MOOSE DAMAGE TO PRE-COMMERCIALLY THINNED BALSAM FIR STANDS IN NEWFOUNDLAND

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ABSTRACT: In Newfoundland, dense balsam fir (*Abies balsamea*) stands dominate many sites after logging. At 10-12 years of age, these stands are mechanically thinned to reduce stem density from about 30,000 stems/ha to 2000 stems/ha. Thinning enhances tree growth through reduction of competition for light and nutrients. An island-wide survey of 21 stands showed that moose had browsed 3-45 percent of firs taller than 1.8 m, and severely damaged (more than 50 percent current growth and leader removed) up to 22 percent of stems >3 m in thinned stands, while unthinned stands received little damage. Moose pellet density was highest in thinned stands and regression analysis suggested that moose pellet density was an important predictor of browsing damage. Regressions of browsing levels in all stands excluding pellets and using vegetation variables indicated that damage decreased with increased young balsam fir density, suggesting that thinning stands resulted in a superior feeding condition for moose. Analysis of data from thinned stands alone showed that browsing intensity was related to the percent of all trees under 3 m that were balsam fir. Thinned stands may produce more food of better quality than do trees growing in the more competitive unthinned condition. Recommendations for management to reduce damage including timing of operations, edge of stand features, and stem density are discussed.

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Moose populations in Newfoundland have achieved exceptionally high levels for a North American herd. Densities are from 1 to 3/km^2 in moose range in the island portion of the province (S. Oosenbrug, Nfld. Wildlife Div., pers. comm.). In Sweden, dense populations of moose has resulted in habitat damage through browsing of second growth forests (Lavsund 1981). An analogous problem of habitat damage in several areas of Newfoundland was previously reported by Pimlott (1963) and Bergerud and Manuel (1968). In the latter case, an attempt was made to reduce browsing on regenerating forest trees through a moose population reduction (Bergerud et al. 1968)

A major component of second (and third) growth forest in the province is balsam fir (*Abies balsamea*). Balsam fir is sometimes heavily browsed by moose (Bergerud and Manuel 1968) although Parker and Morton (1978) found that it was not a preferred food species. Homogeneous stands of balsam fir and mixed stands of fir/white spruce (*Picea glauca*)/black spruce (*P. mariana*) grow in extremely dense stands after logging of fir and fir/spruce sites. At 10 to 12 years after logging, these sites are mechanically thinned to reduce inter-plant competition for light and nutrients which permits more rapid growth of the remaining trees (Baskerville 1965, Piene 1981). Presently about 40,000 ha of forest have received silvicultural treatment on the island, and of this about 26,000 ha were thinned. Stands of unthinned balsam fir are often extremely dense averaging about 30,000 stems/ha and ranging as high as 80,000 stems/ha (M. Lavigne, Can. For. Serv., pers. comm.). Thinning these stands results in more or less evenly spaced trees approximately 2.2 m apart at a density of 2000 stems/ha. Some preliminary observations by foresters suggested that moose were browsing in pre-commercially thinned areas.

The objectives of this study were: 1) to determine the level of damage to thinned sites in several areas of the province, and 2) to determine factors attracting moose to such areas, with a view to providing guidelines to reduce damage.

STUDY AREA AND METHODS

The forests of Newfoundland are boreal and the principal tree species are balsam fir and black spruce (Damman 1983). Other less common species are white spruce, trembling aspen (*Populus tremuloides*), and white birch (*Betula papyrifera*). Climate has a strong maritime influence and is characterized by constant winds, annual precipitation of 100-125 cm with a snowfall of about 300 cm, and temperatures ranging from a February average minimum of -10 C to a July average maximum of 20 C (Banfield 1983).

During the summer of 1986, 21 thinned stands and 16 adjacent unthinned stands located in the western and central areas of the island were surveyed for browsing damage by moose. Sites were chosen based on the criterion that thinning had occurred during the fall of 1983 or the spring of 1984, so that two years of growth had occurred. All sites were accessible by vehicle or all-terrain cycle.

Stands were surveyed for stem density and damage by moose using a point centre method (Batcheler 1975). This method involves placing a number of points within a community, measuring the distance from the point to the nearest plant, from that plant measuring the distance to a second plant, and then measuring the distance from the second plant to a third plant. Each distance describes the radius of a circle providing a measure of density. Points were arbitrarily placed to ensure that all areas of each stand were represented. Pre-sampling of unthinned stands indicated that 50 points was sufficient in dense fir for a standard deviation of approximately 50% of the mean. We sampled for three trees at each of 100 points in thinned stands, and at 50 points in unthinned (control) stands.

Two height classes of trees were censused at each point: 0.5 to 2.9 m, and taller than 3.0 m. Species, height, and level of browsing damage was recorded for each tree in both height classes. Three browsing damage classes were recognized: no damage, light browsing - less than 50% of the annual growth removed, and severe browsing - more than 50 percent of the annual growth removed or trees where the stem had been broken. Moose winter pellet groups were counted on 20 randomly placed 10 m^2 circular plots as an indirect estimate of time spent by moose in each stand (Neff 1968).

