FOREST RESEARCH REPORT

Nova Scotia Department of Natural Resources
Forest Management Planning

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NOVA SCOTIA
Natural Resources

Commercial Thinning Survey: 5-Year Results.

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Introduction

Commercial thinning has a dual role, both as a thinning and a harvesting operation. Ideally, commercial stems are removed that might have otherwise died, releasing longer lived and/or better formed trees so that the remaining trees can increase in size and value. It is a way of capturing volume before mortality occurs (Smith *et al.* 1996).

Commercial thinning is a common practice in Nova Scotia, reaching its peak in 2003-2005 (9000 ha) (Figure 1).

Commercial thinning along with other partial harvesting methods make up 9% of the total harvest for the province (NFD 2010), but it could increase substantially as a result of implementing Nova Scotia's Natural Resources Strategy (NSDNR 2011). The strategy set a target to reduce clearcutting to no more than 50% of harvests.

However, more partial harvesting could result in greater losses due to blowdown, especially with softwoods. This survey provides information regarding blowdown that occurred as a result of commercial thinning and also helps identify site/soil conditions that are risk factors for blowdown.

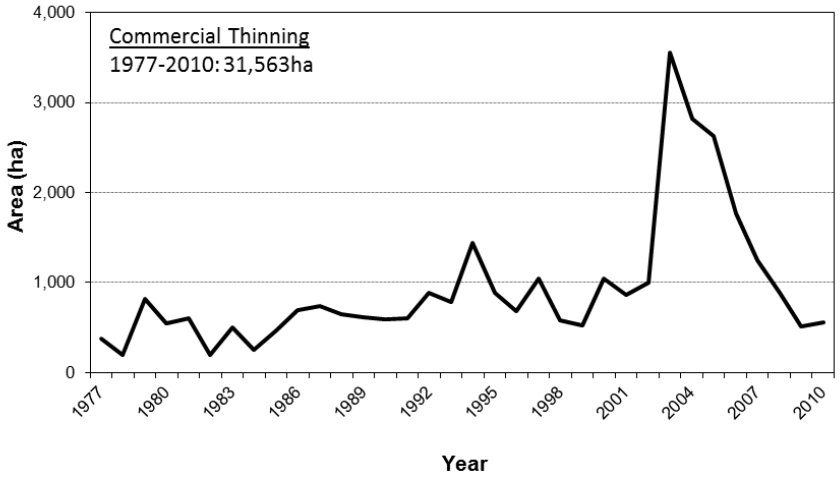

Figure 1. Commercial thinning (ha) in Nova Scotia 1977-2010.

Objective

The objective of this survey is to see what the status of commercial thinning is in the province, in particular;

- Quality of job
- Balsam Woolly Adelgid Damage
- Release Response
- Blowdown
- Basal Area and Volumes Removed

Methods

Study Site Locations and Descriptions

In 2009 and 2010, 71 commercially thinned sites were surveyed (844ha) (Figure 2). These sites were randomly selected from commercial thinning operations performed in 2004 and 2005 (5447ha). Results are therefore approximately 5 years post-thinning. The survey sampled 15% of the area that was commercially thinned during this period.

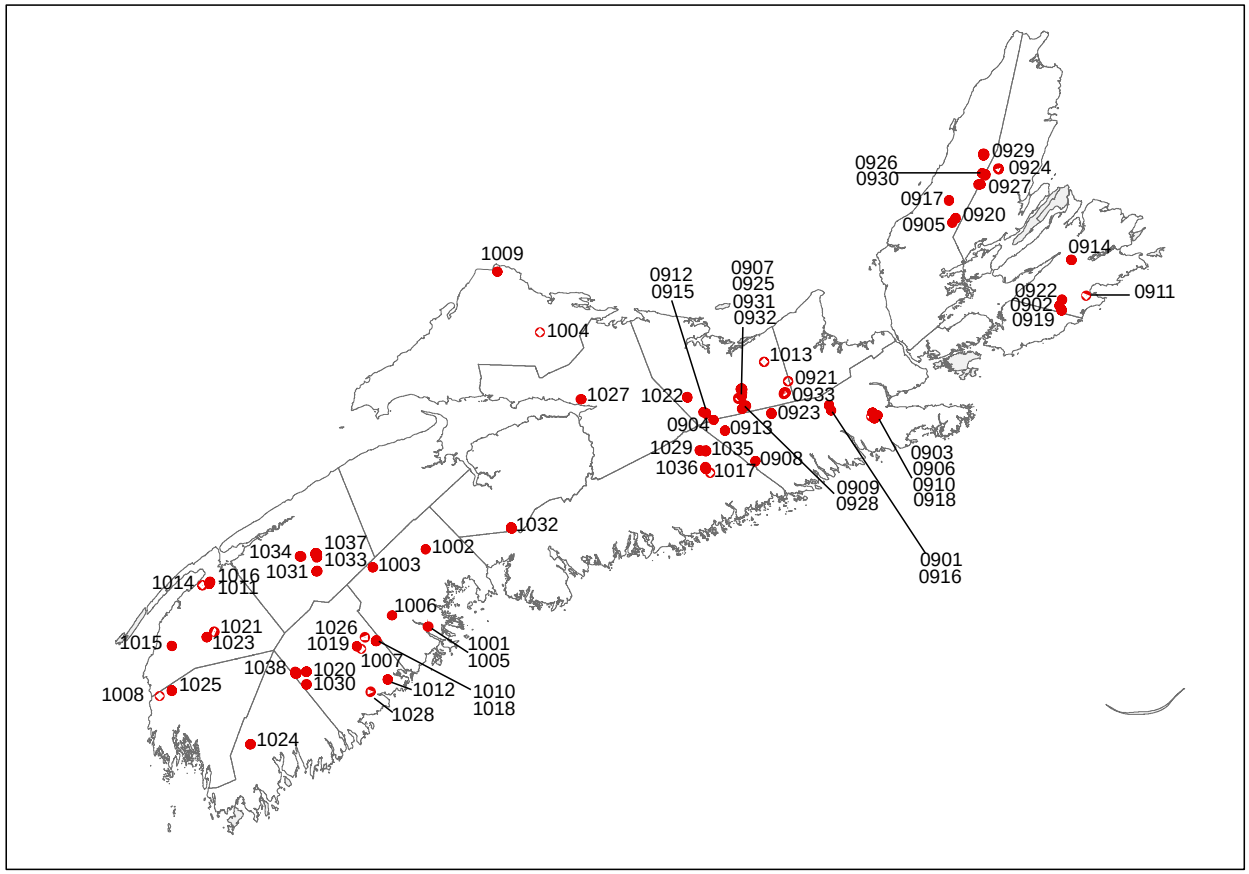

Figure 2. The locations of the 71 commercial thinning sites that were surveyed in Nova Scotia.

Figure 3 shows a summary of the sites that were surveyed. Most sites were dominated by red spruce or balsam fir. The majority of the sites were less than 10 ha in size. Stands of various ages were commercially thinned. Approximately half the stands were previously treated (PCT or planted). Half of the sites surveyed were on Crown land and half were on private land. The sites were evenly distributed by region. Land capability ranged between 4-9 m^3/ha/year (NSDNR 1993).

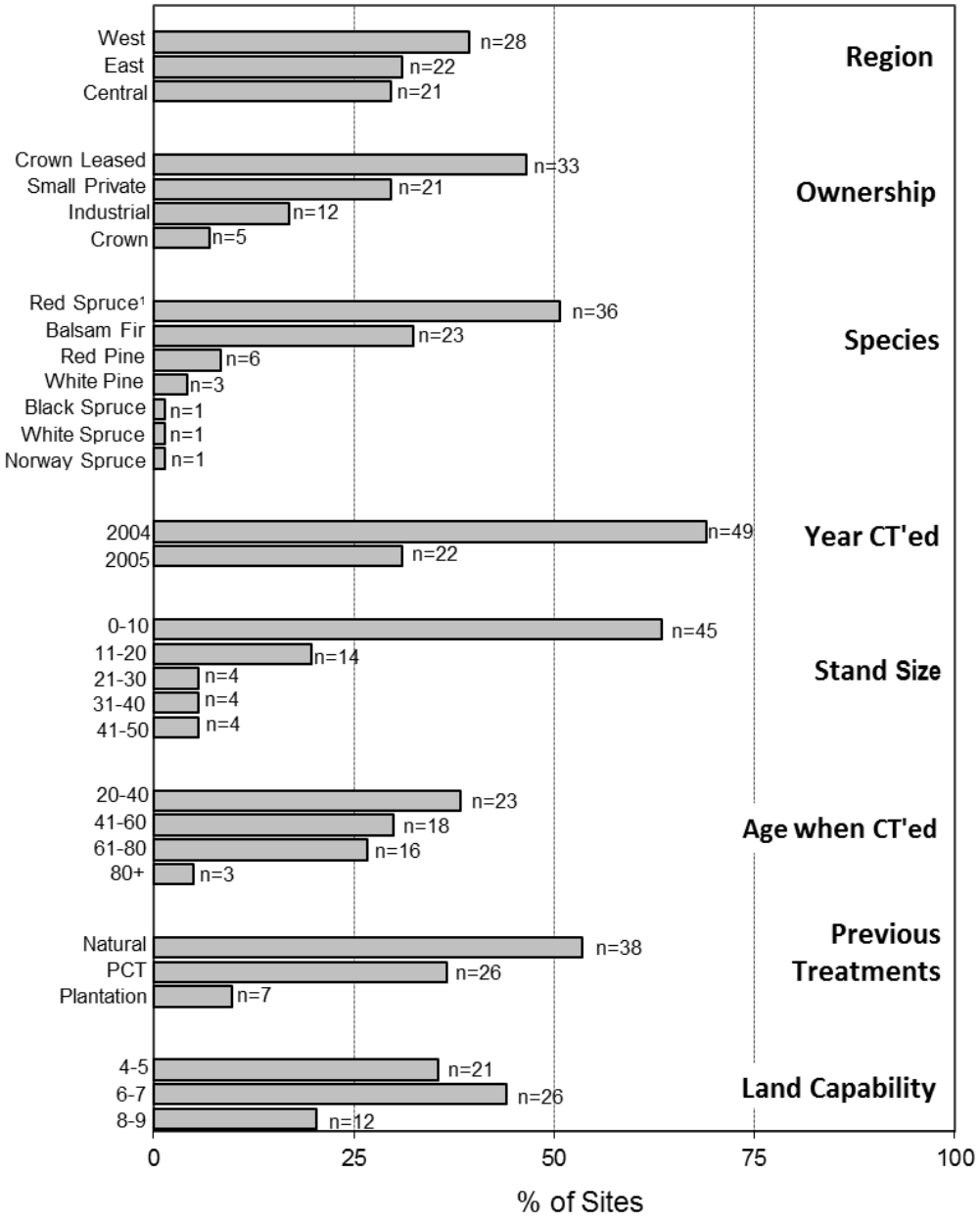

Figure 3. Summary of surveyed commercial thinning sites (n= # of sites).

