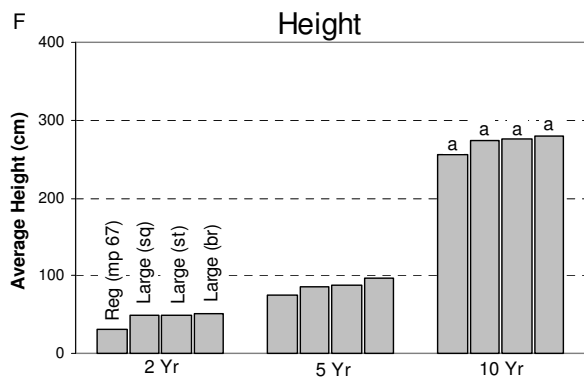
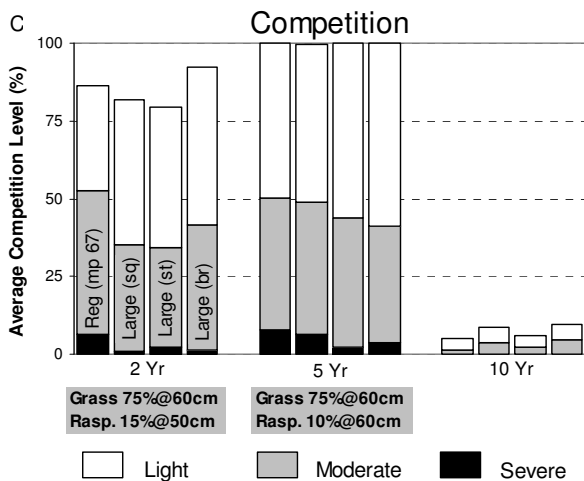


Figure 4. Mayfield 1/3 - A) survival, B) Hylobius, C) competition, D) 5 year photo, E) 10 year photo, F) height.

Graphs A,B,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graph B: The statistics refers to the portion which is dead due to Hylobius. Graphs A,B,C,F: st=styro, sq=square, mp67=multipot 67's, br=bareroot.

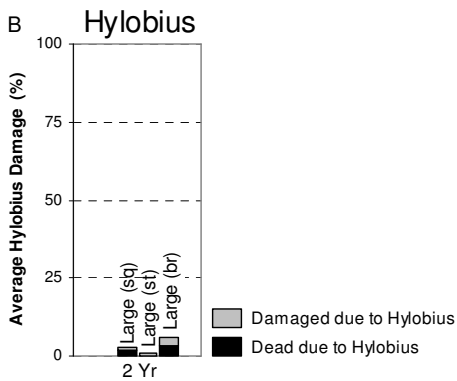
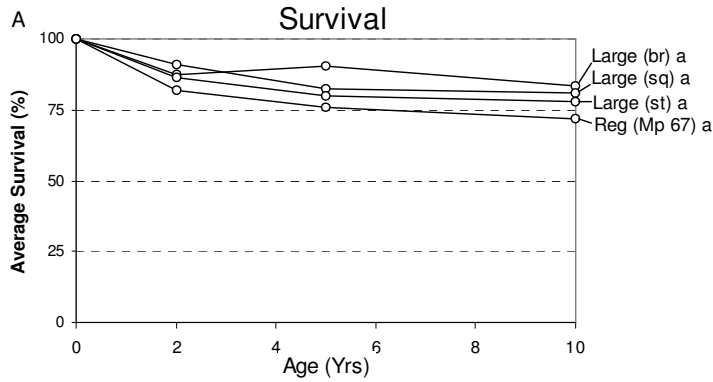
Graph C: grass = couch grass (*Elymus repens*), rasp.= raspberry (*Rubus idaeus*)

Old Field Site/ Light Competition / Left Fallow

Location: Mayfield 2

History: Old field white spruce stand harvested and left for 15 years prior to planting of the trial.

D 5 Years



E 10 Years

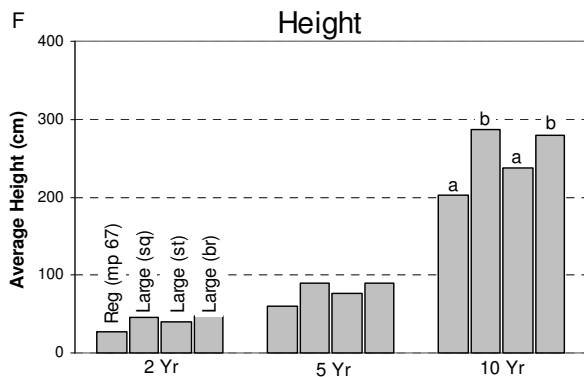
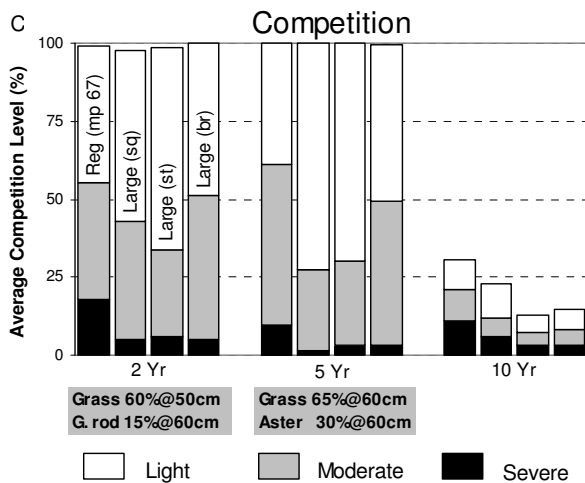


Figure 5. Mayfield 2 - A) survival, B) Hylobius, C) competition, D) 5 year photo shows a tree of average height, E) 10 year photo, F) height. Graphs A,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graphs A,B,C,F: st=styro, sq=square, mp67=multipot 67's, br=bareroot. Graph C: grass= couch grass (*Elymus repens*), G.rod= goldenrod (*Solidago species*), aster (*Aster species*).

Severe Herbaceous Competition/ Replant

Location: Dunmaglass 1, Dunmaglass 2 (combined)
 History: 1st plantations failed then replanted for this trial 5 years after harvest in heavy herbaceous competition.

