# RESPONSE OF VEGETATION TO TREE CRUSHING IN ALASKA

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ABSTRACT: The response after 4 growing seasons of important moose forage species and spruce to tree crushing on the Kenai National Moose Range, Alaska is described. At Willow Lake study area, browse densities were higher in 8 of 10 sample stands and subdominant browse species made up a larger proportion of the browse population than before crushing. At South Moose Research Center (SMRC) study area, an improvement in the browse population has been slower than at Willow Lake, but the 4-year densities are higher than the 2-year densities indicating that the area is beginning to respond favorably. The Mystery Creek study area seemed to be responding slowly, as did the SMRC area, and we are hesitant to make conclusions regarding that area. In all areas, except part of the Mystery Creek area, spruce density was decreased by at least 70%. Density in 8 stands of short spruce (average height less than 1 m) in the Mystery Creek area was reduced only 53%.

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The Kenai National Moose Range, located on the Kenai Peninsula, Alaska, was established in 1941 to perpetuate feeding and breeding habitat of moose (Alces alces gigas). Moose have probably been abundant since the early 1900's, increasing in numbers following major fires in 1926 and 1947 (Spencer and Hakala 1964), and apparently peaking at about 8000 animals in 1971. By 1975 the population declined to about half that number.





Recognizing the importance of seral successional stages to moose, the Kenai National Moose Range began an active habitat management program in 1954. Although prescribed burns, herbicides, and fertilizers were used for habitat management, the most widely used technique was mechanical devices. Early work in 1956 consisted of cutting pole-size stands using chain saws. During the 1960's, habitat management emphasized increasing forage production by knocking down larger stems with tractors with logging chains, rakes, angle blades, Crossville blades and Fleko rolling choppers. In all, over 2400 ha were treated mechanically from 1955-1968. At Slikok Lake, site of most of the large-scale activities, the KNMR files report that the area "has responded unbelievably well".

In 1969 the KNMR purchased 3, 40-ton LeTourneau tree crushers. Until 1972 these machines were used to rehabilitate for erosion control and aesthetics about 4050 ha of the Swanson River fire of 1969. From 1972 until about January 1975 the crushers were inactive due to lack of money for operation. In January, 1975 the crushers were again activated, but this time they were used to knock down vegetation for the purpose of improving forage for moose. These activities lasted until March, 1978.

Despite the long history of habitat management on the Kenai National Moose Range, the effects of habitat management on the response of vegetation, especially moose forage, have not been evaluated. Our studies evaluate the effect of LeTourneau tree crushers on moose forage.

## METHODS

### Study Areas

#### Willow Lake Rehabilitation Area

The Willow Lake area burned during the 1947 fire. This area was

typical of the northern boreal forest which is primarily open, slowly growing spruce interspersed with bogs and well-drained upland sites containing well-developed forests (Viereck 1973). On warm, well-drained sites, the forest consists of mixed stands of white spruce (Picea glauca), paper birch, and aspen (Populus tremuloides). On poorly drained sites, the dominant tree is black spruce (P. mariana). Topography is undulating and forests prior to crushing consisted of mature mixed stands of the former three species and of seral stages of those species and black spruce. Pockets of aspen and willow (Salix sp.) regrowth were mixed with regrowth spruce and birch.

Approximately 445 ha of the Willow Lake area were crushed in the form of a donut during the winter of 1974-75. Pretreatment information on plant composition and soil characteristics was collected during 1974 at 10 stands within the proposed crush area, 10 stands within the proposed burn area, and 10 stands off the treatment area. Only the vegetation of the 10 crushed stands is reported here.

South Moose Research Center (SMRC) Rehabilitation Area

The area south of the Moose Research Center was part of the 1947 fire, and topography was nearly level in this area and vegetation consisted primarily of black spruce regrowth with some mature timber stands. Hardwood shrubs occurred in high densities in localized stands.

Approximately 525 ha were crushed during winter 1975-76 in an irregular manner. Little mature timber was crushed, steep side-hills were avoided, and narrow (< 100 m) strips separated crushed strips. Pretreatment shrub density data were collected on seven sites during summer 1975.