[1]Red spruce (*Picea rubens* Sarg.), Balsam fir (*Abies balsamea* (L.)), Red pine (*Pinus resinosa* Ait.), White pine (*Pinus strobus* L.), Black spruce (*Picea mariana* (Mill.) BSP), White spruce (*Picea glauca* (Moench) Voss), Norway spruce (*Picea abies* (L.) Karst.)

Field Sampling Procedures

A sampling intensity of 1 plot/ha was used with a minimum of 5 plots and a maximum of 25 plots per stand. Plots were established in a uniform grid pattern to provide full coverage of each site. Plots were assigned one of six categories (treated, partially treated, only trails, not treated, untreatable, or clearcut). These categories are defined later in the text (see Table 2). If it was treated or partially treated, then a circular plot was established which spanned between 2 trails (Figure 4). All live, dead, and cut trees were tallied. Damages, site characteristics, soil and vegetation types (Keys *et al.* 2011) were recorded. One tree per plot (average tree of average release) was cored and the sample taken for further analysis. Three hundred and ninety cores were examined for release response (diameter increment) after commercial thinning using the WinDENDRO™ system.[2]

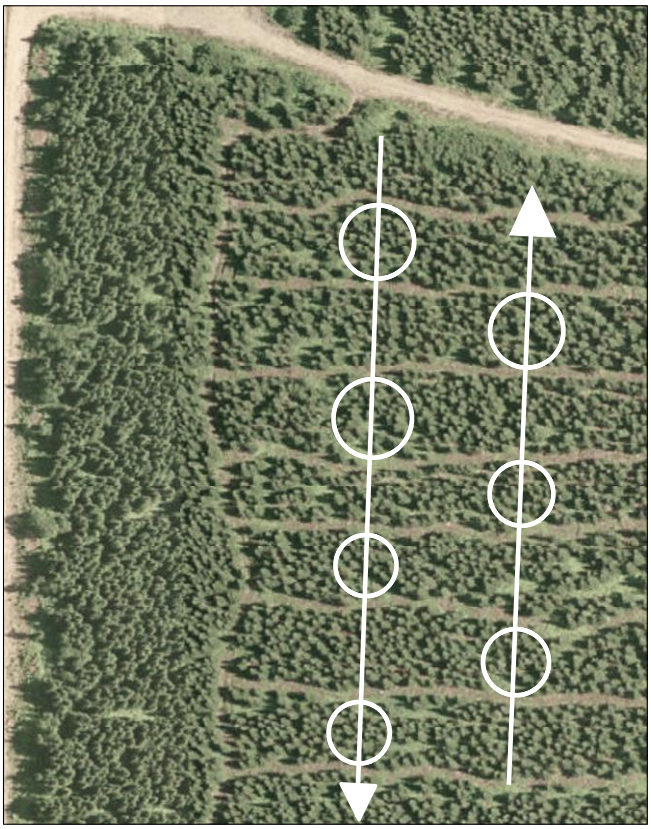

Figure 4. Example of plot layout.

Results

Area Treated

Nine percent (9%) of the area that was commercially thinned was clearcut within 5 years of treatment (Table 1). This area is believed to be salvaged after it was commercially thinned because of blowdown, sirococcus shoot blight (Nicholls and Robbins 1984) or reasons unknown. It is difficult to determine the exact causes of clearcutting in many cases. These classifications are based on a combination of evidence at the site, age of regeneration, deterioration of stumps, experience of field staff, and information from forest industry. Five percent (5%) appears to have been partial harvests in mixed wood stands, where most of the softwood was taken leaving low quality hardwoods.

[2] WinDENDRO™ – Registered trademark of Regent Systems Inc.

Table 1. The proportion of area in each of the following categories (commercially thinned, partial harvest, clearcut) based on sample area of commercial thinning survey.

	% Area	Area (ha)	# Sites		% Area (clear-cut)	% Area (total)	Area (ha)	# Sites
Commercially thinned	86%	729.0	51					
Partial Harvest	5%	37.6	6					
Clearcut	9%	77.7	14	Salvage (reason unknown)	51%	5%	39.9	10
				Salvage (sirococcus)	40%	3%	30.7	2
				Salvage (blowdown)	9%	1%	7.1	2
Total	100%	844.3	71		100%	9%	77.7	14

Table 2 shows the breakdown of the area that was reported as being commercially thinned in Table 1. Only 58% of this area was treated. Thirty-one percent of the area was either not treated, or the treatment done was marginal. For example, trails were harvested, but there was no thinning between trails or it was only thinned on the edge of trails (the centre of the leave strip left unthinned). Ten percent of the area consisted of small areas of unthinned inclusions untreatable for a variety of reasons. However, 1% of the area consisted of large contiguous untreated areas. When a large section of the stand is untreatable, that section could have been excluded from the area reported.

Table 2. The proportion of area that was treated.

Treated	58%		
Partially Treated/ Not Treated	31%	Partially Treated[1]	12%
		Not Treated[2]	9%
		Only Trails[3]	10%
		Total	31%
Untreatable[4] (acceptable)	10%	Wet Area, SMZ, Hw. patch, rock, wildlife clump, natural openings.	
Untreatable[5] (unacceptable)	1%	Large section of stand untreatable all in one area.	
	100%		

[1] **Partially Treated**: only trees on edge of trails were harvested and the centre of the leave strip was not thinned. The average width of the partially treated leave strips was 26m and of this 56% was not treated (15m).

[2] **Not Treated**: no trails and no thinning when there was no reason for it not to be treated.

[3] **Only Trails**: trails are present but no thinning between trails.

[4] **Untreatable (acceptable)**: Untreatable for a specific reason (i.e. wet area, SMZ, etc.....)

[5] **Untreatable (unacceptable)**: Large section of stand untreatable, should have been excluded from the area reported as commercially thinned.

Basal Area and Volume

The width of the leave strips averaged 18 m and trails averaged 5 m wide; therefore 22% of the area consists of trails (Table 3). The average amount of basal area removed in leave strips that were treated was 40%; when including trails 53% was removed. There were many areas that were not treated, if one includes these areas the basal area removed was 32% and 47% respectively excluding and including trails. The average merchantable volume of the stands that were commercially thinned was 221m^3/ha before thinning. It is estimated that 111m^3/ha was removed during thinning in treated areas; across all area 79m^3/ha was removed. The results for individual sites are presented in Appendix 1.

Table 3. The number of stems and the amount of basal area and volume removed during commercial thinning.

	Leave Strip	**Trail**	**Stand Level (Leave Strip + Trail)**
Width	18m	5m	23m
% of Stand	78%	22%	100%
# Stems/ha (before CT)	1,858	-	1,858
# Stems/ha (after CT)[1]	1,040	0	811
% of Stems Removed [1]	44%	100%	56%
Basal Area (before CT)	39m^2/ha	-	39m^2/ha
% Basal Area Removed (treated areas)[1]	40%	100%	53%
% Basal Area Removed (all areas[2])	32%	100%	47%
Merchantable Volume Before Thinning	221m^3/ha	-	221m^3/ha
Merchantable Volume Removed (treated areas)[1]	66m^3/ha	45m^3/ha	111m^3/ha
Merchantable Volume Removed (all areas[2])	45m^3/ha	34m^3/ha	79m^3/ha

[1] Includes only those areas that were treated.
[2]All areas: Includes areas that were not treated.

The average diameter at breast height (DBH) of trees that were cut was 16 cm compared to 17.7 cm for those that were left. In general, most of the sites were thinned from below meaning the smaller trees were removed.

Harvest Damage

On average, 6% of trees were damaged due to harvesting activities (Figure 5). The majority of the sites (67%) had very little damage (≤5%). However, some sites had significant harvesting damage; the worst had 43% of residual trees damaged.

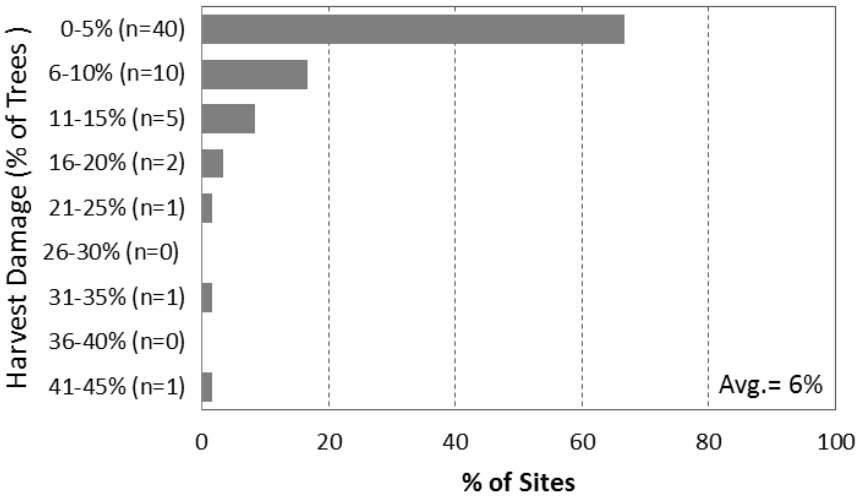

Figure 5. The proportion of sites in each harvest damage category. (n= # of sites)

Balsam Woolly Adelgid

Balsam woolly adelgid (BWA) (*Adelges piceae*) is a major pest in Nova Scotia affecting balsam fir trees. All balsam fir commercial thinnings within mainland Nova Scotia and lower elevation Cape Breton had moderate (25-50%) to severe (+51%) infestations (Figure 6). All of these sites were at an elevation of 200 m or less. The only place in Nova Scotia where BWA was not visible in the crowns was in the Highlands of Cape Breton. Elevation appears to play a role as all these sites are at an elevation of 328 m or greater and have no visible signs of BWA (0%). It has been reported that colder winters at higher elevations reduce BWA overwintering survival, which in turn keeps BWA populations in check (NSDNR 2012).

