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Impact of Tree-length Versus Short-wood Harvesting Systems on Natural Regeneration

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Introduction

Harvesting practices have traditionally involved skidding manually cut tree boles to roadside where processing into products is performed. More recently, harvesting trends have shifted to processing at the stump with mechanical harvester and forwarding short-wood to roadside. There are concerns that this newer harvesting system will leave larger concentrations of slash on site that may damage or suppress the growth of advanced regeneration. A study of four different sites where different clear-cut harvesting systems and/or equipment were used was undertaken to determine the effect these different harvesting methods will have on the growth and development of advanced natural regeneration.

Site Descriptions

Four sites located on Bowater Mersey Paper Company Ltd. holdings were selected for this study. These sites were located at Sixth Lake and Milton, Queens County; East Tremont, Kings County and Crousetown, Lunenburg County (Figure 1). Pre-harvest site characteristics are summarized in Table 1. All of these sites consisted of predominately mature red spruce growing on well-drained soils with moderate duff depths (8 - 13 cm). At all sites except Crousetown, the overstory was relatively well stocked with basal areas averaging approximately 40 m^2/ha. The pre-harvest slash levels at these sites were relatively low with less than 5% of the area covered with slash measuring less than 5 cm deep. At Crousetown, 2 trial areas were established. At this location there was evidence that partial harvesting had previously taken place. This resulted in lower basal areas (24 - 27 m^2/ha) and higher initial slash levels covering 9 - 14% of the area and 9 - 13 cm deep.