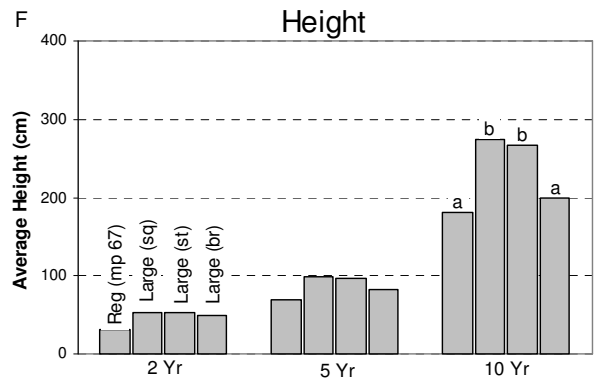
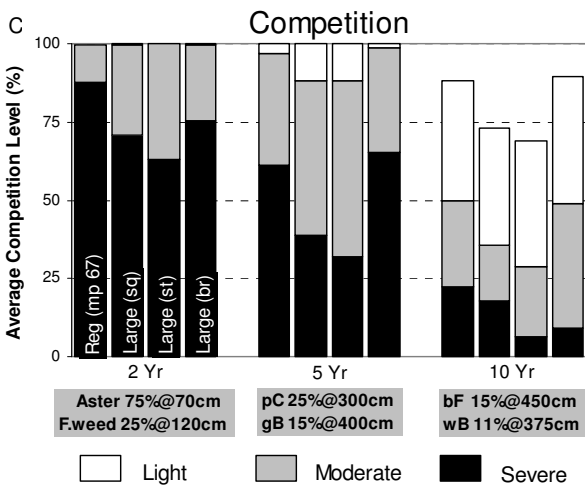
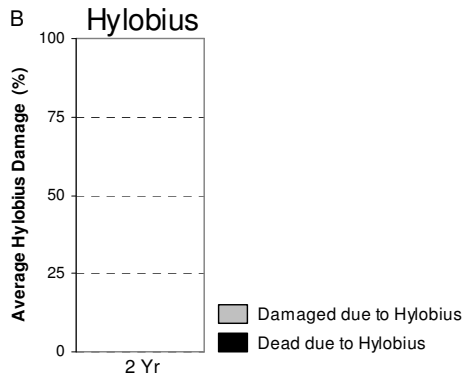
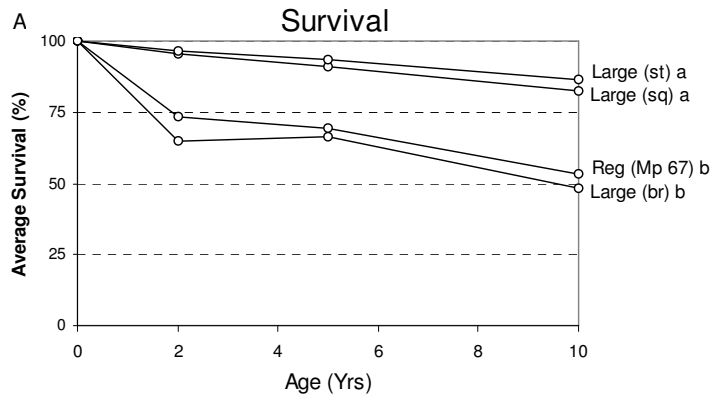


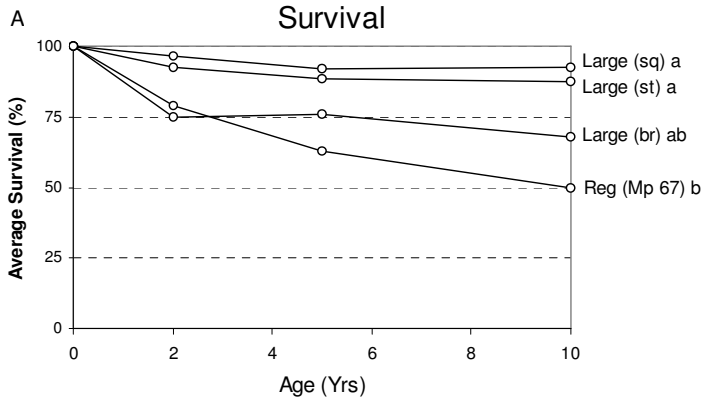
Figure 6. Dunmaglass1/2 - A) survival, B) Hylobius, C) competition, D) 5 year photo of a tree of average height, E) 10 year photo, F) height. Graphs A,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graphs A,C,F: st=styro, sq=square, mp67=multiplot 67's, br=bareroot. Graph C: Aster (*Aster species*), f.weed=fireweed (*Epilobium angustifolium*), pC=pincherry (*Prunus pennsylvanica*), gB=grey birch (*Betula populifolia*), bF=balsam fir (*Abies balsamea*), wB=white birch (*Betula papyrifera*).

Severe Herbaceous Competition/ Replant

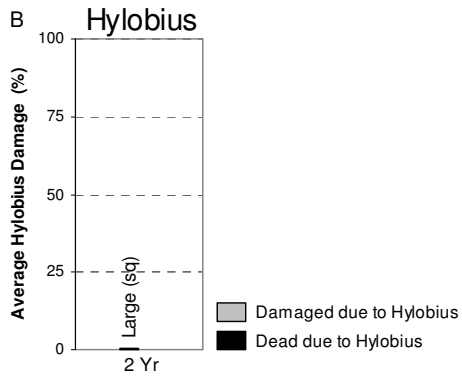
Location: Springfield

History: Replant in heavy herbaceous competition 7 years after harvest. 1st plantation of nS was thought to have failed, however portions recovered.

Now a mixed nS/bS plantation



D 5 Years



E 10 Years

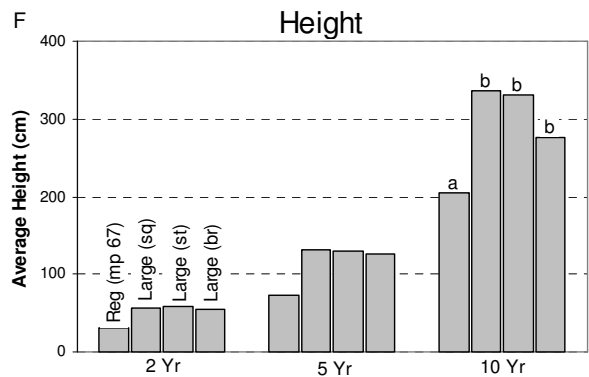
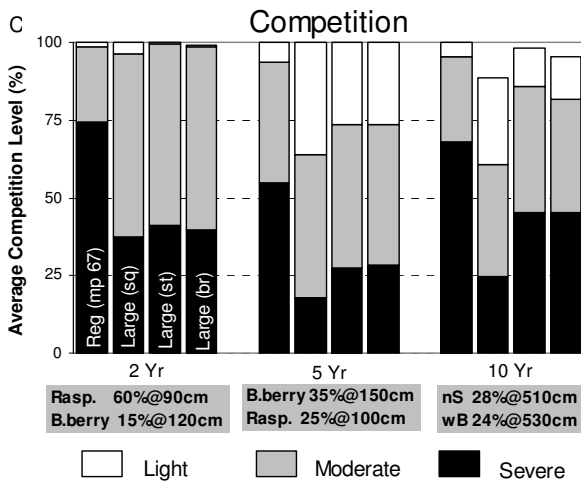