Mystery Creek Road (MCR) Rehabilitation Area

The Mystery Creek Road area, also burned in the 1947 fire, is a





predominantly black spruce or black spruce-aspen regrowth. This area is drier than the previously discussed areas and topography is relatively level in the broad lowlands and undulating in the uplands. Aspen is the dominant browse species, occasionally occurring in pure stands, and willow and birch are scarce.

The crushing pattern was similar to SMRC except that some broad lowlands (30-70 ha) were crushed in their entirety. During winter 1976-77, approximately 930 ha were crushed; 810 ha were crushed in winter 1977-78.

Vegetative Measurements

Stands were selected for study from aerial photographs and ground checks primarily on the basis of their dissimilarity. We wanted to sample a wide variety of vegetative types to be able to evaluate the effect of crushing on as diverse a group of vegetative types as possible. Selected stands were of uniform topography and vegetation and exceeded 0.5 ha in size.

Density of shrubs and saplings over 40 cm tall was estimated by counting all stems of each species occurring in each of 25 randomly placed 1 x 5-m quadrats in each sample stand. We have shown that this is an optimum quadrat size for estimating browse density in this area (Oldemeyer and Regelin 1980). Within each 1 x 5-m quadrat, we nested a 2 x 5-dm quadrat in a constant corner and estimated aerial coverage of each species covering the vertical projection of the the quadrat and shorter than 40 cm after Daubenmire (1959), except that we estimated cover in 7 classes: 0%, >0 - 5%, > 5 - 20%, > 20 - 40%, > 40 - 60%, > 60 - 80%, > 80 - 100%.

Density and aerial cover were sampled the summer before crushing except at SMRC where only density was sampled. Postcrushing samples

were made 2 and 4 growing seasons after crushing. Precrushing density or aerial coverage of each species was compared to postcrushing by t-test.

At Willow Lake, we installed 21 transect lines crossing the crushed area at its widest points and in such a way that no uncrushed cover occurred within 400 m except at the beginning and ending points of the transect line. At 20 m intervals along those lines, we counted pellet groups in a 3 m radius circle.

## RESULTS

### Impact on Spruce

One objective of crushing was to reduce spruce density and hence its competition with important browse species. Spruce density at Willow Lake and SMRC was decreased by 77% and 85%, respectively, by crushing (Tables 1-2). Crushing was not as effective at MCR. Stands MCR 1-18 were part of the crushing program of the 1960's, precrushing spruce heights were only 0.9 m, and density was reduced by an average of 53%. The 1961 KNMR annual Report indicated poor crushing effects on spruce saplings under 1.2 m because they were too flexible to be uprooted or knocked down. We observed a similar response. Spruce densities in stands WL 6-12 at MCR responded similarily to those at Willow Lake and SMRC (Tables 1-3).

### Browse Response

Two additional objectives of crushing were to increase total density of browse and to increase browse diversity by increasing relative densities of subdominant browse species. The most dramatic positive response occurred at Willow Lake where total browse density and diversity increased in 8 of 10 stands (Table 1) and was evident only 2 years after crushing.





Table 1. Woody plant density (stem/ha) at Willow Lake crushed treatment before and after crushing.

| | Paper Birch | | | Aspen | | |
|---|---|---|---|---|---|---|
| Stand | Pre-crush | 2 yrs. after | 4 yrs. after | Pre-crush | 2 yrs. after | 4 yrs. after |
| C-1 | 160 | 880 | 240 | 640[b] | 15,440[a] | 6,080[b] |
| C-2 | 3,840[b] | 3,280[ab] | 800[a] | - | 480 | 480 |
| C-3 | 560 | 16,400 | 12,800 | 7,120[b] | 26,320[a] | 12,640[b] |
| C-4 | 20,800 | 18,480 | 12,240 | 1,280 | 4,080 | 1,760 |
| C-5 | 14,880 | 22,640 | 14,000 | 240[b] | 36,560[a] | 9,630[b] |
| C-6 | 15,120 | 15,920 | 15,760 | 480 | - | 1,040 |
| C-7 | 800 | 2,800 | 5,280 | 2,400 | 400 | - |
| C-8 | 3,120[a] | 25,760[b] | 9,280[ab] | 1,520 | 6,560 | 11,920 |
| C-9 | 11,840 | 10,640 | 10,880 | 1,040[b] | 800[a] | 5,600[b] |
| C-10 | 10,400 | 14,960 | 23,200 | - | - | - |

Note: Densities within the same species and stand superscripted by different letters are significantly different.

