WINTER UTILIZATION BY MOOSE OF GLYPHOSATE TREATED CUTOVERS - AN INTERIM REPORT

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ABSTRACT: Glyphosate is an important silvicultural tool used in the boreal forest. This study was undertaken to determine if the use of this herbicide for controlling competing shrubs in plantations is seriously reducing forage resources and subsequent overwinter utilization by moose (*Alces alces*). Observations were carried out on 4 treated and control paired cutovers near Thunder Bay, Ontario. The numbers of overwinter moose tracks were not significantly different ($P > 0.05$) at 7 and 19 months post-spray, but they indicated a preference for the non-treated control areas ($P < 0.05$) at 31 months post-spray. The number of moose track aggregates were similar in control and glyphosate-treated cutovers ($P > 0.05$), 7 months post-spray, but were more numerous ($P < 0.05$) on control portions, 19 and 31 months after treatment. Total track aggregate area and average track aggregate size were similar ($P > 0.05$) in all time periods, post-treatment. Available moose browse on control plots was four times greater, and utilized browse was 12 times greater, than that on treated areas at 21 months post-spray. Estimated winter moose presence, calculated from pellet counts, was three times greater on untreated than treated areas after 21 months ($P < 0.05$).

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The herbicide glyphosate was approved for forest management applications in Ontario in 1984. It is applied aerially to release natural and planted conifers from competing vegetation after logging. Glyphosate is a systemic herbicide that tends to kill plants completely; hence, there is minimal resprouting of deciduous woody plants, many of which comprise the most important food resources for moose, both summer and winter. Little research has been conducted on the effects of glyphosate on the habitats of boreal forest wildlife species. Consequently, moose managers are concerned that glyphosate application will reduce available browse, and thus, moose habitat quality.

Kennedy and Jordan (1985) studied the impact of 2,4-D and glyphosate on moose browse in the Superior National Forest of northern Minnesota. They found that glyphosate, when used for conifer release, not only can reduce browse resources in subsequent years, but may also encourage heavy stands of grasses, forbs, and raspberries (*Rubus* spp.). Three years after spraying, the glyphosate-treated plantations averaged only one-half of the available browse contained within similar 2,4-D-treated plantations, and only one-quarter of available browse contained within control plantations (Kennedy 1986).

In an effort to obtain a better understanding of glyphosate effects on moose habitat, this 3-year study was initiated in 1986 in northwestern Ontario. The study objectives were:

1. To monitor changes in available browse biomass on glyphosate-treated sites over 3 years and compare with untreated controls; and
2. To examine how vegetation changes affect moose winter utilization patterns.

STUDY AREA

The study area lies within the Abitibi-Price Inc. Spruce River Road Forest Management area, approximately 100 km north-east of Thunder Bay, Ontario (Fig. 1). It is within the Superior zone of the Boreal Forest Region (Rowe 1972), and the vegetation is classified as boreal mixedwood, generally dominated by conifers, principally black spruce (*Picea mariana*), white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), and balsam fir (*Abies balsamea*). The main deciduous tree species