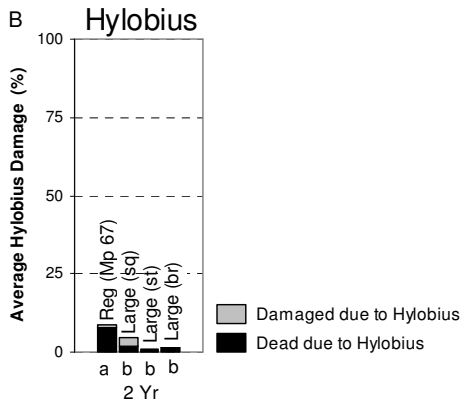
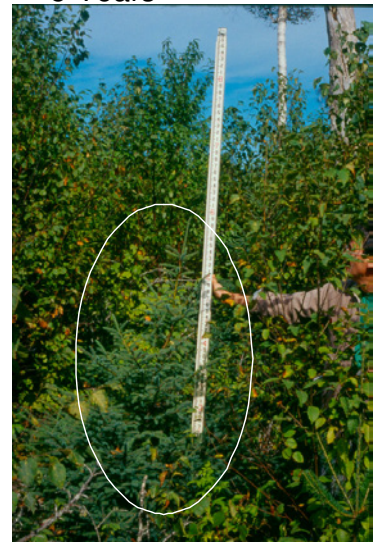
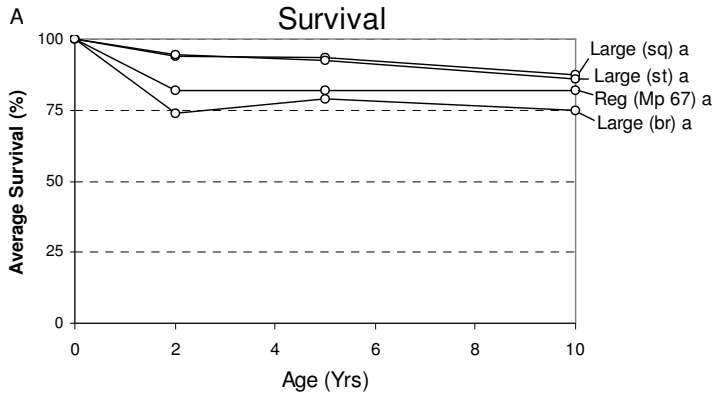
Figure 7. Springfield - A) survival, B) Hylobius, C) competition, D) 5 year photo of a tree of average height, E) 10 year photo, F) height. Graphs A,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graphs A,B,C,F: st=styro, sq=square, mp67=multipot 67's, br=bareroot. Graph C: rasp.= raspberry (*Rubus idaeus*), B.berry= blackberry (*Rubus allegheniensis*), nS= Norway spruce (*Picea abies*), wB= white birch (*Betula papyrifera*).

Severe Hardwood Competition/ Hot Planted

Location: McKeen's Rd

History: Stand was clearcut and hot planted and competition came back heavy to white birch.

D 5 Years



E 10 Years

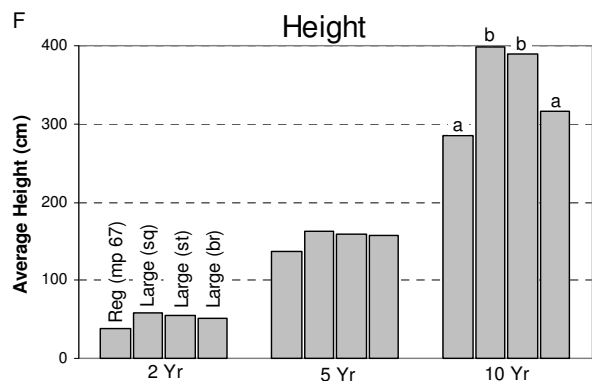
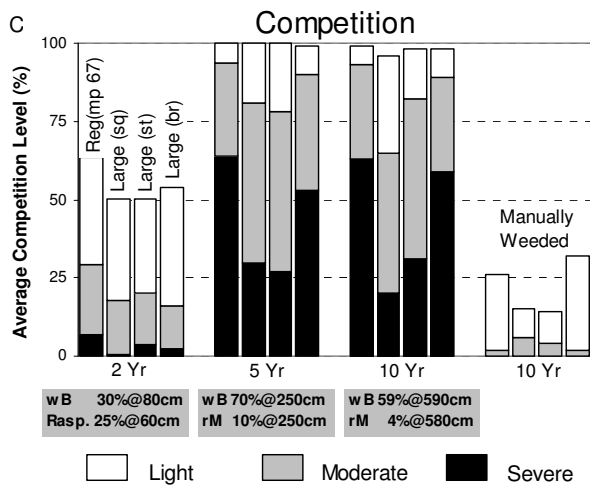
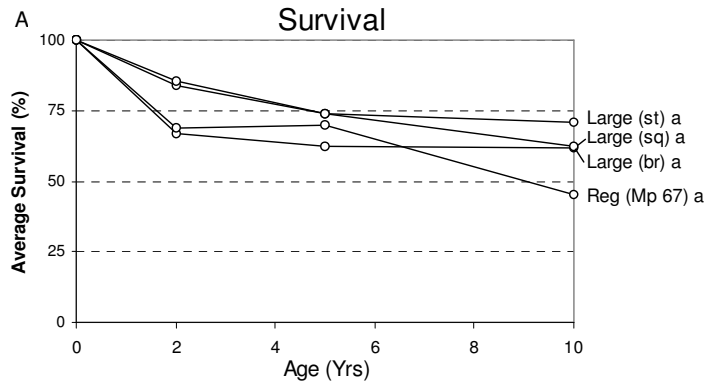


Figure 8. McKeen's Rd - A) survival, B) Hylobius, C) competition, D) 5 year photo shows a tree of average height, E) 10 year photo shows an example of severe competition, F) height. Graphs A,B,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graph B: The statistics refers to the portion which is dead due to Hylobius. Graphs A,B,C,F: st=styro, sq=square, mp67=multipot 67's, br=bareroot. Graph C: wB= white birch (*Betula papyrifera*), rasp.= raspberry (*Rubus idaeus*), rM= red maple (*Acer rubrum*).

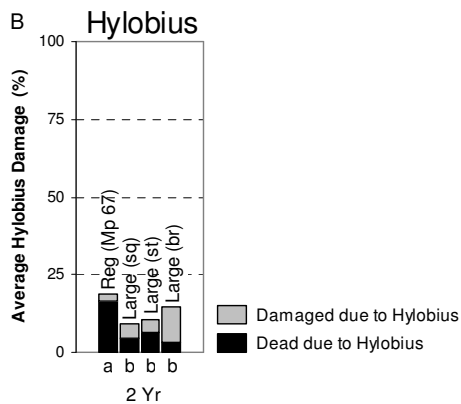
Severe Hardwood Competition/ Hot Planted

Location: Sunnybrae 1

History: Mw stand that was partially cut leaving the hardwood and hot planted. Competition came back heavy to pin cherry.