Table 1 - continued. Woody plant density (stem/ha) at Willow Lake crushed treatment before and after crushing.

| | Willow | | | Spruce | | |
|---|---|---|---|---|---|---|
| Stand | Pre-crush | 2 yrs. after | 4 yrs. after | Pre-crush | 2 yrs. after | 4 yrs. after |
| C-1 | - | - | - | 160 | - | - |
| C-2 | 720 | 1,520 | 2,800 | 16,960[a] | 4,000[b] | 4,560[b] |
| C-3 | - | 320 | 1,280 | - | 160 | 160 |
| C-4 | 4,960 | 6,160 | 10,400 | 11,840[a] | 3,840[b] | 1,920[b] |
| C-5 | 80 | 80 | 2,240 | 320 | 80 | 640 |
| C-6 | 8,800 | 11,600 | 13,520 | 25,680[a] | 5,920[b] | 6,160[b] |
| C-7 | - | 2,160 | 80 | 480 | - | - |
| C-8 | - | 160 | - | 640[a] | 80[b] | 240 |
| C-9 | 5,360 | 6,800 | 6,720 | 10,000 | 3,040 | 2,400 |
| C-10 | 320 | 960 | 1,280 | 6,640[a] | 1,120[b] | 1,440[b] |

Note: Densities within the same species and stand superscripted by different letters are significantly different.





The 2-year responses at SMRC and MCR were unlike the response at Willow Lake. Total browse density was considerably less at SMRC and MCR than at Willow Lake even though precrushing densities were similar. At SMRC total density increased 2 years after crushing at only 1 of 7 stands. Diversity increased in 6 of 7 stands, probably as a result of the low postcrushing total density which allowed the subdominant shrubs to make up a greater proportion of the total density. At MCR total browse density increased in only 5 of 15 stands while diversity increased in 7 of 15 stands after crushing.

At SMRC total browse density, four years after crushing, had increased over precrushing density in 3 of 7 stands and over 2-years-after-crushing density in all 7 stands. At present we cannot explain why SMRC did not respond to crushing as rapidly as did Willow Lake.

### Response of Understory Vegetation

Changes in aerial coverage of lowbush cranberry (Vaccinium vitis-idaea), fireweed (Epilobium angustifolium), and rose (Rosa acicularis) were compared at Willow Lake and MCR because of their importance as summer and winter moose forage (LeResche and Davis 1973, Regelin 1979). Crushing affected aerial coverage of lowbush cranberry where it increased in 3 of 10 stands at Willow Lake and in 3 of 15 stands at MCR. Cover decreased in only 2 stands (Table 4) and was not different from pre-treatment levels in other stands. Fireweed coverage increased in 10 of the 25 stands at both locations and was not different from precrushing levels in the remaining stands. Coverage of rose was little affected by crushing.

### Moose Distribution at Willow Lake

The average maximum distance from undisturbed cover for the circular

Table 2. Woody plant density (stems/ha) at South Moose Research Center crushed area before and after crushing.

| | Paper Birch | | | Aspen | | |
|---|---|---|---|---|---|---|
| Stand | Pre-crush | 2 yrs. after | 4 yrs. after | Pre-crush | 2 yrs. after | 4 yrs. after |
| 501 | 5,200[a] | 880[b] | 3,920[ab] | 800[a] | 400[a] | 2,480[b] |
| 502 | 43,600[a] | 2,400[b] | 5,040[b] | 600 | 240 | 960 |
| 503 | 25,600 | 3,120 | 7,220 | 800 | 80 | 480 |
| 504 | 10,000[a] | 3,840[b] | 11,520[a] | 80 | 80 | 320 |
| 505 | 9,600[a] | 1,440[b] | 3,040[b] | 1,400[a] | 80[b] | 480[ab] |
| 506 | 600 | 240 | 2,000 | 4,600[a] | 11,840[b] | 20,560[b] |
| 507 | 28,200[a] | 7,040[c] | 17,280[b] | - | 1,760[a] | 80[b] |

Note: Densities within the same species and stand superscripted by different letters are significantly different.