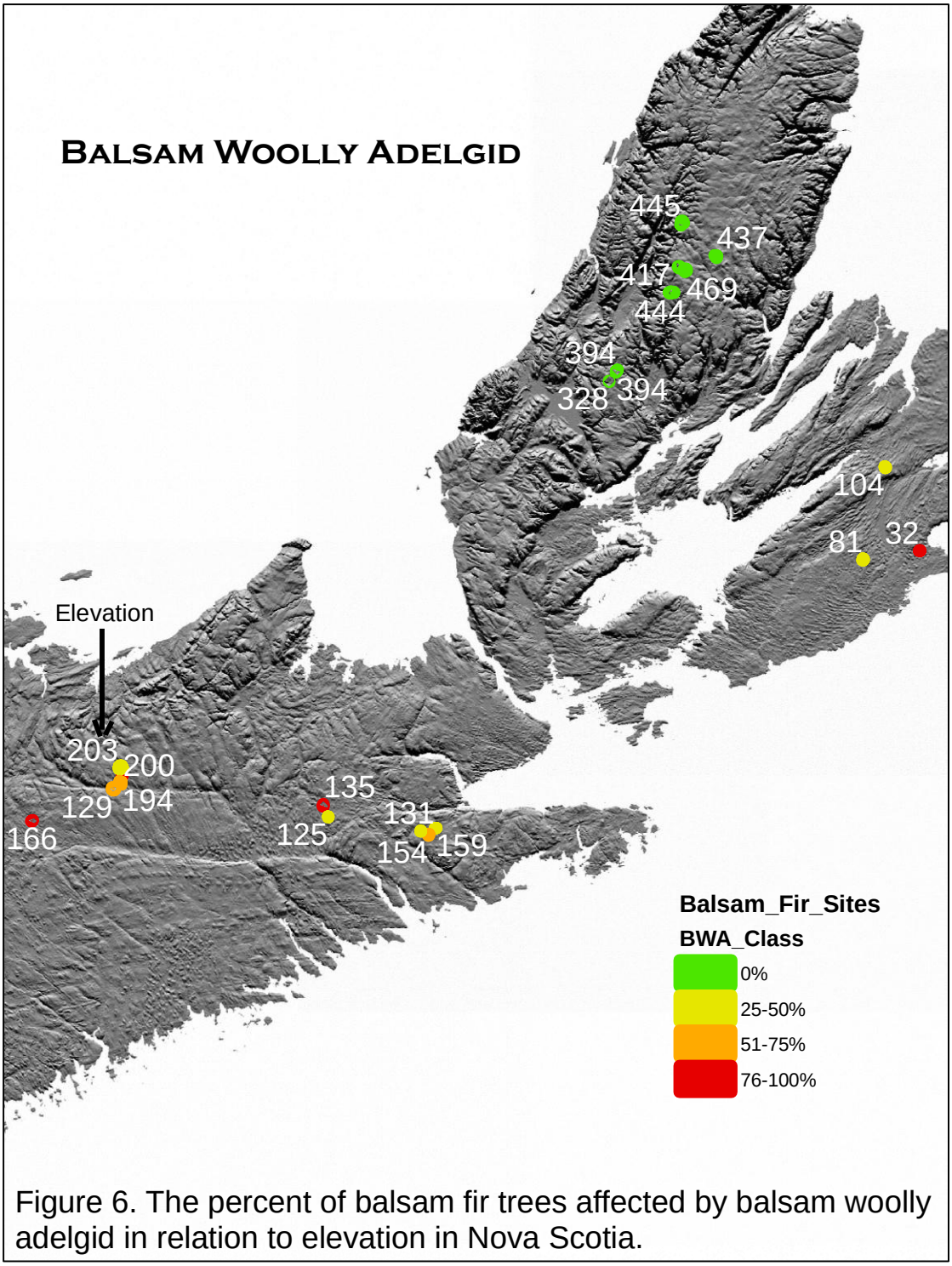

Figure 6. The percent of balsam fir trees affected by balsam woolly adelgid in relation to elevation in Nova Scotia.

Release Response

Commercially thinned trees responded to release from the treatment (Figure 7). The diameter increment started increasing the first year following treatment. Diameter growth went from 0.29 cm/year before thinning to 0.42 cm/year, four years after thinning; an increase of 45%.

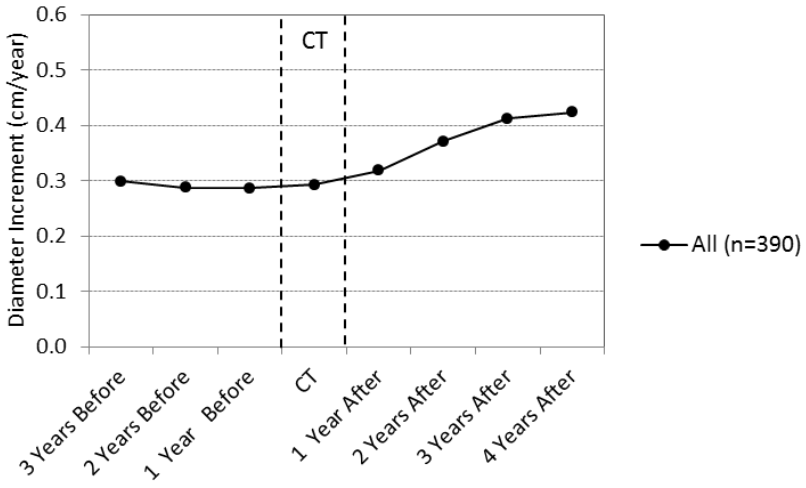

Figure 7. The diameter increment of commercially thinned trees before and after thinning. 390 cores were analyzed.

Eighty-six percent (86%) of the cores were from red spruce and balsam fir. Figure 8 shows the response of these species. The larger diameter (dominant) trees and younger trees had the greatest diameter increment both before and after thinning. However, all trees regardless of size or age responded to release. For more detailed graphs see Appendix 2 and 3. Red spruce did not respond to release as much as balsam fir. This observation may be due to the red spruce being older with less live crown (Table 4).

Table 4. The average age and the percent live crown of balsam fir and red spruce when they were commercially thinned.

	Avg. Age	% Live Crown	# Sites
Balsam fir (Highland)	31	70%	7
Balsam fir	36	58%	13
Red spruce	66	46%	31

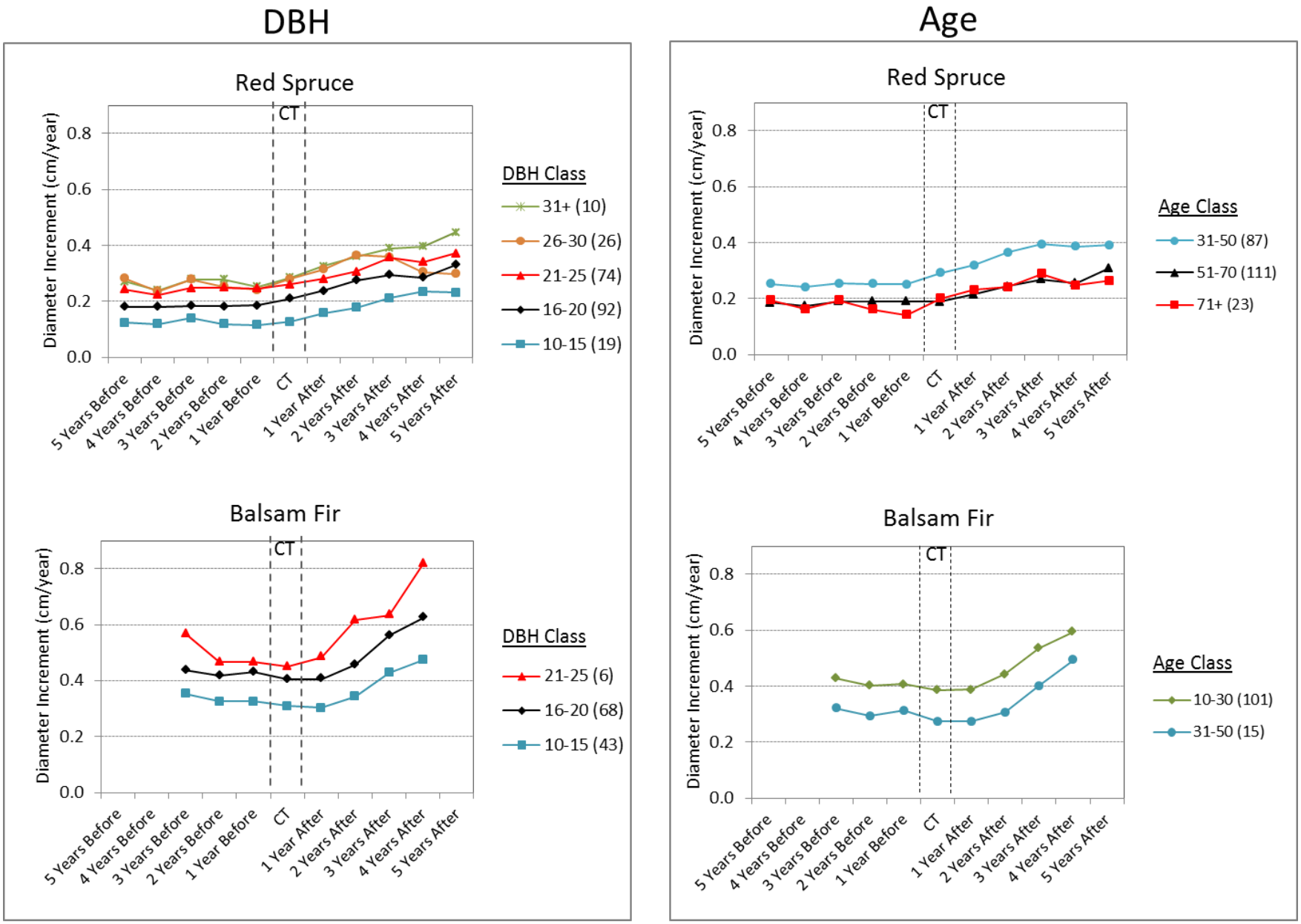

Figure 8. The diameter increment of commercially thinned red spruce and balsam fir before and after thinning categorized by DBH class and age class. Sample sizes are shown in parentheses (n).