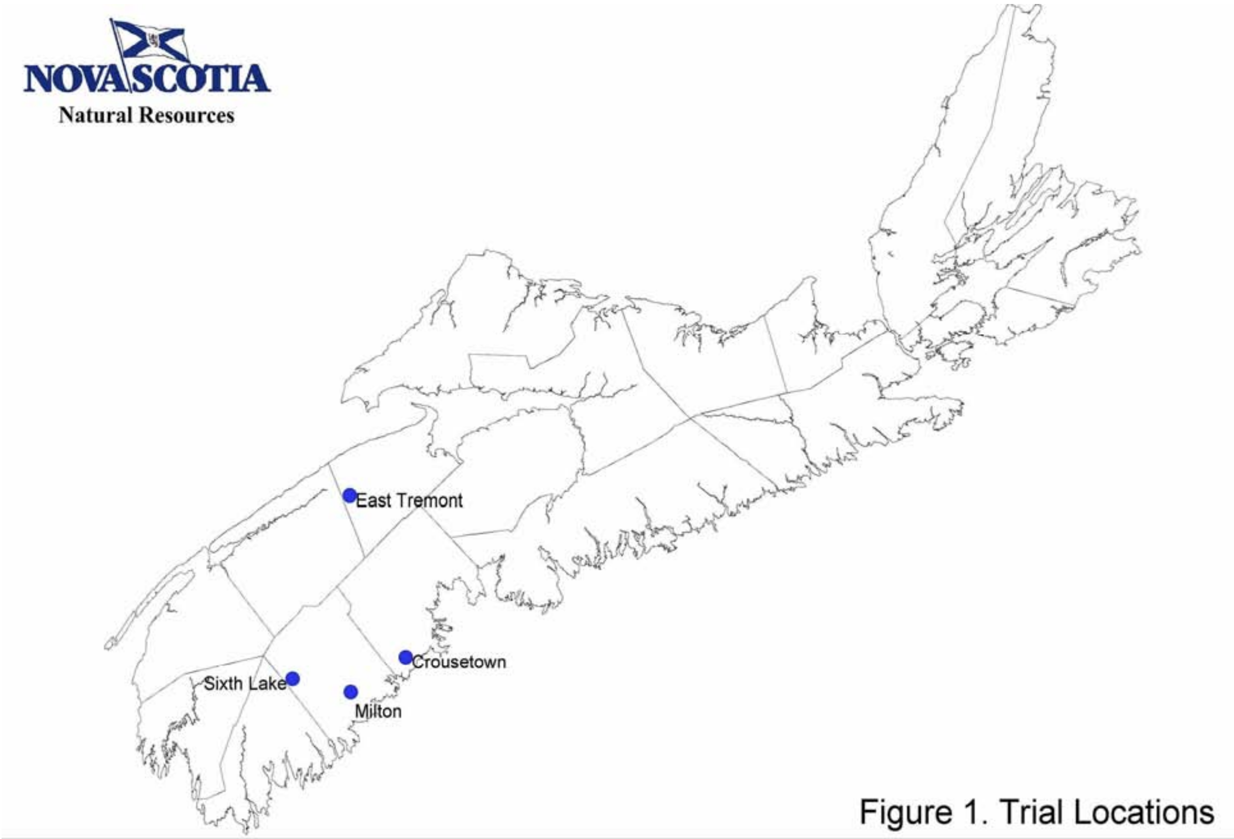


Figure 1. Trial Locations

The pre-harvest levels of softwood regeneration were high in all cases, with stocking ranging from 96 - 100%. This softwood regeneration was predominately red spruce, except at the Crousetown1 site where balsam fir numbers were higher. The initial softwood regeneration at Crousetown1 was taller than at the other sites, with its average height being nearly 30 cm as compared to the next tallest regeneration at East Tremont of 20 cm (Table 2). Softwood advanced regeneration density at Crousetown2 was much higher than at the other sites, with more than double the density per hectare (64,717/ha).

Table 1.		**Pre-harvest (1997) Post-harvest (1998, 1999) Stand Conditions by site***							
				Slash Cover (%)		Slash Depth (cm)			
Location	Year	# of Plots	BA m^2/ha	Mean	Coefficient of Variation**	Mean	Coefficient of Variation**	Average Duff Thickness (cm)	Average Stand Height (m)
Sixth Lake	1997	50	42	1		2		12	18.1
Sixth Lake	1999	46		48	71	26	58		
Milton	1997	50	44	1		1		13	18.3
Milton	1999	50		44	73	42	83		
East Tremont	1997	50	36	0		0		10	16.1
East Tremont	1999	33		40	83	28	64		
Crousetown1	1997	44	24	9		9		8	16.3
Crousetown1	1998	44		38	87	24	71		
Crousetown2	1997	20	27	14		13		9	16.4
Crousetown2	1998	20		36	92	27	70		
	1997	= pre treatment data							
		* All stands were predominately red spruce growing on well-drained soil ** Coefficient of variation is equal to the standard deviation divided by the mean							

Table 2. **Pre-harvest (1997) and Post-harvest (1998, 1999, 2000) Softwood Regeneration Characteristics by Site and Species**

Location	Assess-ment Year	Red Spruce			White Pine			Eastern Hemlock			Balsam Fir			Other			Totals		
		Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %
Sixth Lk.	1997	10	16533	86	7	3703	76	10	7925	84	61	195	8	0	0	0	10	28356	96
Sixth Lk.	1999	9	1553	37	10	212	4	19	282	15	0	0	0	0	0	0	11	2047	41
Sixth Lk.	2000	22	938	36	19	253	9	31	217	13	0	0	0	0	0	0	23	1408	42
Milton	1997	16	10881	84	7	780	26	6	6301	70	15	844	8	0	0	0	12	18806	96
Milton	1999	24	1527	48	16	162	8	11	325	14	20	97	2	0	0	0	21	2111	52
Milton	2000	27	2014	58	29	162	8	23	292	16	0	0	0	0	0	0	27	2468	62
E. Trem.	1997	8	21080	88	5	97	4	5	650	16	59	6594	86	0	0	0	20	28421	98
E. Trem.	1999	10	3132	64	0	0	0	4	58	4	59	1334	39	0	0	0	24	4524	79
E. Trem.	2000	17	3364	46	5	58	4	10	58	4	60	1334	39	0	0	0	28	4814	64
C'town1	1997	44	7161	77	10	74	5	22	1218	23	23	16757	89	44	185	2	29	25395	100
C'town1	1998	39	3027	57	0	0	0	6	627	16	15	5721	64	0	0	0	22	9375	75
C'town1	2000	41	3132	67	0	0	0	20	155	10	35	2591	52	15	77	2	37	5955	76
C'town2	1997	11	46041	100	6	2111	30	5	1705	25	15	14860	85	0	0	0	12	64717	100
C'town2	1998	11	20544	80	10	487	5	7	731	20	15	2923	55	0	0	0	11	24685	85
C'town2	2000	26	14373	85	35	487	5	22	731	10	34	3492	75	20	81	5	28	19164	90

1997 = Pre treatment data
E. Trem. = East Tremont
C'town1 = Crousetown 1
C'town2 = Crousetown 2

Initial hardwood regeneration levels varied more widely by site. High levels of red maple regeneration were found at Sixth Lake and Milton, with pre-harvest stocking greater than 88% and densities exceeding 30,000 stems/ha. No advanced hardwood regeneration was encountered at the Crousetown sites, while intermediate levels of red maple were found at East Tremont (Table 3). At all sites where red maple occurred, it averaged only 5 cm tall before harvesting took place.