Table 2 - continued. Woody plant density (stems/ha) at South Moose Research Center crushed area before and after crushing.

| | Willow | | | Spruce | | |
|---|---|---|---|---|---|---|
| Stand | Pre-crush | 2 yrs. after | 4 yrs. after | Pre-crush | 2 yrs. after | 4 yrs. after |
| 501 | 800 | 640 | 1,840 | 8,000[a] | 720[b] | 1,440[b] |
| 502 | 1,400 | 320 | 720 | 6,200[a] | 800[b] | 560[b] |
| 503 | 1,600[a] | 400[b] | 80[b] | 7,800[a] | 720[b] | - |
| 504 | 1,333 | 960 | 2,160 | 12,000[a] | 5,440[b] | 4,160[b] |
| 505 | 5,000[a] | 1,440[b] | 720 | 15,800[a] | 2,480[b] | 1,520[b] |
| 506 | 400 | - | - | 600 | 400 | 320 |
| 507 | 1,667 | 3,200 | 1,600 | 19,800[a] | 1,760[b] | 2,800[b] |

Note: Densities within the same species and stand superscripted by different letters are significantly different.

plots along the 21 pellet group transects at Willow Lake was 314 m. The average number of pellet groups/plot was 0.61 which we estimated was 217.9 groups/ha or 11.9 moose days/ha using the defecation rates reported by Oldemeyer and Franzmann (unpubl. ms.).

We correlated distance into the crushed area from the edge of cover with the number of pellet groups per plot to determine if cover influenced moose use in the Willow Lake area. Only 4% ($R^2$ = 0.04) of the variation in pellet group counts was due to distance from the edge of cover. Thus, moose used crushed areas randomly to distances of at least 300 m from cover. This contrasts to the smaller distance from cover that Hamilton and Drysdale (1975) found to affect moose distribution.

## DISCUSSION

The pattern of crushing changed during the four years. The Willow Lake area was crushed almost in its entirety. During succeeding years and in the other areas, mature timber stands and sidehills were crushed less frequently. Not crushing mature timber stands and steep sidehills is easily justified from the safety and economic standpoints because those areas are crushed at a slower speed to avoid toppling trees onto the tree crusher or turning the crusher over on a steep hill. In addition, there are good biological reasons for leaving mature stands and sidehills. Aspen suckering and birch seeding from mature stands provide reproduction in crushed areas. Mature stands and uncrushed sidehills also provide a mix of habitat types that provide cover for moose near a food supply.

The proper interspersion of food and cover provide optimum moose habitat. Three examples of interspersion can be given. Hakala (Pers. comm.) reported that 4 adjacent 4-6 ha plots which were mechanically disturbed



Table 3. Woody plant density (stems/ha) at the Mystery Creek Road crushed area before and after crushing.