Amount of Blowdown

Five years after commercial thinning, 6% of the basal area had blown-down and 4% had stem breakage for a total of 10% wind damage (Table 5). An additional 6% of the area was salvaged. This could be due to blowdown, although this was not confirmed in all cases. Areas that were known to be salvaged for other reasons were excluded from Table 5.

Table 5. Wind Damage

	% of BA	Salvage (% of area)
Blowdown	6%	
Stem Breakage	4%	
Wind Damage	10%	6%[1]

[1]See Table 1: Salvage (reason unknown) 5% + Salvage (blowdown) 1% = 6%

Fifty-five percent of sites had basal area losses of 5% or less (Figure 9). Wind damage tended to be fairly minimal when taking into consideration the entire stand, but upon closer examination many of the sites with 5% or more basal area losses tended to have pockets of severe wind damage (Appendix 4). Twenty percent of sites (12/60 sites) had severe wind damage (25+% basal area losses) covering at least 25% of the site (Appendix 4). If you include sites that were potentially salvaged because of blowdown this number is increased to 33% of sites (22/66 sites).

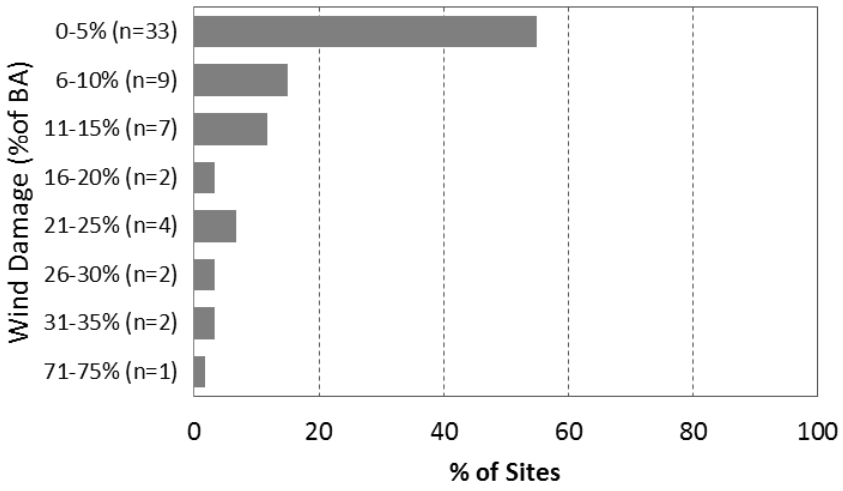

Figure 9 . The proportion of sites in each wind damage category. (n= # of sites)

Blowdown was usually concentrated in pockets. These blowdown pockets can give the impression of large losses, because of their visual impact, but over the entire stand the level of blowdown is usually less. Keep in mind, the results only cover 5-years post-thinning; there is likely to be more blowdown in the future especially in stands that already are partially blown down.

Factors Affecting Blowdown

The survey did reveal some factors that make a stand more prone to blowdown. Sites with stony phase (S-phase) soils experienced some of the most severe blowdown (Figure 10, Figure 11, Appendix 4). S-phase soils have 60 % or more cobbles, stones, and/or boulders in the upper 30 cm of mineral soil such that rooting is restricted (Keys *et al.* 2010). Comparing similar sites, the blowdown on sites with S-phase soils was 14% versus 4% on non S-phase soils (Figure 10).

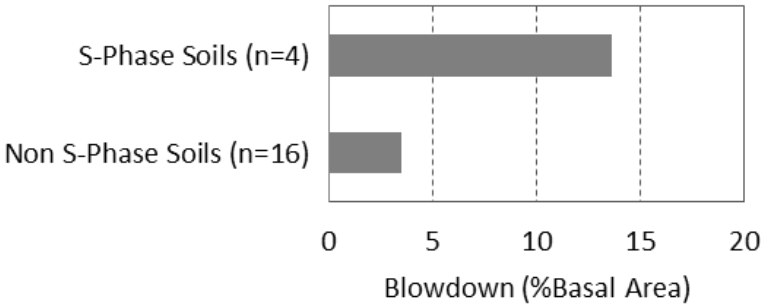

Figure 10 . The blowdown which occurred on sites with S-phase soils compared to non-S-phase soils on similar sites .

The proximity of a tree to an extraction trail also affected it's likelihood of blowing down. Nine percent of the trees bordering trails were blown down, compared to 4% in the interior of leave strips.

Figure 11. Photo of s-phase soils. Notice rock directly under roots.

Soils that are imperfectly drained or shallow to bedrock are known to be prone to blowdown (Keys *et al.* 2010). The sites with these attributes did tend to have more blowdown than others (Appendix 4). However, there were too few sites surveyed with these characteristics to make any definitive conclusions. Height diameter ratio and exposure are other factors that have been connected to blowdown (McGrath and Ellingsen 2009, McGrath 2010), but this survey did not reveal any conclusive trends regarding these factors.

Summary

- **Treated:** 58% of the area submitted as being commercially thinned was treated.
- **Not Treated:** 31% of the area was either not treated or the treatment done was marginal (i.e. trails were harvested but there was no thinning between trails or it was only on the edge of trails).
- **Untreatable:** 11% of the area was untreatable.
- **Harvest Damage:** 6% of trees were damaged due to harvesting.
- **Balsam Woolly Adelgid (BWA):** No visible signs of BWA in the crowns of trees in the Cape Breton Highlands. All other balsam fir sites showed at least moderate levels of BWA.
- **Release Response:** Diameter increment increased by 45% (0.29 cm/year before thinning to 0.42 cm/year four years after thinning).
- **Wind Damage:**
    - 10% of the basal area sustained wind damage (blowdown=6%+stem breakage=4%), plus 6% of the area was salvaged (possibly because of blowdown).
    - 55% of sites had basal area losses of 5% or less.
    - 20% of sites had severe wind damage (25+% basal area losses covering at least 25% of the site), if you include sites that were potentially salvaged because of blowdown this number is increased to 33%.
- **Blowdown on Trails:** 9% of the trees bordering extraction trails were blown down, compared to 4% in the interior of the leave strip.
- **S-Phase Soils:** Of the 18 sites with the worst wind damage (>10% BA), 7 were growing on S-phase soils.
- **Leave Strips and Trails:** Average width of leave strips=18 m; average width of trails=5 m
- **# Stems:** 44% of stems were removed from leave strips.
- **Basal Area Removal (BAR):** 40% (within leave strips), including trails it is 53%.
- **Gross Merchantable Volumes:** 221 m^3/ha (before CT); 111 m^3/ha removed in treated areas; 79m^3/ha removed including all areas.
- **Thin from Below:** On average most of the sites were thinned from below meaning the smaller trees were removed (DBH cut trees=16.0 cm; DBH trees left =17.7 cm).

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Appendix 1: Commercial thinning survey.