D 5 Years



E 10 Years

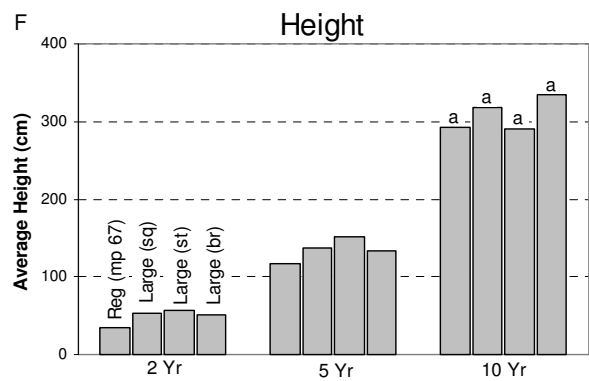
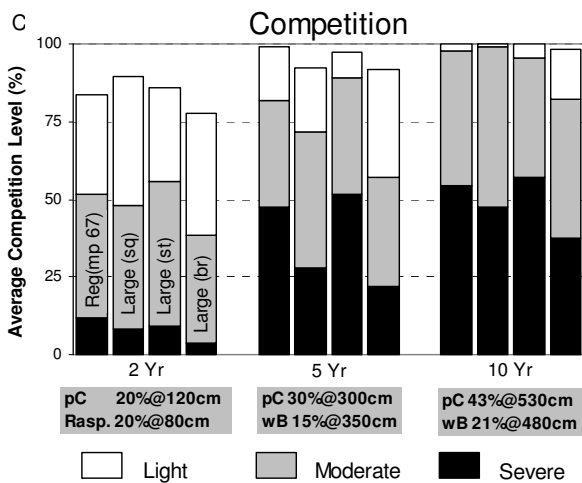
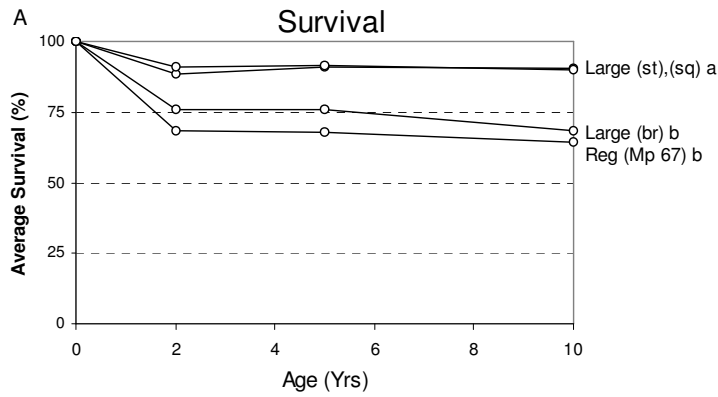


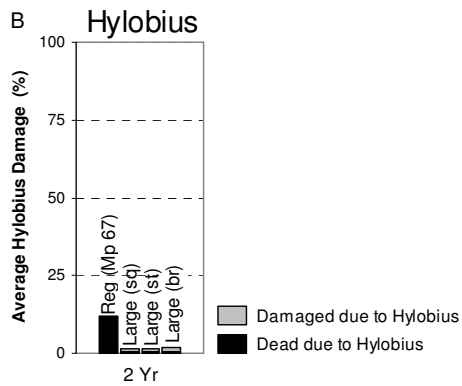
Figure 9. Sunnybrae 1- A) survival, B) Hylobius, C) competition, D) 5 year photo shows a tree of average height, E) 10 year photo shows an example of severe competition, F) height. Graphs A,B,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graph B: The statistics refers to the portion which is dead due to Hylobius. Graphs A,B,C,F: st=styro, sq=square, mp67=multipot 67's, br=bareroot. Graph C: pC=pin cherry (*Prunus pensylvanica*), rasp.= raspberry (*Rubus idaeus*), wB=white birch (*Betula papyrifera*).

Severe Hardwood Competition/ Hot Planted

Location: Sunnybrae 2
 History: Mw stand that was clearcut and hot planted.
 Competition came back heavy to red maple and white birch.



D 5 Years



E 10 Years

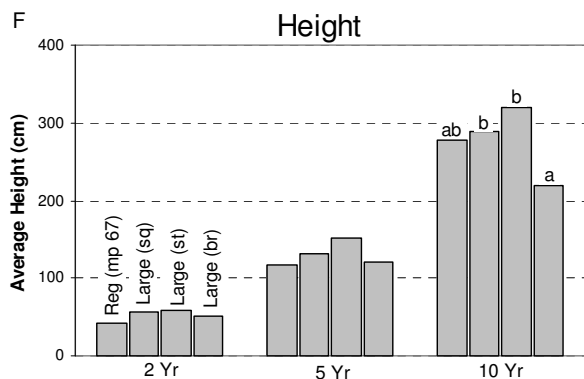
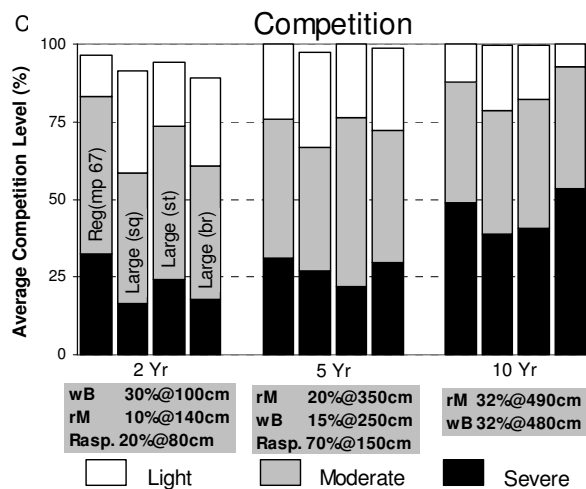


Figure 10. Sunnybrae 2- A) survival, B) Hylobius, C) competition, D) 5 year photo shows a tree of average height, E) 10 year photo shows an example of severe competition, F) and height. Graphs A,F: The stock types which do not have a letter in common are statistically different ($p < 0.05$). Graphs A,B,C,F: st=styro, sq=quare, mp67=multipot 67's, br=bareroot. Graph C: wB=white birch (*Betula papyrifera*), rM=red maple (*Acer rubrum*), rasp.= raspberry (*Rubus idaeus*).