| Stand | Paper Birch | | Aspen | | Willow | | Spruce | |
|---|---|---|---|---|---|---|---|---|
| | Pre-crush | 2 yrs. after | Pre-crush | 2 yrs. after | Pre-crush | 2 yrs. after | Pre-crush | 2 yrs. after |
| MCR 1 | 80 | 320 | 160 | 560 | - | 160 | 2,960[a] | 1,200[b] |
| MRC 2 | 80 | 320 | 400 | 80 | 800 | 160 | 3,600 | 1,440 |
| MRC 11 | - | 80 | 2,000 | 2,000 | 480[a] | 3,520[b] | 3,280 | 1,840 |
| MRC 12 | - | - | 1,360 | 3,680 | 880 | 1,840 | 11,200[a] | 3,360[b] |
| MRC 13 | 80 | - | 4,080 | 2,560 | 1,000 | 1,680 | 9,360[a] | 3,280[b] |
| MRC 14 | 560 | 240 | 6,800 | 5,840 | 560 | 720 | 9,040[a] | 4,720[b] |
| MRC 17 | 160 | 320 | 8,400 | 5,680 | 1,680 | 1,360 | 5,600 | 4,880 |
| MRC 18 | - | - | 9,600 | 6,640 | 2,960[a] | 80[b] | 4,720[a] | 2,640[b] |
| WL 6 | 1,200 | 800 | 7,040[a] | 4,160[b] | 2,000 | 4,640 | 16,800[a] | 4,560[b] |
| WL 7 | 160 | 80 | 2,880[a] | 11,200[b] | - | - | 480 | 80 |
| WL 8 | 2,480 | 2,560 | 5,280[a] | 21,280[b] | 880 | 1,040 | 7,440[a] | 2,000[b] |
| WL 9 | 5,800 | 880 | 7,920[a] | 2,800[b] | 2,080 | 2,880 | 4,320 | 5,840 |
| WL 10 | - | - | 480 | 480 | 320 | 240 | 20,400[a] | 7,840[b] |
| WL 11 | - | - | 3,520 | 1,840 | 160 | 400 | 6,400[a] | 2,640[b] |
| WL 12 | 3,360 | 1,280 | 240 | 560 | 320[a] | 1,680[b] | 5,280[a] | 1,120[b] |

Note: Densities within the same species and stand superscripted by different letters are significantly different.

Table 4. Changes in aerial cover of lowbush cranberry, fireweed and rose after crushing (+ indicates significant increase, - indicates significant decrease, and 0 indicates no change in aerial cover).

| Stand | | Lowbush cranberry | Fireweed | Rose |
|---|---|---|---|---|
| Willow Lake | C 1 | + | + | 0 |
| | C 2 | + | + | 0 |
| | C 3 | 0 | + | 0 |
| | C 4 | 0 | + | 0 |
| | C 5 | + | + | 0 |
| | C 6 | 0 | 0 | - |
| | C 7 | 0 | + | + |
| | C 8 | 0 | + | 0 |
| | C 9 | 0 | 0 | 0 |
| | C 10 | 0 | 0 | 0 |
| Mystery Creek Road | MCR 1 | 0 | 0 | |
| | MCR 2 | 0 | 0 | |
| | MCR 11 | 0 | 0 | |
| | MCR 12 | + | 0 | |
| | MCR 13 | 0 | 0 | |
| | MCR 14 | 0 | 0 | |
| | MCR 17 | + | 0 | |
| | MCR 18 | 0 | + | 0 |
| | WL 6 | + | 0 | |
| | WL 7 | 0 | + | |
| | WL 8 | 0 | 0 | 0 |
| | WL 9 | - | 0 | 0 |
| | WL 10 | 0 | + | |
| | WL 11 | 0 | 0 | |
| | WL 12 | - | 0 | |



revegetated rapidly into willow and aspen stands, but were soon overbrowsed because they were so small. The Kenai Moose Research Center (MRC) is located in a portion of the 1947 burn where mature timber stands comprise about 37% of the vegetative types and paper birch is the dominant browse species. Moose surveys during the early 1970's, over 20 years after the fire, averaged over 6 moose/km$^2$ in this area indicating its productivity as winter moose range. The mechanical disturbance that occurred over a 5-10 year period at Slikok Lake on the KNMR provided over 2400 ha of browse with little cover interspersion. This area still has a good mix of browse species, probably because moose made less initial use of the areas far from cover and because it was so large a disturbance.

In planning a successful crushing project, it appears to us that three factors must be taken into account: 1) The area crushed must not be so small that it is easily over-browsed by moose, 2) The width of crushing should be narrow enough to insure seeding for regeneration, and 3) The browse:spruce ratio for the entire area should be greater than 4:1 (somewhat less than the average ratio at Willow Lake and more than the ratio at the two other locations). While we do not have specific data to support the following recommendations, our experience leads us to recommend that crushed strips not be wider than 400 m and uncrushed strips not be less than 20 m. The ratio of crushed to uncrushed areas should be similar to the 60:40 ratio at the MRC and no block of crushing be less than 3 km$^2$.

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