T-tests were used to examine differences in vegetation variables and pellet density between thinned and unthinned stands (Sokal and Rohlf 1981). Stepwise multiple linear regression (Draper and Smith 1966), with correlated variables removed, was used to examine the percentage of stems browsed in all stands using the following variables: density of pellet groups per plot, density /m^2 of balsam fir, black spruce, white spruce, deciduous shrub species combined, average height (m) of the stand, average height of residual black spruce, density of balsam fir under 3 m, percent of the stems under 3 m that was balsam fir, and the average height under 3 m. The analysis was run a second time omitting moose pellet group density in order to assess effects of vegetation variables. The same pair of analyses was run among thinned stands alone to determine if there were some common factors which influenced the level of damage by moose without the influence of the over-riding difference in fir density between thinned and unthinned stands.

RESULTS

Level of damage to thinned stands of balsam fir varied in different areas of the province. The Noel Paul Brook drainage area in the central part of the province and the Cormack area in the west were most heavily browsed, while the least browsed stands were located in the Serpentine area, close to Corner Brook, also in the west. Severe damage to more than 20 percent of the fir stems taller than 0.5 m occurred on five of the 21 thinned

Table 1. Moose damage to thinned and unthinned balsam fir (*Abies balsamea*) stands in Newfoundland. Light damage refers to less than 50% of the annual growth removed and severe damage to more than 50% of the annual growth removed and/or the stem broken. (N = number of stands sampled.)

		Mean percent of balsam fir stems browsed by height class					
		3.0-6.0 m			0.5-2.9m		
Site	N	Light	Heavy	Range heavy	Light	Heavy	Range heavy
Unthinned:							
W. Noel Paul	5	2.6	0.2	0-0.8	2.8	0.5	0-1.9
E. Noel Paul	3	0.4	0	0	2.4	0.2	0-0.8
Cormack	1	0	0	0	1.2	0.6	
Deer Lake	3	1.3	0	0	2.9	0	
Serpentine	2	0	0	0	2.6	0	
Jeffrey's	1	0	0	0	0	0.7	
Thinned:							
W. Noel Paul	5	42.6	10.0	0.7-17.9	22.2	18.4	2.4-29.7
E. Noel Paul	2	30.5	2.6	0-3.8	23.3	9.9	7.2-11.9
Cormack	2	34.6	9.9	3.7-15.4	19.8	23.8	19.9-31.2
Deer Lake	6	10.3	3.3	0.5-11.6	7.0	8.9	0.7-22.1
Serpentine	3	7.4	2.3	1.1-4.2	6.7	4.2	2.6-5.4
Jeffrey's	3	14.9	4.4	1.1-9.7	10.9	6.3	1.5-13.6

sites surveyed. Percentage of stems browsed in unthinned stands was substantially less than in thinned stands. Severe damage to unthinned stands occurred to less than 2 percent of the trees in all cases, and generally occurred along edges. No damage was found to nine of 16 unthinned stands surveyed (Table 1). On average, 321 stems/ha were severely damaged in thinned stands (both height classes combined) compared to 79 stems/ha in unthinned sites.

Structure and composition of stands changed as a result of thinning. The obvious change was in density of conifers, but thinned stands also contained a higher percentage of deciduous shrub species, and a lower density of deciduous trees (mostly white birch) over 3 m ($P < 0.01$ in all cases). Density of moose pellet groups was higher in thinned compared to unthinned stands ($P < 0.001$) (Table 2).

Amounts of light and heavy damage in individual stands were correlated (r_s=0.64, P=0.002). Light damage was more common and less variable than heavy damage but because important predictor variables were sometimes different, results for both damage classes are given (Table 3).

Moose pellet group density was the most important variable influencing increased browsing damage as suggested by three of four regressions where pellets were included (Table 3, columns 1 and 3). However, the percent of stems heavily damaged increased with lower density of balsam fir trees under 3 m in thinned compared to unthinned stands, while moose pellet groups accounted for only 7% of the variance (Table 3, column 1).

When unthinned stands were deleted from calculations, moose pellet groups was the most important variable explaining damage within thinned stands (Table 3, column 3). This clearly indicates that damage is a function of moose density. However from a forest management perspective, the fact that in-

Table 2. Summary statistics for variables characterizing browsing rates by moose in thinned and unthinned stands and used in regression and principle components analyses analyses.

	Unthinned		Thinned	
Variable	Mean	Std. dev.	Mean	Std. dev.
Density Fb>3m[a]/m^2	0.224	0.153	0.042	0.013
Density Sb>3m /m^2	0.018	0.020	0.005	0.006
Density Sw>3m /m^2	0.010	0.021	0.003	0.003
Density decid. spp. >3m /m^2	0.014	0.029	0.001	0.002
Mean Ht >3m (m)	3.54	0.32	3.66	0.29
Ht Sb>3m (m)	3.82	0.47	3.91	0.32
Density Fb<3m /m^2	1.83	0.78	0.211	0.114
% Fb<3m	87.30	10.35	56.35	21.29
Density decid. spp. <3m /m^2	0.209	0.203	0.239	0.266
% decid. <3m	11.57	9.79	40.09	22.10
Mean ht <3m (m)	1.53	0.14	1.42	0.18
Pellet groups/10m^2	0.07	0.13	0.47	0.43

[a] <3m or >3m refers to height class; Fb=balsam fir (*Abies balsamea*), Sb=black spruce (*Picea mariana*), Sw=white spruce (*Picea glauca*); Decid.=all deciduous species (primarily *Betula papyrifera*).

creased time by moose in a stand results in higher damage suggests nothing about whether some habitat features might attract moose to certain stands more than to others. Regressions which included only vegetation variables (Table 3, columns 2 and 4) generally indicated that the density of small balsam fir (<3 m) and the percent of stems of all species that was small balsam fir were two important variables influencing the amount of browsing by moose.