Summary

- Larger diameter seedlings had better survival on hot planted sites which had high levels of Hylobius, especially the bareroot stock which had the largest root collar diameter.
 - Mayfield 4 - Bareroot stock survival was 73%, square 45%, styro 34%, and regular 23% (Figure 3a).
 - Mayfield1/3 - Bareroot stock survival was 81%, square 72%, styro 62%, and regular 47% (Figure 4a).
- Of the seedlings that were damaged by Hylobius a greater proportion of the smaller stock types died as a result of their injuries.
 - Mayfield 4 - 96% of the regular stock (mp 67) seedlings that were fed upon by Hylobius died, 83% of the styro, 78% of the square, and 44% of the bareroot (Figure 3b).
 - Mayfield 1/3 - 79% of the regular stock (mp 67) seedlings that were fed upon by Hylobius died, 65% of the square, 59% of the styro, and 34% of the bareroot (Figure 4b).
- On the old field site that was left fallow before planting, there was little difference in survival between the regular (72%) and the large stock types (bareroot 84%, square 81%, styro 78%) (Figure 5a).
- On the sites which contained severe herbaceous competition at the time of plantation establishment, the square and styro large stock types showed superior survival and height (Figure 6af,7af).

Survival: Dunmaglass 1/2: square 82%, styro 86%, regular 54%.

Springfield: square 93%, styro 87%, regular 50%.

Height: Dunmaglass 1/2: square 274m, styro 267m, regular 181m.

Springfield: square 335m, styro 330m, regular 205m.

- The bareroot stock performed poorly on several sites, this points towards the possible pitfalls of using this stock type (Figures 6,7,8,9,10).
- On the mixedwood sites that were hotplanted, the square and styro large stock types achieved higher survival than the regular stock (Figure 8a,9a,10a).
 - McKeen's Rd: styro 86%, square 87%, regular 82%.
 - Sunnybrae 1: styro 71%, square 62%, regular 45%.
 - Sunnybrae 2: styro 90%, square 90%, regular 64%.

However, this treatment still did not provide enough of a competitive advantage to keep the seedlings ahead of the hardwood competition. Much of these sites are now overtopped with hardwoods.

Discussion

Undoubtedly larger stock outperformed regular stock in most cases. The larger seedlings have a greater capacity for survival and growth because of a larger root collar diameter and a more developed root system and crown. Before considering planting large stock the potential benefits should be weighed against the additional costs. Larger seedlings are more costly to produce because they take longer to grow, require more resources, and occupy more nursery space for a longer period of time. Larger seedlings (square and styro) are approximately 3-4 times the price of regular seedlings and bareroot stock is approximately 5 times (Lemieux 2007). In addition, the cost of planting large stock would be more than conventional stock. St-Amour (1995) reported that it took twice as long to plant a hectare with 340cc plug volume seedlings as compared to 110cc seedlings.

Old Field Softwood Sites

Some of the key site indicators for predicting Hylobius risk on recent cutovers include the softwood content of the previous stand, abundant moss cover, and few regenerating stems (Pendrel 1990). This is a fairly accurate description of many old field sites in Nova Scotia. Therefore, Hylobius can be a serious problem when these types of sites are planted soon after harvest as was the case with the Mayfield 4 trial site. The bareroot stock which had the largest root collar diameter was the most successful (73% survival). However, stock of this size and age is costly to produce and operationally is difficult to plant because of its size and exposed roots.

The intermediate sized stock types (square=45%, styro=34%) did better than the regular stock (23%) but survival was still unsatisfactory. The root collar diameter of 4.6mm, which was the average size of the square and styro stock types, was not enough to reduce mortality to acceptable levels when the Hylobius presence was severe. Therefore, when planting smaller stock under these conditions it might be better to delay planting for a few years after harvest to alleviate or reduce the hylobius threat.

Severe Herbaceous Competition

In Nova Scotia, sites are often left for a few years after harvest in high risk areas to avoid the Hylobius threat and also to see if natural regeneration is sufficient to avoid planting. However, if planting is delayed a thick layer of herbaceous competition can become established making it difficult for planted seedlings to thrive. In situations like this when herbicides are not used, it was hypothesized that larger seedlings would be in a better position to overcome competition.

The Dunmaglass and Springfield sites were failed plantations that had been left for 5-7 years after harvest and had excessive raspberry, aster, fireweed, and blackberry vegetation at the time of trial establishment. Based on the results at these sites, large stock (square, styro) resulted in increased survival and growth in the presence of severe herbaceous competition. Dunmaglass 1 and Dunmaglass 2 were manually weeded at nine years after plantation establishment, demonstrating that even with the use of large stock many plantations will still require maintenance.

Hardwood Competition

It can be especially difficult to establish plantations in the presence of hardwood competition without the aid of herbicides. Hardwood and mixedwood sites often come back heavily to hardwood coppice after being cut. Hardwood coppice tends to be faster growing than softwoods and quickly overtakes and suppresses planted seedlings. Manual weeding is an option but its effects are usually short lived as hardwoods tend to sprout back vigorously.

Based on the results of the McKeen's Road and Sunnybrae sites, hot planting with large stock still does not provide enough of a growth advantage to keep the seedlings ahead of hardwood competition. These trials are now mostly overtopped with hardwoods. It's clear that these types of sites will require at least one, if not successive manual weedings to establish a plantation regardless of whether regular or large stock is used. Therefore, if these sites are to be planted without the aid of herbicides one should be aware of the additional investment in monitoring and manual weeding that will likely be necessary.

Conclusions

Using large stock was advantageous when planting areas with excessive herbaceous competition. Also, planting larger diameter seedlings reduced mortality from *Hylobius*. Under severe *Hylobius* presence, seedlings with a root collar diameter of 7.7mm showed good survival. However, survival of seedlings with root collar diameters of approximately 4.6mm were not satisfactory. Large stock that was hot planted on sites with hardwood competition were not able to outgrow the competition.

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I would like to acknowledge Brian White of the Nova Scotia Department of Natural Resources (NSDNR) for initiating this trial and for his leadership and involvement during the early stages of this trial. I would also like to acknowledge Tim McGrath with the NSDNR in Truro for his leadership and involvement in the later stages of this trial and also for his assistance in editing this report. Dave Arseneau with the NSDNR in Truro should be acknowledged for his efforts in trial establishment, data collection and data editing over the years. New Page (formerly Stora Enso Port Hawkesbury Ltd.) were also instrumental in the planning and implementation of this trial. Peter Neily and Michee Lemieux with NSDNR and Edwin Swift with the Canadian Forest Service provided editorial comments.