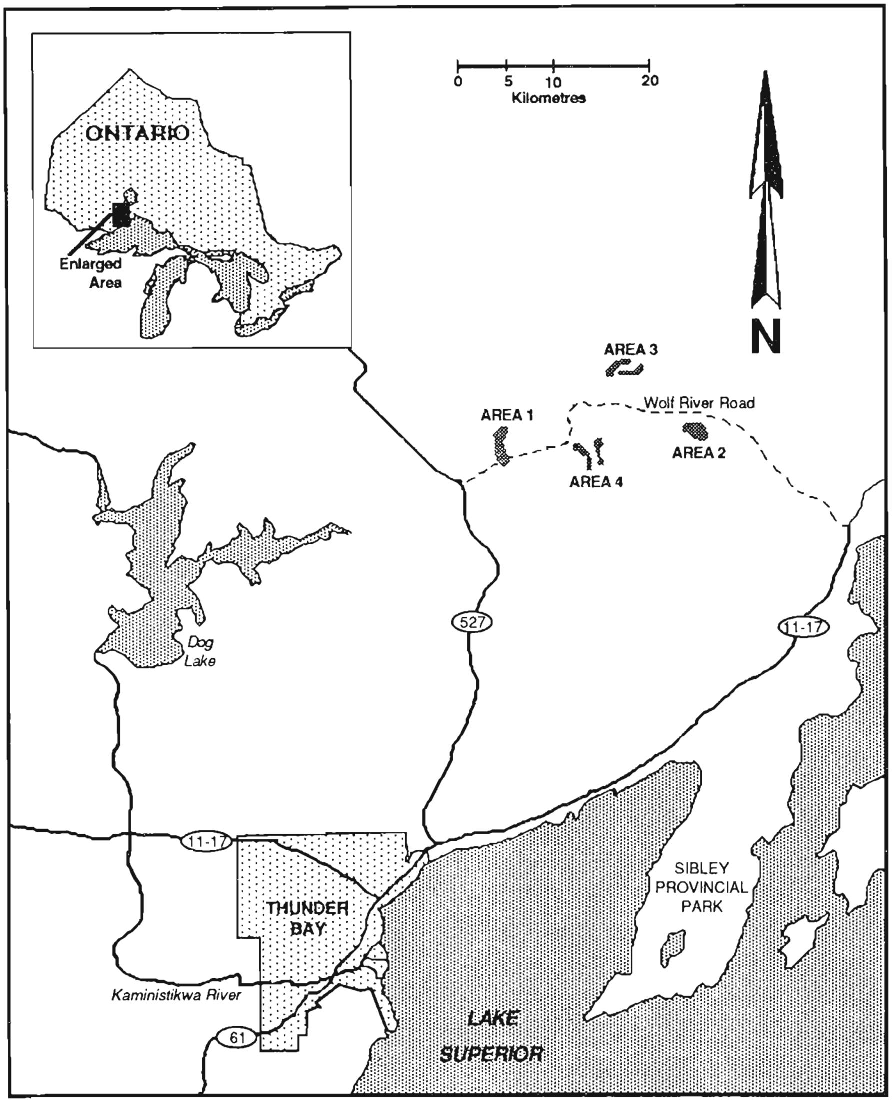

Figure 1. Location of four study areas near Thunder Bay, Ontario.

present are white birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*).

Four paired cutovers (areas 1 - 4) of different sizes, treated aerially with glyphosate (1.44-1.53 kg acid equivalent per ha), and with a known history of harvest and silvicultural treatment, were selected (Table 1). All cutovers were planted with black spruce. Area 1 was planted 4 years before spraying. Areas 2 and 3 were planted the year before treatment, while area 4 was planted 3 years pre-treatment. For areas 1 and 2, a single cutover was divided in half with one side treated, the other left as a control, and for areas 3 and 4, two similar adjacent cutovers were chosen as the experimental pair.

Areas 1, 3, and 4 consist of shallow morainal deposits underlain by early Precambrian bedrock, consisting of light-coloured metamorphic rock, mostly granitic schist and gneiss. The soils are coarse-loamy in texture, derived primarily from granitic parent materials. Area 2 is located over a late Precambrian sedimentary formation consisting of red

Table 1. Silvicultural background of four control (C) and glyphosate-treated (T) study areas in the Spruce River Forest of northcentral Ontario.

Area	Size(ha) C/T	Year Harvested	Dominant Species[1]	Site Preparation: Chemical	Site Preparation: Mechanical	Release Treatment[2] (kg/ha)	Release Treatment[2] (year)
1	106/94	1973 & 1979	Pj	none	1980	1.44	1985
2	110/170	1973 - 1982	Po	2,4-D[3]	1983	1.53	1985
3	40/43	1983	Po	none	1984	1.53	1986
4	56/76	1978	Bw	none	1982	1.53	1986

[1] - dominant tree component before harvest

[2] - August application of glyphosate (Tradename - Vision)

[3] - 2.89 kg/ha

Pj - Jack Pine Po - Trembling Aspen Bw - White Birch

shale. The soils derived from this material are of much finer texture than those in the other three areas, though they can be quite gravelly. Ground moraines are more dominant here and the tills tend to be deeper (Anon. 1984).

The general study area is considered to be good moose habitat, due in part, to a history of logging disturbance, and the resulting vegetative mosaic. Estimated study area densities of 0.41 moose/km^2 are above average for the surrounding locale, where estimated densities are 0.34 moose/km^2 based on a standard aerial inventory (OMNR 1981) conducted in 1987-88 .

METHODS

Winter utilization by moose of each cutover pair was assessed by an annual spring (May - June) browse and pellet group survey after snow melt, and weekly observational flights during the winter period, December to March.

For this paper, winter utilization by moose was based on observations recorded over a two-year post-spray period for all four areas.

Pellet Group Survey

A baseline was arbitrarily established along the longitudinal axis of each cutover. Transects were then laid out perpendicular to the baseline from a random start. Subsequent transects were systematically placed 150 m apart across the entire cutover to ensure uniform coverage. Moose pellet groups were counted on a 2 m wide continuous strip along each transect. Only pellet groups that were deposited since the previous fall were tallied. These were identified by their colour and position on top of the previous growing season's leaf litter and grass. Only groups with > half the pellets within the strip were counted. Overwinter moose densities, on treated and control areas, were estimated using an average daily deposition rate of 13.0 pellet groups per moose per day (Timmermann 1974) over a 198-day period for both winters.