The density of tall black spruce accounted 29 percent of the variance for thinned sites alone in the light damage regressions. Principle components analysis was used as a check of the importance of black spruce as a variable in the system (Green 1979). Of the twelve variables in the analysis (Table 2), black spruce density ranked sixth suggesting minor importance (most important variables were density of small balsam fir and density of tall balsam fir). A review of the data showed that on three of the most heavily browsed sites there was a high density of spruce and this probably accounted for the regression result.

Qualitative observations indicated three situations which enhanced browsing damage: pockets of thinned fir surrounded on three sides by uncut timber, thinned fir close to thetop of a ridge of uncut timber, and thinned stands which contained islands of uncut timber.

DISCUSSION

The parallels between Newfoundland and Swedish moose herds and resultant problems for the forest industry are remarkable. Thinned stands of balsam fir present similar early successional habitat to moose as do plantations of Scots pine (*Pinus sylvestris*) reported by Lavsund (1981). Damage levels found in this study were similar to those reported by Lavsund.

Results suggest that moose damage to balsam fir increases markedly as a direct

Table 3. Summary of stepwise multiple regression analyses for the dependent variable of moose browsing on balsam fir trees in thinned and unthinned stands in Newfoundland. (Significant variables reported.)

		Stand type comparisons			
Damage Class		Thin/unthin (pellet[a] included)	Thin/unthin (pellet excluded)	Thin only (pellet included)	Thin only (pellet excluded)
Light	r^2	0.81	0.52	0.81	0.62
	P	<0.001	<0.01	<0.001	<0.001
	Partial r^2	Pellet=0.70	Fbsh=0.40	Pellet=0.66	Sb3+=0.29
		Fbsh[b]=0.08	Sb3+=0.06	%Fbsh=0.07	%Fbsh=0.24
		%Fbsh=0.03	%Fbsh=0.06	Sb3+=0.06	Fbsh=0.09
Heavy	r^2	0.93	0.82	0.71	0.18
	P	<0.001	<0.001	<0.001	<0.05
	Partial r^2	Fbsh=0.86	Fbsh=0.82	Pellet=0.71	%Fbsh=0.18
		Pellet=0.07			

[a] Pellet=pellet group density /10 m^2 plot.

[b] Fbsh=density of balsam fir/m^2 (*Abies balsamea*) <3m; %Fbsh=% of all stems <3m that were balsam fir; Sb3+=density of black spruce/m^2 (*Picea mariana*) >3m.

result of commercial reduction of stand density, and increases with increased time spent by moose in the stand (or increased density of moose). No stand characteristics other than the percent of all shrubs that were balsam fir were important in influencing use by moose. Deciduous shrub density was unimportant as a predictor of moose browsing.

Balsam fir trees growing in unthinned stands are stressed as a result of competition and do not grow as well as those spaced more widely apart (Piene 1981). Foliage increments average 10 to 15 % higher in thinned compared to unthinned stands in Newfoundland (Lavigne 1985), and Piene (1981) reported height growth increased by an average of 33 % in stands with 6-10,000 stems/ha compared to stands with 40,000 stems/ha. There is a linearly increasing relationship between height and amount of browse produced by individual balsam fir trees in Newfoundland (Parker and Morton 1978), and Bergerud and Manuel (1968) reported that chlorotic fir was less browsed by moose than were greener trees. The latter authors found poorer looking trees contained lower protein and potassium than did healthier trees. These observations suggest that fir trees from thinned stands produce more food per tree, and food of better quality than is available in dense stands where competiton among trees for light and nutrients is greater.

Further investigations are proceeding with the null hypothesis that quality and quantity of food available to moose in thinned and unthinned stands is the same. We are currently testing twig size, twig weight, stand foliage production, and nutritional content of annual growth from balsam fir trees in thinned and unthinned stands. We are also examining the hypothesis that different spacings between trees may influence rates of browsing.

Initial management recommendations include: 1) straightening all edges of thinned stands in order to reduce total edge of a stand, 2) removal of all standing timber while harvesting stands that are expected to regenerate to balsam fir, 3) reducing the percentage of fir within a stand where possible by leaving deciduous species during mechanical thinning, and 4) reducing the density of fir under 3 m tall by delaying thinning operations in areas of known high moose density until the average stand height is near 3 m (ie., delaying thinning for three to five years beyond the current standard for stand age of about 10 years).

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