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Appendix 1. Site Summaries

Location	Stand #	Pre-Harv. Type	Harv. Treat.	Spp.	Block	Stock Type	Survival (%)			Height (cm)			Hylobius		Competition (%)										
							2 Yr	5 Yr	10 Yr	2 Yr	5 Yr	10 Yr	% Dam	% Dead	2 Yr			5 Yr			10 Yr				
															Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev		
Mayfield #1	9604	Sw (of)	CC	Hot P	bS	4	mp/67	92	40	45	32	73	258	9	2	31	58	5	46	33	21	4	4	0	
							9	mp/67	62	30	25	24	55	218	31	24	46	46	0	39	50	11	0	0	0
							12	mp/67	85	62	57	29	69	287	16	12	39	14	2	67	28	6	18	3	0
								Avg.	80	44	42	28	66	254	18	13	39	39	2	50	37	13	7	2	0
							2	square	97	73	82	50	68	284	5	2	53	34	0	37	49	14	10	6	0
							6	square	90	68	63	53	82	264	12	5	37	37	0	56	37	7	5	8	0
							11	square	95	80	83	47	95	265	12	5	32	23	5	72	24	4	4	6	0
								Avg.	94	74	76	50	82	271	10	4	41	31	2	55	36	9	6	7	0
							5	styro	83	38	52	46	80	218	28	14	44	34	0	37	63	0	6	6	0
							8	styro	88	75	73	50	80	286	23	10	47	25	0	66	34	0	7	0	0
							10	styro	97	80	75	45	76	238	17	3	33	3	0	77	21	2	4	4	0
								Avg.	89	64	67	47	79	247	23	9	41	21	0	60	39	1	6	4	0
							1	bareroot	85	70	75	53	108	268	12	3	49	41	2	57	38	5	9	0	0
							3	bareroot	98	92	93	49	83	245	13	0	61	31	0	45	47	8	7	0	0
							7	bareroot	93	83	87	49	95	269	22	3	70	21	0	79	17	4	4	0	0
	Avg.	92	82	85	50	95	261	16	2	60	31	1	61	34	5	7	0	0							
Mayfield #2	9605	Sw (of)	CC	Re Plant	bS	4	mp/67	87	73	72	30	55	209	0	0	40	44	15	44	40	16	12	19	14	
							9	mp/67	72	70	63	26	66	215	0	0	51	40	7	43	58	0	8	5	8
							12	mp/67	87	85	80	28	60	186	0	0	40	29	31	30	58	12	10	6	10
								Avg.	82	76	72	28	60	203	0	0	44	38	18	39	52	9	10	10	11
							2	square	93	80	75	50	86	300	8	5	27	64	7	71	29	0	11	2	7
							6	square	95	92	90	43	92	293	0	0	65	28	4	72	26	2	17	11	9
							11	square	85	75	77	46	89	268	0	0	73	22	4	74	23	3	4	4	2
								Avg.	91	82	81	46	89	287	3	2	55	38	5	73	26	1	11	6	6
							5	styro	88	77	72	43	73	242	3	0	53	40	6	51	47	2	12	2	2
							8	styro	88	88	92	40	77	264	0	0	66	28	4	86	14	0	0	0	0
							10	styro	83	75	70	38	78	206	0	0	76	16	8	73	20	7	5	10	7
								Avg.	86	80	78	40	76	237	1	0	65	28	6	70	27	3	5	4	3
							1	bareroot	85	92	82	50	105	280	8	0	25	73	2	60	37	2	4	4	0
							3	bareroot	85	90	79	47	80	266	10	10	67	24	10	38	58	4	13	4	7
							7	bareroot	92	90	90	48	83	293	0	0	55	42	4	52	44	4	2	6	4
	Avg.	87	91	84	48	89	280	6	3	49	46	5	50	46	3	6	5	3							

Pre-Harv. = Pre-harvest stand type, Treat. = Treatment, Spp. = Species, % Dam = % Damaged, Mod = Moderate, Sev = Severe, Sw (of) = Softwood (old field), CC = Clearcut, Hot P = Hot Plant, bS = Black spruce

Location	Stand #	Pre-Harv.	Harv. Type	Treat.	Spp.	Block	Stock Type	Survival (%)			Height (cm)			Hylobius		Competition (%)									
								2 Yr	5 Yr	10 Yr	2 Yr	5 Yr	10 Yr	% Dam	% Dead	2 Yr			5 Yr			10 Yr			
								Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev						
Mayfield #3	9606	Sw (of)	CC	Hot P	bS	4	mp/67	50	42	43	30	78	269	31	29	33	57	10	32	64	4	0	0	0	
							9	mp/67	78	70	72	36	89	250	16	8	19	66	9	37	61	2	0	2	0
							12	mp/67	50	43	42	30	90	254	39	37	33	37	13	80	16	4	0	0	0
								Avg.	59	52	52	32	86	258	28	24	29	53	11	50	47	3	0	1	0
							2	square	88	82	88	51	101	328	19	10	60	32	0	57	43	0	4	2	0
							6	square	50	38	48	50	85	220	61	47	40	40	0	27	59	14	0	0	0
							11	square	70	60	65	46	83	279	43	30	57	38	0	53	44	0	8	0	0
								Avg.	69	60	67	49	90	276	41	29	53	37	0	46	49	5	4	1	0
							5	styro	65	43	53	51	88	286	44	32	74	26	0	44	56	0	0	0	0
							8	styro	67	67	55	50	100	300	43	31	40	50	0	56	38	5	3	0	0
							10	styro	77	72	65	54	102	326	33	21	33	54	13	58	35	7	3	3	0
								Avg.	70	61	58	52	97	304	40	28	49	43	4	53	43	4	2	1	0
							1	bareroot	90	93	88	57	121	331	8	3	41	56	2	64	34	2	8	8	0
							3	bareroot	72	53	58	51	93	279	26	17	51	44	0	61	39	0	0	3	0
							7	bareroot	87	78	83	53	81	289	37	13	33	50	4	45	52	2	4	0	0
								Avg.	83	75	76	54	98	300	24	11	42	50	2	57	42	1	4	3	0
Mayfield #4	9607	Sw (of)	CC	Hot P	bS	4	mp/67	20	12	18	30	94	285	78	76	17	75	0	71	29	0	0	0	0	
							9	mp/67	13	12	12	32	86	286	84	84	63	38	0	29	57	14	0	0	0
							12	mp/67	32	37	40	33	105	294	61	54	47	53	0	50	50	0	17	13	0
								Avg.	22	20	23	32	95	288	74	71	42	55	0	50	45	5	6	4	0
							2	square	70	55	53	46	95	262	46	29	31	64	0	67	33	0	9	3	0
							6	square	38	47	48	47	107	351	68	61	48	35	0	59	41	0	0	0	0
							11	square	40	33	35	44	96	280	76	58	54	33	4	28	61	11	5	0	0
								Avg.	49	45	45	46	99	298	63	49	44	44	1	51	45	4	5	1	0
							5	styro	25	23	28	52	109	249	56	53	60	27	0	57	36	7	6	6	0
							8	styro	30	32	30	48	125	364	78	67	61	17	0	56	44	0	11	0	0
							10	styro	60	40	45	45	106	315	55	36	31	44	0	43	52	4	7	4	0
								Avg.	38	32	34	48	113	309	63	52	51	29	0	52	44	4	8	3	0
							1	bareroot	83	78	78	46	97	285	53	17	38	52	8	65	33	2	13	0	0
							3	bareroot	70	58	68	50	108	273	46	29	33	60	5	69	29	3	5	0	0
							7	bareroot	80	72	72	49	91	288	52	20	44	33	0	73	24	2	0	0	0
								Avg.	78	69	73	48	99	282	50	22	38	48	4	69	29	2	6	0	0