Treatments

Sixth Lake, Milton and East Tremont were clear-cut harvested between July and August of 1998. Crousetown was clear-cut harvested in the summer of 1997. A conventional harvesting system was used at Sixth Lake, where the trees were felled, limbed and topped at the stump with a chainsaw and skidded tree-length to roadside using a cable skidder. A slasher then manufactured the wood into primary wood products at roadside. At Milton, East Tremont and Crousetown a cut- to- length harvesting system was used. The trees were manufactured into primary forest products at the stump using a mechanical harvester and then transported short-wood to roadside using a forwarder. The equipment used at Milton was a Timberjack 1270 tired single-grip harvester and a 4 wheel drive forwarder. At Crousetown, a Timberjack 608 tracked single-grip harvester was used with a 4 wheel driver forwarder. At East Tremont the same type of harvester was used as at Milton except an 8 wheel drive forwarder was used (Table 4).

Table 3. **Pre-harvest (1997) and Post-harvest (1998, 1999, 2000) Hardwood Regeneration Characteristics by Site and Species**

Location	Assess-ment Year	White Birch Seed			Red Maple Seed			Yellow Birch Seed			Trembling Aspen Seed			Totals		
		Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %
Sixth Lk.	1997	9	422	4	5	33195	86	0	0	0	0	0	0	5	33617	88
Sixth Lk.	1999	6	847	20	7	1659	52	0	0	0	0	0	0	7	2506	61
Sixth Lk.	2000	16	5847	82	23	1552	44	0	0	0	0	0	0	18	7399	89
Milton	1997	0	0	0	5	90199	98	6	357	8	0	0	0	5	90556	98
Milton	1999	10	812	24	13	14811	88	8	7406	64	0	0	0	11	23029	94
Milton	2000	37	2436	50	33	9842	86	30	8023	74	36	130	4	32	20431	96
E. Trem.	1997	0	0	0	5	6659	48	0	0	0	0	0	0	5	6659	48
E. Trem.	1999	16	4292	32	8	696	21	0	0	0	10	58	4	15	5046	46
E. Trem.	2000	70	5568	75	27	812	32	20	58	4	91	580	11	66	7018	75
C'town1	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town1	1998	5	480	11	9	3174	45	9	369	7	0	0	0	8	4023	52
C'town1	2000	24	541	24	25	928	24	26	1083	26	58	155	7	27	2707	55
C'town2	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town2	1998	10	81	5	9	731	30	0	0	0	0	0	0	9	812	35
C'town2	2000	21	406	15	24	1137	45	20	974	5	0	0	0	22	2517	50
	1997	= Pre treatment data														

Table 4.	Harvesting, processing and extraction methods by site			
Site	Harvesting System	Feller/Processor	Extraction	Harvest Time
Sixth Lake	tree-length[1]	chainsaw/roadside slasher	cable skidder	summer 1998
Milton	short-wood[2]	tired harvester	4 wheel drive forwarder	summer 1998
East Tremont	short-wood	tired harvester	4 wheel drive forwarder	summer 1998
Crousetown1	short-wood	tracked harvester	4 wheel drive forwarder	summer 1997
Crousetown2	short-wood	tracked harvester	8 wheel drive forwarder	summer 1997

[1] Fell, delimb and top with chainsaw at stump and extract tree-length bole by cable skidder to roadside and processed with a slasher
[2] Fell, delimb and top at stump with mechanical harvester, extract boles in short-wood lengths with a forwarder to roadside.

Methods

Fifty circular regeneration plots with a radius of 1.4m were established at all sites, except Crousetown where 44 plots were put in at block 1 and 20 plots at block 2. The plots were evenly spaced on cruise lines that were established evenly over the site. Each site was measured prior to harvesting, then regeneration plots were re-established at the same location and post assessment data collected.