Stand ID	Area (ha)	County	Ownership[1]	Year CT'ed	Species[2]	LC[3]	Age @ CT	Sample Size (# Trees)[4]	Plots: % CC[5]	Plots: % Not treated	Plots: % Un treatable	Plots: % Only trails	Plots: % Treated	Partially Treated Plots: % Part. Treated	Partially Treated Plots: Leave Strip (m)	Partially Treated Plots: % leave strip not treated	Leave Strips and Trails: Leave Strip Width (m)	Leave Strips and Trails: Trail Width (m)	Leave Strips and Trails: % of Stand in Trails	Leave Strips and Trails: Ghost Trails	DBH & Height & Crown: DBH (Cut) (cm)	DBH & Height & Crown: DBH (Left) (cm)	DBH & Height & Crown: DBH (all) (cm)	DBH & Height & Crown: Height (m)	DBH & Height & Crown: Avg. h/d Ratio	DBH & Height & Crown: Avg. Live Crown Ratio	# Stems: Before CT	# Stems: After CT (leave strip)	Basal Area: Before CT (m^2/ha)	Basal Area: % BAR treated areas (leave strip)	Basal Area: %BAR all areas (leave strip)	Merchantable Volume: Treated Leave Strips: Before CT (m^3/ha)	Treated Leave Strips: After CT (m^3/ha)	Treated Leave Strips: Cut (leave strips) (m^3/ha)	Treated Areas: Cut (leave strips) (m^3/ha)	Treated Areas: Cut (trails) (m^3/ha)	Treated Areas: Cut (total) (m^3/ha)	All Areas: Cut (leave strips) (m^3/ha)	All Areas: Cut (trails) (m^3/ha)	All Areas: Cut (total) (m^3/ha)	All Areas: Cut (CC) (m^3/ha)	Wind Damage: Blow-down (% BA)	Wind Damage: Broken tops (% BA)	Damages: % BWA[6]	Damages: % Harv. Dam.
0901	2.1	GU	CL	2004	bF	5	34	71		20%		40%	40%				20	4.3	18%	Y	10.5	9.8	10.0	8.1	0.81	66%	2,140	1,420	17	41%	15%	38	23	15	12	7	19	5	5	10		0%	0%	20%	1%
0902	2.2	CB	CL	2004	TL/xS				100%																																				
0903	2.3	GU	CL	2004	bF	5	36	89					40%	60%	35	72%	28	5.0	15%	Y	10.5	12.7	11.5	8.6	0.74	67%	2,561	1,200	27	48%	25%	81	52	29	25	12	37	14	11	25		10%	9%	37%	9%
0904	2.4	PI	CL	2004	rP	9	24	21			40%	20%	40%				15	4.4	23%	N	16.8	16.8	16.8	12.6	0.75	33%	1,425	787	32	50%	30%	170	93	76	59	40	98	23	24	47		0%	11%	*NA	0%
0905	2.7	IN	CL	2004	bF(H)	8	20	160					100%				18	5.1	22%	Y	16.2	15.4	15.6	10.8	0.69	78%	1,607	1,133	31	35%	32%	138	93	45	35	30	66	35	30	66		0%	1%	0%	3%
0906	2.8	GU	CL	2004	bF	4	45	110			20%		60%	20%	35	40%	29	5.5	16%	Y	11.8	14.5	13.3	10.5	0.79	61%	2,495	1,332	35	40%	33%	141	97	44	37	23	60	27	17	44		27%	5%	45%	35%
0907	2.8	PI	CL	2004	bF	8	29	57		20%			80%				12	4.9	28%	N	16.9	14.2	15.2	10.1	0.67	52%	1,821	1,193	33	47%	34%	140	76	64	46	40	85	36	32	68		3%	4%	95%	0%
0908	3.6	GU	CL	2004	xS				80%	20%																				80%														
0909	3.9	PI	CL	2004	rP					100%																																			
0910	4.0	GU	CL	2004	BF				80%	20%																																			
0911	4.4	CB	CL	2004	bF	6	40	181			20%		80%				22	5.2	19%	Y	15.9	18.5	17.8	12.5	0.70	51%	1,368	952	34	27%	24%	174	134	39	32	33	65	26	26	52		2%	3%	76%	0%
0912	4.5	PI	CL	2004	bF	8	30	23		20%		40%	40%				12	4.5	27%	N	13.3	10.7	11.8	9.1	0.77	56%	2,537	1,577	28	53%	19%	93	41	52	38	25	63	15	20	35		3%	0%	92%	4%
0913	5.2	GU	CL	2004	xS				60%	40%																				60%														
0914	5.8	CB	CL	2004	bF	6	31	237					83%	17%	26	34%	23	4.6	17%	Y	13.5	15.9	15.0	10.5	0.70	68%	1,864	1,133	33	35%	30%	140	99	41	34	23	58	32	23	55		0%	1%	41%	3%
0915	6.0	PI	CL	2004	rP	8	20	68					100%				12	4.1	25%	N	12.6	13.5	13.1	8.5	0.65	52%	2,059	972	28	54%	50%	91	48	43	32	23	55	32	23	55		2%	0%	*NA	3%
0916	6.3	GU	CL	2004	bF	6	34	98			17%	17%	67%				22	4.1	16%	Y	16.5	15.9	16.1	10.5	0.65	55%	1,303	840	27	41%	30%	116	72	44	37	18	56	25	15	40		0%	0%	89%	1%
0917	6.6	IN	CL	2004	bF(H)				100%																																				
0918	6.8	GU	CL	2004	bF	4	48	178		14%	14%	14%	57%				23	5.7	20%	Y	13.2	14.3	13.8	9.6	0.69	59%	2,418	1,226	36	49%	30%	141	80	61	48	28	77	28	20	48		9%	7%	64%	43%
0919	7.5	CB	CL	2004	bF				63%	38%																																			
0920	8.5	IN	CL	2004	bF(H)	7	27	157		11%			56%	33%	43	52%	28	5.1	16%	Y	14.7	14.4	14.5	8.7	0.60	80%	1,419	925	23	39%	25%	86	55	31	26	13	40	19	11	30		0%	2%	0%	5%
0921	9.4	PI	CL	2004	wS	9	20	168		22%	11%		67%				17	4.4	21%	Y	12.8	12.8	12.8	9.6	0.75	51%	2,592	1,352	33	52%	36%	119	62	57	45	25	70	30	17	47		2%	5%	*NA	21%
0922	10.1	CB	CL	2004	bF	7	35	190			30%	10%	60%				17	4.7	22%	Y	15.1	15.0	15.0	12.2	0.81	59%	2,470	1,490	44	43%	34%	211	126	85	66	46	112	40	32	72		2%	2%	37%	4%
0923	10.9	GU	CL	2004	rP	8	34	42		27%	18%	9%	45%				16	4.9	24%	N	18.7	22.6	20.8	13.6	0.65	35%	992	508	34	43%	22%	198	123	75	57	48	104	26	26	52		0%	0%	*NA	7%
0924	14.1	VI	CL	2004	bF(H)	4	38	368			14%		57%	29%	30	59%	22	5.2	19%	Y	12.9	13.2	13.1	8.4	0.64	64%	2,544	1,454	34	45%	34%	114	67	47	38	22	60	27	17	44		11%	3%	0%	5%
0925	16.5	PI	CL	2004	bF	7	30	21		63%		25%	13%				13	4.7	27%		14.2	17.0	15.8	10.2	0.65	59%	1,543	857	30	39%	4%	130	87	43	31	36	67	4	13	17		5%	20%	69%	10%
0926	16.8	IN	CL	2004	bF(H)	5	29	340		24%		6%	47%	24%	42	75%	26	5.3	17%	Y	13.5	12.8	13.0	8.2	0.63	71%	2,037	1,248	27	45%	22%	90	51	38	32	15	47	17	10	27		0%	1%	0%	2%
0927	28.0	IN	CL	2004	bF(H)	6	31	887			4%		96%				20	5.5	22%	Y	17.5	14.4	15.8	9.8	0.62	72%	2,034	1,144	40	54%	54%	166	71	95	74	36	110	71	35	106		3%	1%	0%	19%
0928	25.4	PI	CL	2004	rP				100%																																				
0929	33.8	IN	CL	2004	bF(H)	7	33	824					100%				20	5.5	22%	Y	14.3	15.2	14.8	9.5	0.64	63%	1,815	971	31	44%	44%	123	71	52	41	26	67	41	26	67		2%	2%	0%	13%
0930	34.9	VI	CL	2004	bF(H)	5	39	850				4%	96%				19	5.6	23%	Y	14.3	15.1	14.8	9.2	0.62	64%	1,922	1,190	33	36%	34%	128	84	44	34	29	63	33	29	62		1%	1%	3%	3%
0931	36.4	PI	CL	2004	bF	8	29	200		8%	12%	32%	48%				14	5.0	26%	Y/N	15.3	15.0	15.1	11.0	0.73	60%	1,595	1,150	28	29%	16%	126	88	38	28	33	60	13	26	39		2%	1%	69%	6%
0932	40.9	PI	CL	2004	bF/rS	7	31	24	20%	16%	36%	20%	8%				14	5.3	28%		18.8	18.6	18.7	12.2	0.65	38%	1,404	864	38	42%	8%	206	126	79	57	58	115	5	16	62	41	64%	11%	25%	8%
0933	49.1	PI	CL	2004	nS	9	29	220		36%	8%	4%	52%				12	5.2	30%	Y/N	15.2	13.0	13.9	10.0	0.72	60%	2,271	1,428	34	45%	25%	144	76	68	47	43	90	25	24	49		15%	5%	*NA	5%

[1]Ownership: CL=Crown Leased

[2]Main Species: bF=Balsam Fir, bF(H)=Balsam Fir (highlands), nS=Norway Spruce, rP=Red Pine, rS=Red Spruce, TL=Eastern Larch, wS=White Spruce, xS=Red and Black Spruce (mixed stand)

[3]LC: Land Capability is a measure of site productivity and is explained in the Nova Scotia Forestry Field Handbook (NSDNR 1993).

[4]Sample Size: Some stands have a small sample size (does not include stumps). A plot was established (trees measured) if it was treated or partially treated. Those stands that had a lot of area clearcut, not treated, untreatable, and only trails will have a small sample size.

[5]%CC (reason for clearcut): Partial Harvest=0908, 0913; Salvage (reason unknown)= 0902, 0910, 0917, 0919, 0932; Salvage (sirococcus)=0928

[6]% BWA: Balsam Woolly Adelgid

*NA= Not applicable

Appendix 1(continued): Commercial thinning survey.