Pre-Harv. = Pre-harvest stand type, Treat. = Treatment, Spp. = Species, % Dam = % Damaged, Mod = Moderate, Sev = Severe, Sw (of) = Softwood (old field), CC = Clearcut, Hot P = Hot Plant, bS = Black spruce

Location	Stand #	Pre-Harv.	Harv. Type	Treat.	Spp.	Other Treat.	Age (Yrs)	Block	Stock Type	Survival (%)			Height (cm)			Hylobius		Competition (%)								
										2 Yr	5 Yr	10 Yr	2 Yr	5 Yr	10 Yr	% Dam	% Dead	2 Yr			5 Yr			10 Yr		
										Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev					
McKeen's Rd.	9608	Mw	CC	Hot P	bS	M.Weed	7	4	mp/67	82	80	82	39	137	333	11	11	35	14	4	10	29	60	24	2	0
								9	mp/67	80	83	82	35	122	277	7	7	35	25	8	2	40	58	10	41	47
								12	mp/67	83	82	82	41	154	245	7	6	32	28	8	6	20	73	2	18	80
									Avg.	82	82	82	38	138	285	9	8	34	22	7	6	30	64	12	20	42
							7	2	square	92	92	88	59	163	420	10	5	29	13	0	9	47	44	9	6	0
								6	square	97	95	87	58	161	374	2	0	34	19	2	18	54	28	29	48	23
								11	square	93	93	87	57	166	401	2	0	34	20	0	31	52	17	33	42	17
									Avg.	94	93	87	58	163	398	5	2	33	17	1	19	51	29	24	32	13
							7	5	styro	98	95	93	56	157	407	0	0	36	29	7	19	61	19	29	43	25
								8	styro	98	95	83	58	165	395	2	2	31	15	2	18	49	33	4	60	36
								10	styro	88	88	82	50	154	367	2	0	25	6	2	28	43	28	10	4	0
									Avg.	95	93	86	55	159	390	1	1	30	17	3	22	51	27	14	36	20
							7	1	bareroot	82	82	83	49	156	298	7	3	39	14	4	2	29	67	8	24	66
								3	bareroot	62	77	63	50	150	293	2	2	41	14	3	7	37	57	11	37	53
								7	bareroot	77	78	78	54	166	357	0	0	35	13	0	19	45	36	30	2	0
	Avg.	74	79	75	51	157		316	3	2	38	14	2	9	37	53	16	21	40							
Dunmaglass #1	9609	Sw	CC	Re Plant	bS	M.Weed	9	4	mp/67	38	30	27	27	61	161	0	0	0	0	100	0	24	76	44	44	6
								9	mp/67	98	85	68	33	71	173	0	0	0	14	86	0	24	76	63	27	5
								12	mp/67	87	88	83	33	68	226	0	0	0	21	79	0	36	64	36	28	2
							9		Avg.	74	68	59	31	67	187	0	0	0	12	88	0	28	72	48	33	4
								2	square	88	73	47	53	93	265	0	0	0	0	100	0	32	68	57	25	4
								6	square	93	90	85	56	84	256	0	0	0	27	73	0	65	35	51	18	2
							9	11	square	97	97	92	48	101	319	0	0	3	43	53	18	67	16	20	9	0
									Avg.	93	87	75	52	93	280	0	0	1	23	76	6	54	40	43	17	2
								5	styro	93	83	70	53	96	216	0	0	0	29	71	0	31	69	83	7	5
							9	8	styro	97	93	93	51	96	298	0	0	0	76	24	11	62	27	34	13	0
								10	styro	98	97	95	51	88	271	0	0	0	47	53	2	69	29	40	9	5
									Avg.	96	91	86	52	93	262	0	0	0	51	49	4	54	42	53	9	3
							9	1	bareroot	45	57	33	53	87	189	0	0	0	7	93	0	9	91	50	50	0
								3	bareroot	48	37	18	50	75	206	0	0	0	0	100	0	11	89	55	27	0
								7	bareroot	87	77	70	46	64	207	0	0	0	67	33	0	55	45	64	19	10
									Avg.	60	57	40	50	75	201	0	0	0	25	75	0	25	75	56	32	3

Pre-Harv. = Pre-harvest stand type, Treat. = Treatment, Spp. = Species, % Dam = % Damaged, Mod = Moderate, Sev = Severe, Mw = Mixedwood, Sw = Softwood, CC = Clearcut, Hot P = Hot Plant, bS = Black spruce, M.Weed = Manually weed