Results

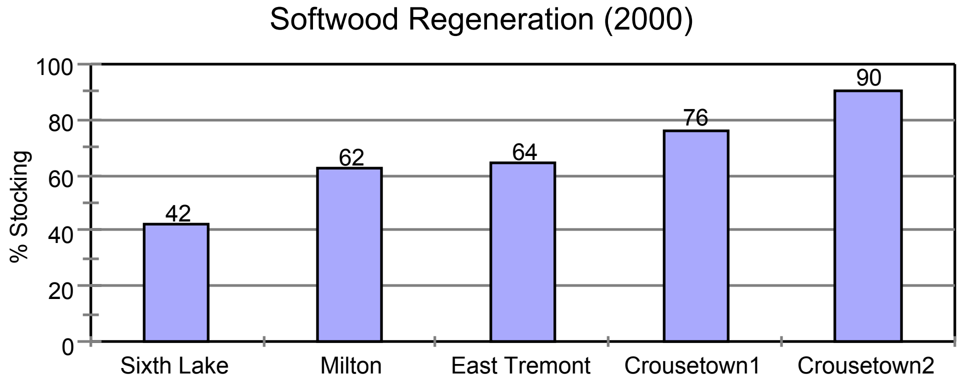
Slash Loads

After harvesting, slash loads increased at all sites with slash covering approximately 40% of the ground and averaging approximately 25 cm deep (Table 1). The only exception was at Milton where the slash was almost twice as deep (42 cm). This site contained the tallest trees and highest stocking before harvesting. As an indicator of how variable the distribution of slash was after harvest, the coefficient of variation of the estimated slash cover and depth were calculated. The slash depth and cover were slightly more variable in the short-wood harvested areas (Milton, East Tremont and Crousetown) as compared to the tree-length harvested area (Sixth Lake), although the conditions were variable throughout, with average deviation from the mean exceeding 50% in all cases (Table 1).

Softwood Regeneration

Softwood regeneration stocking after harvesting was reduced at all sites (Table 2). The largest reductions occurred at Sixth Lake, where tree-length harvesting was used. Softwood stocking was reduced to 42% and the number of softwood stems (1,408/ha) was only 5% of the pre-harvest level at this location by the fall-2000 assessment. Where mechanical harvesters were used to fell and process trees and wood was extracted using forwarders, the reduction in softwood regeneration was not as severe. At Milton and East Tremont, stocking levels were approximately 60% and regeneration densities were 15% of pre-harvest levels. At Crousetown, regeneration was even less impacted by harvesting with stocking ranging between 76 and 90% and densities more than 23% of pre-harvest values (Figure 2). At Crousetown, the high softwood regeneration levels could be attributed, at least partially, to the pre-harvest stand conditions. Regeneration height at Crousetown1 was initially taller than at the other sites with heights averaging 29 cm, at least 50% greater than the height at the other sites. At Crousetown2, the initial density of softwood regeneration was 64,718 stems/ha, more than double the density at the other sites.

Figure 2 - Post Harvest Stock Levels



Hardwood Regeneration

Post-harvest red maple seedling levels at Sixth Lake, Milton and East Tremont were reduced in a similar fashion to the softwood regeneration (Table 3). Despite being at reduced levels, red maple maintained its presence at these sites with stocking of 44, 86 and 32% respectively at Sixth Lake, Milton and East Tremont. At Crousetown, moderate levels of red maple have seeded in subsequent to harvest and have reached stocking levels of 24 and 45% respectively at block 1 and 2 by the 2000 assessment. Red maple advanced regeneration was initially shorter than the softwood regeneration but after being released during the harvest, has caught up in height to the softwood regeneration. Red maple averaged 20 - 30 cm in height, similar to softwood heights by the 2000 assessment.

Although advanced birch regeneration was minimal at all sites before harvesting, high levels of white and yellow birch have seeded in at the Sixth Lake, Milton and East Tremont locations. At Milton and Sixth Lake, the birch has quickly overtopped the softwood regeneration. In fact, at East Tremont the white birch occupies 75% of the area and averages twice as tall as the softwood regeneration. Lower levels of birch were found at the Crousetown sites.

Pin cherry has germinated post-harvest at all sites, with highest levels occurring at East Tremont with stocking of nearly 90%, densities greater than 10,000 stems/ha and heights nearly three times the average for softwood (Table 5). Sprouting of harvested red maple and birch has also occurred, although they remain at relatively low levels (Table 6).