Stand ID	Area (ha)	County	Ownership[1]	Year CT'ed	Species[2]	LC[3]	Age @ CT	Sample Size (# Trees)[4]	Plots: % CC[5]	% Not treated	% Untreatable	% Only trails	% Treated	Partially Treated Plots: % Part. Treated	Leave Strip (m)	% leave strip not treated	Leave Strips and Trails: Leave Strip Width (m)	Trail Width (m)	% of Stand in Trails	Ghost Trails	DBH & Height & Crown: DBH (Cut) (cm)	DBH (Left) (cm)	DBH (all) (cm)	Height (m)	Avg. h/d Ratio	Avg. Live Crown Ratio	# Stems: Before CT	After CT (leave strip)	Basal Area: Before CT (m^2/ha)	% BAR treated areas (leave strip)	%BAR all areas (leave strip)	Merchantable Volume: Treated Leave Strips: Before CT (m^3/ha)	After CT (leave strip) (m^3/ha)	Cut (leave strips) (m^3/ha)	Treated Areas: Cut (leave strip) (m^3/ha)	Cut (trail) (m^3/ha)	Cut (total) (m^3/ha)	All Areas: Cut (leave strips) (m^3/ha)	Cut (trails) (m^3/ha)	Cut (total) (m^3/ha)	Cut (CC) (m^3/ha)	Wind Damage: Blow-down (% BA)	Broken tops (% BA)	% Harv. Dam.
1001	2.2	LU	SP	2005	rS	9	51	152			20%		80%				23	4.3	16%		15.9	18.1	17.3	16.3	0.94	35%	2,132	1,362	50	31%	31%	328	235	93	78	52	130	63	42	104		0%	0%	1%
1002	2.3	LU	SP	2004	rS		76	6	40%	20%		20%	20%				8	3.7	33%		15.2	18.4	16.7	17.6	1.05	39%	2,600	1,200	57	44%	49%	381	220	161	108	126	234	22	50	72	152	0%	4%	0%
1003	2.3	LU	SP	2005	rS	7	60	65	40%				60%				20	4.5	19%		15.2	18.1	17.2	14.6	0.85	43%	1,565	1,038	36	26%	26%	223	168	55	45	42	87	27	25	52	89	0%	2%	0%
1004	2.3	CU	SP	2005	bS	5	66	133					100%				16	4.8	23%		14.2	17.2	15.8	13.6	0.86	38%	2,468	1,244	48	40%	40%	281	179	101	78	64	142	78	64	142		4%	5%	8%
1005	2.6	LU	SP	2004	rS	6	66	118					100%				17	4.3	20%		15.9	18.5	17.3	15.7	0.91	35%	2,344	1,224	55	40%	40%	356	222	135	107	72	180	107	72	180		0%	1%	1%
1006	2.6	LU	SP	2005	rS	6	70	62					80%	20%	17	59%	14	3.8	21%		14.9	20.3	17.3	15.5	0.89	44%	2,244	940	53	42%	38%	340	207	133	105	72	176	93	70	163		1%	5%	0%
1007	2.7	QU	SP	2004	rS	5	69	53		20%			80%					*NDT			15.4	18.0	16.6	14.4	0.87	46%	1,600	662	35	51%	41%	197	100	97	97	0	97	78	0	78		7%	9%	2%
1008	2.8	YA	SP	2005	rS				100%																																		
1009	2.9	CU	SP	2004	rS	6	46	73		40%			40%	20%	27	65%	23	4.5	16%		13.9	15.0	14.6	12.7	0.87	54%	1,846	1,123	31	35%	17%	162	106	57	47	27	74	22	15	38		3%	0%	3%
1010	3.1	QU	IM	2004	rS	7	53	28			20%		80%				10	5.2	35%		17.1	19.1	17.9	14.9	0.83	51%	2,110	844	53	54%	54%	340	163	177	116	118	233	92	94	187		3%	0%	11%
1011	3.2	DI	SP	2004	rS	7	58	60	20%		20%		60%				23	5.7	20%		13.1	19.6	15.6	16.0	1.03	48%	2,522	832	48	47%	47%	298	177	120	97	58	155	58	35	93	60	0%	0%	3%
1012	4.9	QU	SP	2004	rS	6	77	36					100%					*NDT			16.9	30.0	21.5	16.2	0.75	52%	1,250	360	46	43%	44%	312	203	109	109	0	109	109	0	109		0%	9%	0%
1013	5.3	PI	SP	2005	rP				100%																																		
1014	5.3	DI	SP	2005	rS	5	73	44	40%				60%				16	3.6	19%		16.7	21.9	19.6	16.2	0.83	55%	1,434	733	43	35%	35%	290	194	96	78	54	132	47	33	79	116	0%	0%	2%
1015	5.8	DI	SP	2004	rS	5	120	74					100%					*NDT			29.6	32.0	30.8	20.1	0.65	51%	646	309	48	48%	48%	395	203	192	192	0	192	192	0	192		4%	0%	0%
1016	6.6	DI	SP	2005	rS	6	64	61			14%		86%				11	3.3	24%		14.3	19.6	17.7	14.9	0.84	52%	1,776	1,072	44	25%	26%	266	206	60	46	64	110	39	55	94		2%	2%	0%
1017	6.6	HX	CR	2005	rS	4	68	89		14%	14%	14%	43%	14%	50	80%	37	4.3	11%	Y	13.2	18.1	15.8	13.7	0.87	38%	2,446	1,196	48	36%	19%	278	195	84	75	29	104	34	20	54		22%	2%	15%
1018	6.9	QU	IM	2004	rS	7	51	63	14%	14%			71%				13	5.0	27%		20.1	21.7	21.0	15.2	0.72	49%	1,204	716	42	36%	30%	260	162	98	72	70	142	51	50	101	37	1%	0%	10%
1019	7.6	QU	SP	2005	wP	6	55	80			25%	13%	63%				15	6.4	30%	N	20.0	19.6	19.7	15.7	0.80	46%	1,061	745	32	31%	26%	208	146	62	44	62	106	27	47	74		0%	3%	3%
1020	7.7	QU	IM	2005	rS	6	47	83		13%	13%	13%	38%	25%	17	48%	16	4.8	23%	N	17.2	16.3	16.6	12.6	0.76	47%	1,761	1,238	38	31%	18%	209	141	68	52	48	100	27	36	62		2%	0%	2%
1021	8.2	DI	SP	2004	rS	6	55	74			25%		75%				15	5.2	26%		12.6	18.6	16.1	13.5	0.83	59%	1,985	1,072	41	28%	28%	226	176	50	37	59	96	28	45	72		0%	0%	0%
1022	8.5	PI	SP	2004	rS				100%																																		
1023	10.2	DI	IM	2005	rS	7	71	94			10%		90%				12	4.4	27%		12.3	20.3	16.9	14.8	0.88	52%	1,817	933	41	25%	26%	240	197	43	31	65	97	28	59	87		2%	7%	1%
1024	11.2	SH	SP	2005	wP	5	64	26	36%		18%		46%					*NDT			31.1	21.6	26.4	17.7	0.67	42%	980	520	54	65%	80%	393	118	275	275	0	275	126	0	126	141	9%	17%	0%
1025	11.7	YA	SP	2004	rS	8	50	96			25%		75%				13	5.7	31%		15.0	20.8	17.4	13.7	0.79	52%	2,031	753	48	46%	47%	284	164	120	83	88	171	62	66	128		2%	1%	2%
1026	11.9	QU	SP	2005	wP	7	52	169			17%		83%				13	4.0	24%		14.1	17.3	15.9	14.8	0.93	43%	2,123	1,158	42	35%	36%	242	164	79	60	58	118	50	48	98		0%	4%	0%
1027	11.9	CO	CR	2005	rS	4	114	89			8%	25%	50%	17%	17	42%	17	4.9	23%		14.3	20.4	18.4	16.1	0.87	31%	1,645	1,039	44	22%	15%	299	244	54	42	68	110	25	62	87		19%	8%	15%
1028	12.6	QU	IM	2004	rS	7	56	55					100%					*NDT			19.7	24.0	21.4	17.4	0.81	49%	1,115	423	40	51%	52%	283	146	137	137	0	137	137	0	137		0%	0%	7%
1029	13.4	HX	CR	2004	rS	5	70	157			23%		69%	8%	28	46%	26	4.5	15%	Y	15.1	19.3	17.2	13.8	0.80	45%	1,962	928	46	40%	39%	275	173	102	87	41	128	64	31	95		10%	2%	3%
1030	15.5	QU	IM	2004	rS	7	59	204				13%	63%	25%	20	50%	18	5.9	25%	N	18.9	20.2	19.8	15.1	0.76	55%	1,220	873	38	26%	19%	246	184	62	47	60	107	35	59	94		8%	5%	5%
1031	15.7	AP	IM	2005	rS	7	59	229			20%	7%	53%	20%	27	67%	18	5.7	24%	N	20.9	19.3	19.7	15.3	0.78	40%	1,643	1,230	50	27%	21%	330	234	96	73	79	152	44	59	103		6%	9%	10%
1032	18.4	HN	IM	2005	rS	8	58	132	33%		17%	6%	33%	11%	19	42%	15	5.3	26%	N	16.5	20.1	18.7	15.8	0.84	44%	1,746	1,043	48	30%	26%	319	227	93	68	83	152	27	40	67	105	24%	7%	7%
1033	19.8	AP	IM	2005	rS	4	51	51		5%	10%	24%	5%	57%	20	59%	21	5.6	21%	N	19.4	17.4	18.3	15.0	0.82	39%	2,132	1,169	56	49%	16%	359	174	185	146	75	221	41	67	108		2%	5%	4%
1034	21.4	AP	IM	2005	rS	5	68	101		5%	19%	38%	24%	14%	16	62%	13	5.8	31%	N	18.5	18.4	18.4	13.1	0.71	52%	1,474	1,087	39	26%	10%	226	166	60	42	71	112	12	52	65		2%	2%	4%
1035	23.4	HX	CR	2005	rS	5	90	262		4%	4%		78%	13%	15	60%	14	4.5	24%	N	15.8	20.1	18.2	15.1	0.83	45%	1,694	917	44	34%	30%	284	195	89	67	68	136	56	62	118		18%	7%	5%
1036	38.7	HX	CR	2005	rS	5	66	526			4%		76%	20%	24	63%	20	4.5	19%	Y	13.1	15.9	14.6	13.4	0.92	35%	3,178	1,720	53	36%	32%	294	198	96	78	55	133	65	51	116		11%	2%	16%
1037	43.6	AP	IM	2004	rS	5	69	131		17%	8%	13%	42%	21%	21	55%	15	5.6	27%	N	19.6	19.0	19.2	13.2	0.69	52%	1,323	875	38	35%	20%	223	144	79	58	60	118	30	43	72		5%	2%	11%
1038	45.8	QU	IM	2005	rS	5	64	179			12%	24%	20%	44%	17	45%	19	5.5	22%	N	16.7	17.0	16.9	14.8	0.87	34%	2,194	1,487	49	31%	16%	304	208	96	74	68	142	32	62	94		5%	5%	5%
71	844.3														26	56%	18	5	22%		16.0	17.7	16.8	13.0	0.77	51%	1,858	1,040	39	40%	32%	221	139	82	66	45	111	45	34	79		6%	4%	6%