Location	Stand #	Pre-Harv.	Harv. Type	Treat.	Spp.	Other Treat.	Age (Yrs)	Block	Stock Type	Survival (%)			Height (cm)			Hylobius		Competition (%)											
										2 Yr	5 Yr	10 Yr	2 Yr	5 Yr	10 Yr	% Dam	% Dead	2 Yr			5 Yr			10 Yr					
										Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev								
Dunmaglass #2	9610	Sw	CC	Re Plant	bS	M.Weed	9	1	mp/67	70	67	45	32	68	210	0	0	0	0	98	5	60	35	59	22	19			
								4	mp/67	82	88	70	30	67	217	0	0	0	37	63	15	66	19	29	45	7			
								12	mp/67	65	57	28	30	77	99	0	0	0	0	100	0	3	97	0	0	94			
									Avg.	72	71	48	31	71	175	0	0	0	12	87	7	43	50	29	22	40			
									M.Weed	9	2	square	98	90	87	52	117	336	0	0	0	49	51	13	70	17	58	17	6
									M.Weed	9	6	square	100	100	92	49	104	296	0	0	0	47	53	40	52	8	38	24	9
										11	square	98	95	90	55	88	170	0	0	0	5	95	0	11	89	0	15	85	
											Avg.	99	95	90	52	103	267	0	0	0	34	66	18	44	38	32	19	33	
									M.Weed	9	5	styro	100	100	97	52	105	280	0	0	0	30	70	37	58	5	38	26	7
									M.Weed	9	8	styro	97	95	75	58	98	263	0	0	0	29	71	21	51	28	20	38	9
									M.Weed	9	10	styro	93	93	88	52	93	273	0	0	0	11	89	2	64	34	25	42	13
											Avg.	97	96	87	54	99	272	0	0	0	23	77	20	58	22	27	35	10	
									M.Weed	9	3	bareroot	57	78	62	53	96	196	0	0	3	24	74	0	53	47	32	49	14
									M.Weed	9	7	bareroot	77	73	43	43	83	167	0	0	0	26	74	0	25	75	23	54	19
									M.Weed	9	9	bareroot	75	77	63	47	90	225	0	0	0	20	80	9	46	46	18	39	13
			Avg.	70	76	56	48	90	196	0	0	1	23	76	3	41	56	25	47	15									
Sunnybrae #1	9611	Mw	PC	Hot P	bS			4	mp/67	83	80	48	40	118	251	7	7	32	42	12	2	19	79	0	34	66			
								9	mp/67	68	62	47	35	123	357	18	18	37	34	2	35	46	16	7	54	39			
								12	mp/67	55	67	40	31	110	268	31	24	27	42	21	15	38	48	0	42	58			
									Avg.	69	70	45	35	117	292	19	16	32	40	12	17	34	47	2	43	54			
								2	square	87	72	60	58	147	299	5	2	27	50	13	14	33	52	3	44	53			
								6	square	90	82	75	54	113	318	7	4	44	37	7	18	53	24	0	49	51			
								11	square	75	68	52	47	151	336	15	8	53	31	4	29	44	7	0	61	39			
									Avg.	84	74	62	53	137	318	9	4	42	39	8	21	43	28	1	52	48			
								5	styro	80	67	57	51	149	279	15	6	25	50	6	15	48	35	9	59	32			
								8	styro	92	87	93	60	167	294	5	5	40	38	5	4	40	52	5	32	63			
								10	styro	85	68	63	59	140	299	11	9	25	51	16	5	25	68	0	24	76			
									Avg.	86	74	71	57	152	291	10	7	30	46	9	8	38	51	5	38	57			
								1	bareroot	50	52	48	49	133	368	4	0	43	47	3	23	48	26	17	48	34			
								3	bareroot	85	73	70	53	130	297	27	5	41	35	2	57	23	20	17	33	50			
								7	bareroot	65	62	67	52	136	339	13	4	33	23	5	24	35	19	15	53	28			
	Avg.	67	62	62	51	133	335	15	3	39	35	3	35	35	22	16	45	37											

Pre-Harv. = Pre-harvest stand type, Treat. = Treatment, Spp. = Species, % Dam = % Damaged, Mod = Moderate, Sev = Severe, Sw = Softwood, Mw = Mixedwood, CC = Clearcut, PC = Partial cut, Hot P = Hot Plant, bS = Black spruce, M.Weed = Manually weed

Location	Stand #	Pre-Harv.	Harv. Type	Treat.	Spp.	Block	Stock Type	Survival (%)			Height (cm)			Hylobius		Competition (%)									
								2 Yr	5 Yr	10 Yr	2 Yr	5 Yr	10 Yr	% Dam	% Dead	2 Yr			5 Yr			10 Yr			
								Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev	Light	Mod	Sev						
Sunnybrae #2	9612	Mw	CC	Hot P	bS		4	mp/67	75	80	75	45	139	272	12	12	18	47	24	33	35	31	0	38	62
							9	mp/67	57	72	63	40	124	309	21	21	15	68	18	33	44	23	18	42	39
							12	mp/67	73	52	55	42	87	254	2	2	7	39	55	6	55	39	18	36	45
								Avg.	68	68	64	42	117	278	12	12	13	51	32	24	45	31	12	39	49
							2	square	85	87	87	62	126	340	2	0	27	47	20	27	29	37	10	35	56
							6	square	88	93	92	51	120	232	2	2	34	36	15	38	42	21	22	47	31
							11	square	93	93	92	57	149	294	0	0	38	43	14	27	48	23	31	37	30
								Avg.	89	91	90	57	132	289	1	1	33	42	16	31	40	27	21	40	39
							5	styro	95	97	97	54	137	299	0	0	16	51	26	36	47	17	22	31	47
							8	styro	90	82	85	58	149	326	2	0	15	54	30	14	55	31	12	41	47
							10	styro	88	95	88	62	171	336	2	2	30	43	17	21	61	18	17	53	28
								Avg.	91	91	90	58	152	320	1	1	20	49	24	24	54	22	17	42	41
							1	bareroot	75	72	75	52	120	231	2	2	16	44	24	21	42	37	4	22	73
							3	bareroot	77	73	63	52	135	232	4	0	24	52	20	20	48	32	13	45	42
							7	bareroot	75	82	67	47	109	196	0	0	44	33	9	39	37	20	5	50	45
	Avg.	76	76	68	50	121	220	2	1	28	43	18	27	42	30	8	39	53							
Springfield	9613	Sw	CC	Re-plant	bS		4	mp/67	98	85	80	35	78	207	0	0	2	29	69	4	55	41	8	19	73
							9	mp/67	87	63	37	32	57	189	0	0	2	21	77	3	28	69	0	32	68
							12	mp/67	52	40	32	28	83	218	0	0	0	23	77	13	33	54	5	32	63
								Avg.	79	63	50	32	73	205	0	0	1	24	75	6	39	55	5	27	68
							2	square	95	93	93	52	106	321	0	0	9	61	30	29	52	20	27	25	25
							6	square	100	88	88	59	143	301	2	0	2	62	37	43	43	13	19	45	26
							11	square	95	95	97	58	143	384	0	0	0	54	46	37	42	21	38	38	22
								Avg.	97	92	93	56	131	335	1	0	3	59	37	36	46	18	28	36	25
							5	styro	95	92	88	57	133	360	0	0	2	74	25	44	44	13	11	51	32
							8	styro	90	93	97	61	143	341	0	0	0	69	31	25	55	20	21	45	34
							10	styro	93	80	77	58	115	289	0	0	0	32	68	10	40	50	4	26	70
								Avg.	93	88	87	59	130	330	0	0	1	58	41	27	46	28	12	41	45
							1	bareroot	82	80	75	52	137	314	0	0	0	65	35	29	46	25	7	44	49
							3	bareroot	70	75	73	58	126	277	0	0	2	62	33	33	44	22	14	34	48
							7	bareroot	72	72	55	55	117	238	0	0	0	49	51	16	47	37	21	30	39
	Avg.	75	76	68	55	127	276	0	0	1	59	40	26	46	28	14	36	45							

Pre-Harv. = Pre-harvest stand type, Treat. = Treatment, Spp. = Species, % Dam = % Damaged, Mod = Moderate, Sev = Severe, Mw = Mixedwood, Sw = Softwood, CC = Clearcut, Hot P = Hot Plant, bS = Black spruce

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