Table 5. Pre-harvest (1997) and Post-harvest (1998, 1999, 2000) Non-commercial Hardwood Regeneration Characteristics by Site and Species

Location	Assess-ment Year	Grey Birch Seed			Pin Cherry Seed			Striped Maple Seed			Mountain Maple Seed			Totals		
		Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %
Sixth Lk.	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sixth Lk.	1999	0	0	0	11	918	20	0	0	0	0	0	0	11	918	20
Sixth Lk.	2000	0	0	0	54	1516	42	0	0	0	0	0	0	54	1516	42
Milton	1997	0	0	0	0	0	0	0	0	0	9	1169	22	9	1169	22
Milton	1999	0	0	0	14	325	16	0	0	0	0	0	0	14	325	16
Milton	2000	60	32	2	61	260	14	40	32	2	0	0	0	59	324	18
E. Trem.	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Trem.	1999	0	0	0	36	4814	54	0	0	0	0	0	0	36	4814	54
E. Trem.	2000	150	58	4	71	13224	89	0	0	0	0	0	0	71	13282	89
C'town1	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town1	1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town1	2000	0	0	0	68	967	17	0	0	0	0	0	0	68	967	17
C'town2	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town2	1998	0	0	0	15	244	10	0	0	0	0	0	0	15	244	10
C'town2	2000	0	0	0	63	1543	30	0	0	0	0	0	0	63	1543	30
	1997	= Pre treatment data														

Table 6. **Pre-harvest (1997) and Post-harvest (1998, 1999, 2000) Hardwood Coppice Characteristics by Site and Species**

Location	Assess-ment Year	White Birch Coppice			Red Maple Coppice			Yellow Birch Coppice			Trembling Aspen			Totals		
		Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %	Hgt (cm)	Stems/ha	Stock %
Sixth Lk.	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sixth Lk.	1999	28	353	2	83	388	4	0	0	0	0	0	0	57	741	7
Sixth Lk.	2000	30	144	2	121	577	7	0	0	0	0	0	0	103	721	9
Milton	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milton	1999	0	0	0	160	617	2	0	0	0	0	0	0	160	617	2
Milton	2000	60	65	2	108	1689	10	30	65	2	0	0	0	104	1819	14
E. Trem.	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Trem.	1999	78	754	11	100	232	4	0	0	0	100	116	4	85	1102	18
E. Trem.	2000	103	812	7	0	0	0	0	0	0	0	0	0	103	812	7
C'town1	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town1	1998	0	0	0	97	2067	7	50	627	2	0	0	0	86	2694	9
C'town1	2000	40	309	5	304	2243	5	0	0	0	0	0	0	272	2552	10
C'town2	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town2	1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C'town2	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1997	= Pretreatment data														

Overall, hardwood regeneration levels were lowest at the Crousetown blocks with 50% stocking and heights equivalent to softwood regeneration in the 20 - 30 cm range. Competition due to hardwoods will be more severe at the other sites, especially at Milton and East Tremont. At Milton, this competition is mainly due to red maple, while at East Tremont birch and pin cherry are the main competitors.

Hardwood regeneration at the Sixth Lake location where skidding was utilized to extract wood was not more prevalent than at the other locations where forwarding was used.

Summary & Discussion

1. Levels of softwood regeneration were reduced at all sites after harvesting. The most severe reductions occurred at the site harvested using tree-length methods with manual felling and extraction to roadside with a skidder. Less severe reductions in regeneration occurred where mechanical harvesters were used to fell and process at the stump and extraction was performed using forwarders. Slash levels were not more severe at the sites where short-wood harvesting was utilized. The lower success of softwood regeneration in the tree-length harvested area could have been due to skidding harvested trees through the advanced regeneration.

2. Advanced red maple regeneration was initially much shorter in height than softwood regeneration. Subsequent to harvest it outgrew the softwood regeneration and was equal to or exceeded the height of the softwood regeneration 2 - 3 years following harvest.

3. At all sites, moderate amounts of birch and pin cherry have seeded-in after harvesting and will result in competition to the advanced regeneration. In some cases the height of these species is more than double the height of the softwood regeneration. The regeneration of these hardwoods was not different in the tree-length harvested area compared to the short-wood harvested areas.

4. Softwood regeneration levels were maintained at their highest levels and hardwood regeneration at their lowest levels post-harvest at Crousetown. This could have been a result of previous partial harvests providing a shelterwood effect to the advanced softwood regeneration.

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