[1]Ownership: CL=Crown Leased, CR=Crown, IM=Industrial, SP=Small Private

*NDT: No discernable trails

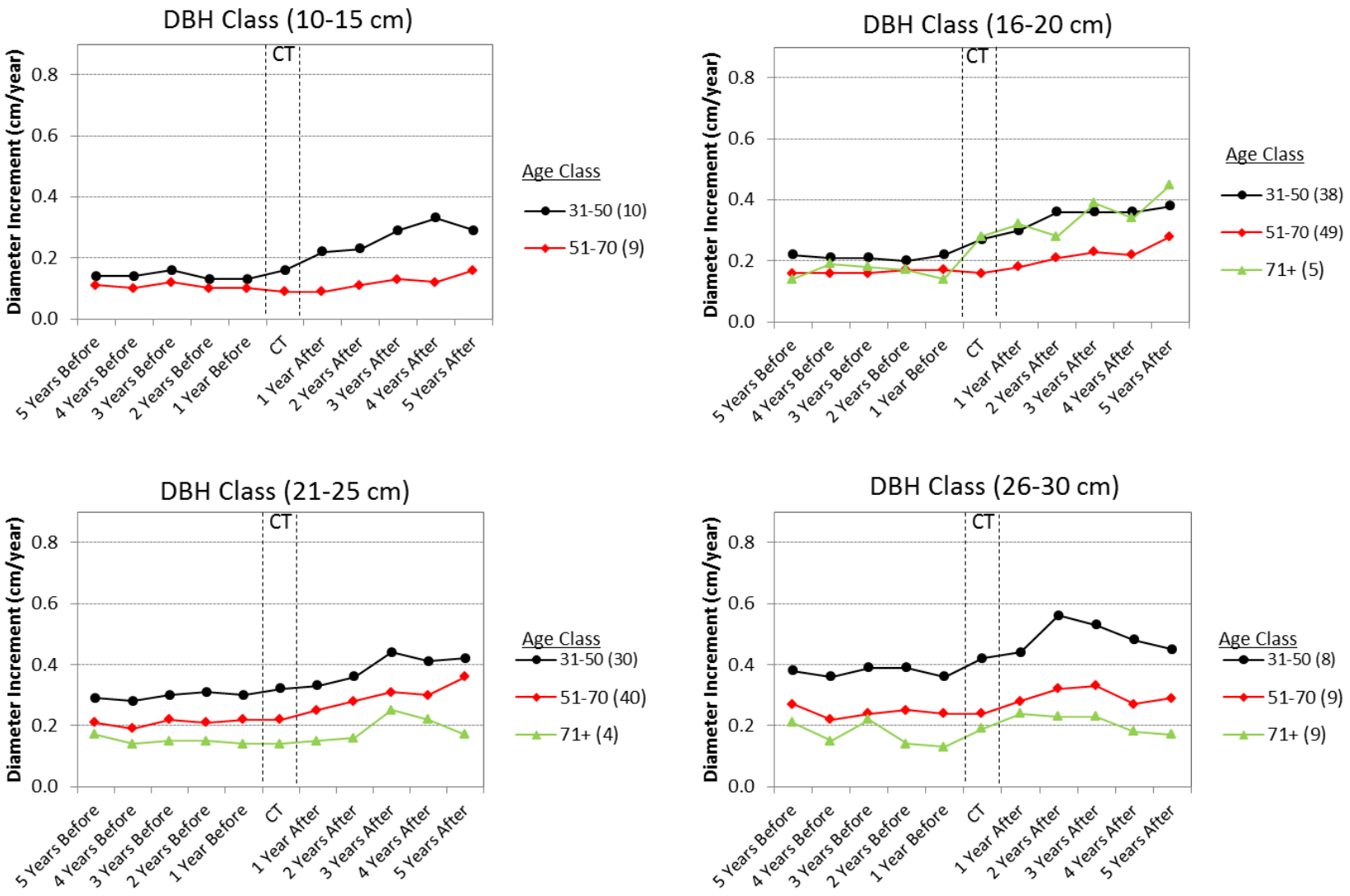
[2]Main Species: bS=Black Spruce, rP=Red Pine, rS=Red Spruce, wP=White Pine

[3]LC: Land Capability is a measure of site productivity and is explained in the Nova Scotia Forestry Field Handbook (NSDNR 1993).

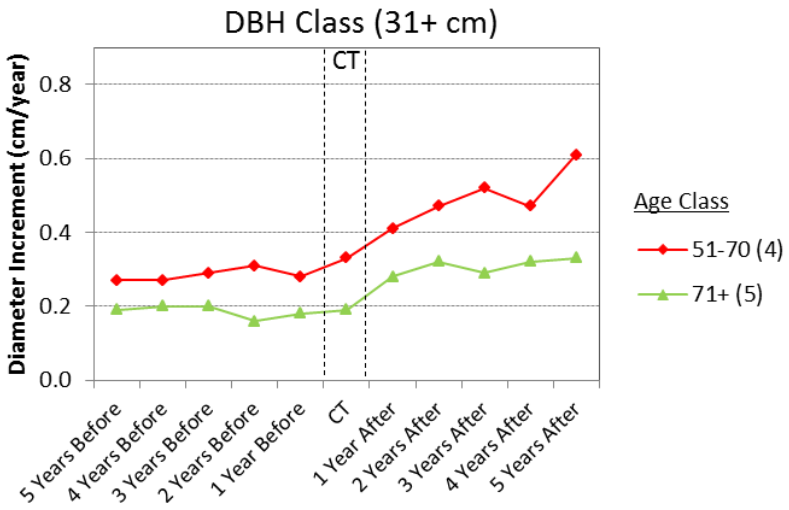
[4]Sample Size: Some stands have a small sample size (does not include stumps). A plot was established (trees measured) if it was treated or partially treated. Those stands that had a lot of area clearcut, not treated, untreatable, and only trails will have a small sample size.

[5]%CC (reason for clearcut): Partial Harvest=1002, 1007, 1024, 1028; Salvage (reason unknown)= 1003, 1008, 1011, 1014, 1022; Salvage (sirococcus)=1013; Salvage (blow-down)=1018, 1032

Red Spruce

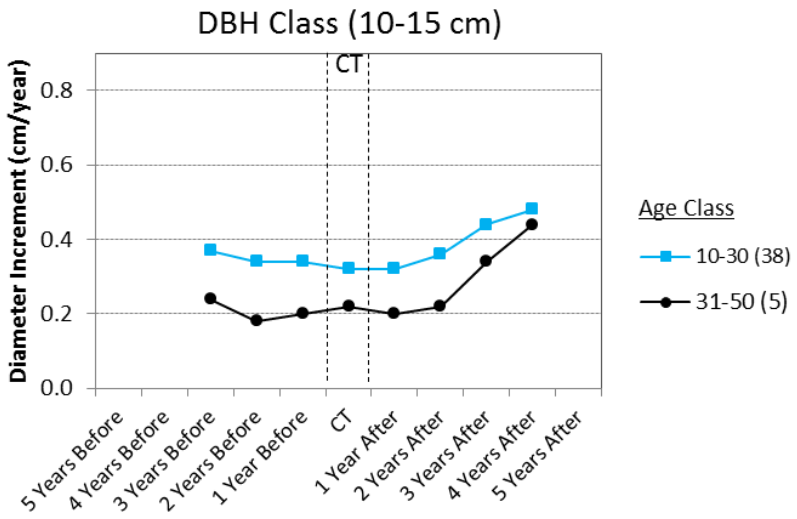


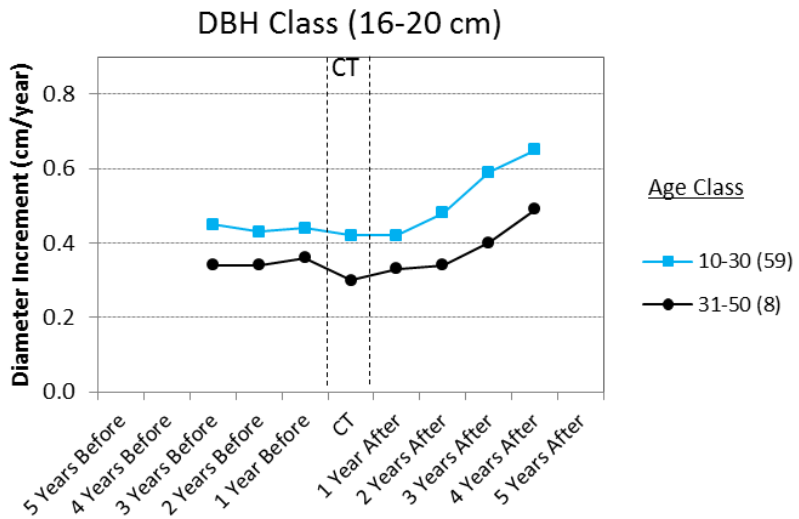
Appendix 2. The diameter increment of commercially thinned red spruce before and after thinning categorized by DBH class and age class. Sample sizes are shown in parentheses (n).

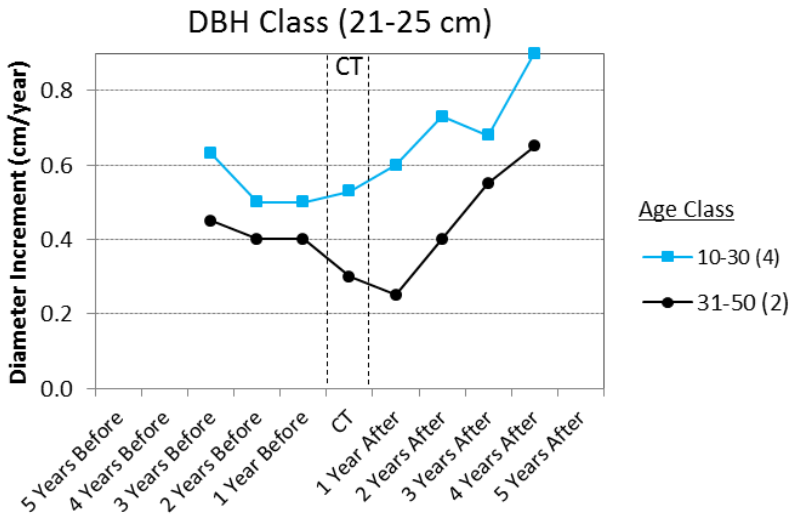


Appendix 2 continued. The diameter increment of commercially thinned red spruce before and after thinning categorized by DBH class and age class. Sample sizes are shown in parentheses (n).

Balsam Fir







Appendix 3. The diameter increment of commercially thinned balsam fir before and after thinning categorized by DBH class and age class. Sample sizes are shown in parentheses (n).

Appendix 4. Summary of wind damage by site and risk factors (sorted in order of most to least wind damage).

			Wind Damage				Pockets of severe wind damage (% of stand)			Soils[1]					Site Characteristics							
Stand ID	Spe-cies	Sample Size (# trees)	Blow-down (% BA)	Stem Breakage (%BA)	Wind Damage (%BA)	Area Sal-vage	25-49% of BA	50+% of BA	25+% of BA	Soil Types (listed in order of frequency)	S-Phase Soils	Limita-tions	G-Phase Soils	Root-ing Depth	Exp.[2]	Cut Edge	Slope Pos.[3]	Eleva-tion (m)	Pre-vious Treat.[4]	Avg. h/d Ratio[5]	% BAR
0932	bF/rS	24	64%	11%	75%	20%		50%	50%	ST3,2		Imperfect		26	M	Y	F	200	PCT	0.70	42%
0906	bF	110	27%	5%	32%		50%		50%	ST3, 2-S	S	Imperfect		32	M		L	131	PCT	0.79	40%
1032	rS	132	24%	7%	31%	33%	11%	22%	33%	ST2,2-G,15-G,3-G		Shallow	G	*40	ME/E	Y	M-H	127		0.84	30%
1027	rS	89	19%	8%	26%			25%	25%	ST2,3				40	M		M	41		0.87	22%
1024	wP	26	9%	17%	26%		20%	20%	40%	ST2,3,2-G			G	30	M/MS		M	44		0.67	65%
1035	rS	262	18%	7%	25%		33%	14%	47%	ST2, 2-S	S			35	ME/M	Y	M	182	PCT	0.83	34%
0925	bF	21	5%	20%	24%			50%	50%	ST9		Imperfect		26	M		M/U	194		0.65	39%
1017	rS	89	22%	2%	24%		20%	20%	40%	ST2-L, 2-S	S			23	ME		U	157	PCT	0.87	36%
0933	nS	220	15%	5%	21%		8%	15%	23%	ST2				50	M		L/F	183	Plant.	0.72	45%
0903	bF	89	10%	9%	19%		20%		20%	ST2-L, 3-L				32	M		F	159	PCT	0.74	48%
1007	rS	53	7%	9%	16%		50%		50%	ST2				42	MS		L	73		0.87	51%
0918	bF	178	9%	7%	15%					ST2-S	S			32	M		F	154	PCT	0.69	49%
1031	rS	229	6%	9%	15%		33%		33%	ST2-G,2,3-G,3			G		ME		U/M	196		0.78	27%
1036	rS	526	11%	2%	14%		12%	16%	28%	ST2-L,3-L, 2-S	S			35	M/ME	Y	L	151	PCT	0.92	36%
0924	bF	368	11%	3%	13%		8%	8%	16%	ST2-S	S			25	E		H/U	437	PCT	0.64	45%
1030	rS	204	8%	5%	13%			7%	7%	ST2-L,2L-S	S			26	M		F	106	PCT	0.76	26%
1029	rS	157	10%	2%	12%		17%		17%	ST2,3,4				22	ME/M	Y	M/U	180	PCT	0.80	40%
0904	rP	21	0%	11%	11%					ST2-L				30	M/MS		F	161	Plant.	0.75	50%
1038	rS	179	5%	5%	10%		19%		19%	ST2				30	MS		L	106		0.87	31%
1012	rS	36	0%	9%	9%		20%		20%	ST2				42	M		U	78		0.75	43%
1004	bS	133	4%	5%	9%					ST2				30	MS		M	103		0.86	40%
1023	rS	94	2%	7%	9%		10%	10%	20%	ST2				48	MS		L/M	109		0.88	25%
0907	bF	57	3%	4%	8%		25%		25%	ST2-L				38	MS		F/L	200		0.67	47%
1037	rS	131	5%	2%	7%		6%		6%	ST2, 2-G,3,3-G			G	20	M		U	237	PCT	0.69	35%
1033	rS	51	2%	5%	7%		8%	8%	16%	ST2-G,3-G			G	39	M/ME		U	229		0.82	49%
0921	wS	168	2%	5%	7%		17%		17%	ST8				38	M		F/L	199		0.75	52%
1006	rS	62	1%	5%	6%					ST2-L,3-G			G	30	ME		U	143	PCT	0.89	42%
0911	bF	181	2%	3%	5%					ST8				27	E	Y	F	32		0.70	27%
1015	rS	74	4%	0%	4%					ST2,3,15		Shallow		*40	M		F	62		0.65	48%
1034	rS	101	2%	2%	4%					ST2,3,2-G,3-G,4			G	43	M/ME		U	238	PCT	0.71	26%
1026	wP	169	0%	4%	4%			9%	9%	ST2				38	MS	Y	L	97		0.93	35%
0922	bF	190	2%	2%	4%					ST2				30	E		F	81		0.81	43%
1002	rS	6	0%	4%	4%					ST1				28	M/ME	Y	L	115	PCT	1.00	44%
0927	bF	887	3%	1%	4%					ST2,3				23	E		H/U	417	PCT	0.62	54%
1016	rS	61	2%	2%	4%					ST2				47	MS		L	120		0.84	25%
0929	bF	824	2%	2%	4%		4%		4%	ST2				23	E		H/U	445	PCT	0.64	44%
0931	bF	200	2%	1%	3%					ST2-L				44	MS		L	129	PCT	0.73	29%
0912	bF	23	3%	0%	3%					ST2-L				23	M		F	166		0.77	53%
1009	rS	73	3%	0%	3%					ST1				21	M		F	38	PCT	0.87	35%
1010	rS	28	3%	0%	3%					ST2				31	M	Y	U	107		0.83	54%
1019	wP	80	0%	3%	3%					ST2					MS		L	94		0.80	31%
0930	bF	850	1%	1%	3%					ST2-L				24	E		U	469	PCT	0.62	36%
1025	rS	96	2%	1%	2%					ST2-L,3-L				40	M		M	67	PCT	0.79	46%
0915	rP	68	2%	0%	2%					ST2				35	M		H/U	175	Plant.	0.65	54%
1020	rS	83	2%	0%	2%					ST2, 2-S	S			34	MS		F	96	PCT	0.76	31%
0920	bF	157	0%	2%	2%					ST2-L				38	E		H	394	PCT	0.60	39%
1003	rS	65	0%	2%	2%	40%				ST2					MS	Y	L	98		0.85	26%
1005	rS	118	0%	1%	1%					ST1,14-U				30	ME		M	50		0.91	40%
0926	bF	340	0%	1%	1%					ST2				41	E		M	444	PCT	0.63	45%
0905	bF	160	0%	1%	1%					ST2				35	S		L	328	PCT	0.69	35%
1018	rS	63	1%	0%	1%	14%				ST2-S,2	S			23	M	Y	M	94		0.72	36%
0914	bF	237	0%	1%	1%					ST2				32	MS	Y	L	104	PCT	0.70	35%
1028	rS	55	0%	0%	0%					ST2				28	M		U	94		0.81	51%
0901	bF	71	0%	0%	0%					ST2-L				25	MS		L	125		0.81	41%
0916	bF	98	0%	0%	0%					ST5				46	M		L	135		0.65	41%
0923	rP	42	0%	0%	0%					ST3		Imperfect		34	M		F	145	Plant.	0.65	43%
1001	rS	152	0%	0%	0%					ST1					MS		L	24		0.94	31%
1011	rS	60	0%	0%	0%	20%				ST2-L,3-L				41	M		M	114		1.03	47%
1014	rS	44	0%	0%	0%	40%				ST2				42	M/MS	Y	L	86		0.83	35%
1021	rS	74	0%	0%	0%					ST2,3,2-L				35	ME		U	149	PCT	0.83	28%
60			6%	4%	10%									*with shallow spots							

For footnotes see next page

Appendix 4 continued. Summary of wind damage by site and risk factors (sites that were salvaged after they were commercially thinned).

			Wind Damage				Pockets of severe wind damage (% of stand)			Soils[1]					Site Characteristics						
Stand ID	Spe-cies	Sample Size (# trees)	Blow-down (% BA)	Stem Breakage (%BA)	Wind Damage (%BA)	Area Sal-vage	25-49% of BA	50+% of BA	25+% of BA	Soil Types (listed in order of frequency)	S-Phase Soils	Limita-tions	G-Phase Soils	Root-ing Depth	Exp.[2]	Cut Edge	Slope Pos.[3]	Eleva-tion (m)	Previous Treat.[4]	Avg. h/d Ratio[5]	% BAR
0902	TL/xS					100%				ST2-L				25	E		F	68			
0910	bF					80%									ME		U	170			
0917	bF					100%				ST2-L				21	E	Y	U	246			
0919	bF					63%				ST2, 3				32	E	Y	L/F	36			
1008	rS					100%				ST2				30	M		U	30			
1022	rS					100%				ST5				16	M		M	200			

[1] for soils information refer to Keys *et al.* 2010

[2] Exposure: S=Sheltered, MS=Moderately Sheltered, M=Moderate, ME=Moderately Exposed, E=Exposed

[3]Slope Position: F=Flat, L=Lower, M=Middle, U=Upper, H=Hilltop

[4]Previous Treatment: PCT=Pre-Commercial Thinning, Plant=Plantation

[5]h/d Ratio= Height/diameter Ratio