Browse Survey

Permanent sample plots were established along each transect line in each of the four paired cutovers. Fifty-nine 2 m x 2 m permanent sample plots were established in 1986, and expanded in 1987 by enlarging the plot size to 4 m x 4 m. In addition, the number of plots assessed was increased to 425. Plots were spaced at 60 m intervals using a random start, and the centre point was permanently marked by a numbered stake. Each plot was searched for 10 common deciduous tree and shrub species (*Acer spicatum*, *Alnus viridis* ssp. *crispa*, *Amelanchier* spp., *Betula papyrifera*, *Cornus sericea*, *Corylus cornuta*, *Populus tremuloides*, *Prunus pensylvanica*, *Salix* spp., and *Sorbus* spp.) whose twigs are generally eaten by moose in winter (Timmermann and McNicol 1988). Vegetative sampling methods for enumerating twigs were modified after Passmore and Hepburn (1955). A twig was considered to be any shoot at least 2.5 cm in length, occurring either lateral to, or at the end of a branch. During counting, no consideration was given as to whether or not a twig contained current year's growth or more than current year's growth. Twig counts were tabulated in each of three height classes: 51-100 cm; 101-200 cm; and 201-350 cm. For each browsed twig occurring on the 59 plots assessed in 1986, the diameter at point of browsing (dpb) was measured. A mean dpb was then calculated for each species at each height class.

An available twig was then defined as that portion of the shoot distal to the mean dpb. Available browse biomass was the weight of woody material distal to the mean dpb, calculated as the number of twigs times the mean weight per twig for each species at each height class for treated and control areas. Similarly, utilized biomass was calculated as the number of bites times the mean weight per twig for each species at each height class for both treatments.

Estimates of mean twig weights were ascertained by clipping a sample of twigs for each species at each height class, at mean dpb for that species and height class for control and treated areas (14 months post-spray for areas 1 and 2, and 2 months post-spray for areas 3 and 4). Fourteen thousand twigs were clipped and collected in total. These samples were then oven-dried at 70°C for at least 24 hours, removed, and weighed (0.001 g).

Aerial Survey

Weekly reconnaissance flights were conducted over all study areas during the period mid-December to mid-March, 1986-87 and 1987-88. Weekly surveys were made from either a Cessna 180 or a DeHavilland Turbo Beaver aircraft. All flights were made between 1000 and 1500 hours, at an average altitude of 250 m, and at an average airspeed of 120 km/hr. Search patterns were similar to those of McNicol (1976) and Todesco *et al.* (1985). The location of tracks, track aggregates, and moose were recorded on clear acetate sheets that overlaid aerial photomosaics (scale 1:15,840). A "track" was our interpretation of a direct movement of one or more animals between two distinct points, while a "track aggregate" was composed of a looping, over-crossing set of tracks which we interpreted as an area of concentrated feeding activity (McNicol 1976, Todesco 1988) (Fig. 2). The same overlay was used on successive weeks until a major snowfall had obliterated old tracks to avoid duplicate recording. These data were entered into a geographic information system (GIS) for measurement of cutover areas, habitats within cutovers, and track aggregate areas.

Moose tracks observed in winter were considered to be evidence that a moose had visited either the treated or control portions of the cutover. The number of moose tracks was expected to be in proportion to the area of the treated and control plots. A track aggregate was considered to be a particular place in the cutover where a moose had searched for and/or consumed browse. The numbers of track aggregates were also expected to be in proportion to the area treated and remaining as control. Track aggregate area was assumed to be proportional to the amount of time spent feeding on either the treated or control area over the winter period. The total area covered by track aggregates was the area of individual track aggregates summed over the winter period and was assumed to be representative of the total time spent on either the control or treated area. Average track aggregate size was calculated as the total track aggregate area divided by the number of track aggregates. The average size of a track aggregate was assumed to be proportional to the time spent during each feeding session: the larger the average size, the more time spent searching and/or browsing.

Snow Conditions

Snow stations were monitored on areas 1 and 4 as described by Passmore (1953). Each consisted of 10 points, 30 metres apart, where weekly snow depth was measured and crust strength estimated. Average snow station depths were calculated for the period, mid-December to mid-March, 1986-87 and 1987-88.

Data Analysis

For the purpose of analysis, observations from the aerial surveys in the winter were arranged according to the time since spraying. Observations occurring at 7 months post-spray (0 growing seasons) were made during the winter of 1986/87 on areas 3 and 4 only. Data occurring at 31 months post-spray (2 growing seasons) came from the aerial survey conducted during the winter of 1987/88 over areas 1 and 2 only. To obtain data at 19 months post-spray (1 growing season), observations from the 1986/87 aerial survey over areas 1 and 2 were combined with the observations from areas 3 and 4 obtained during the winter of 1987/88.

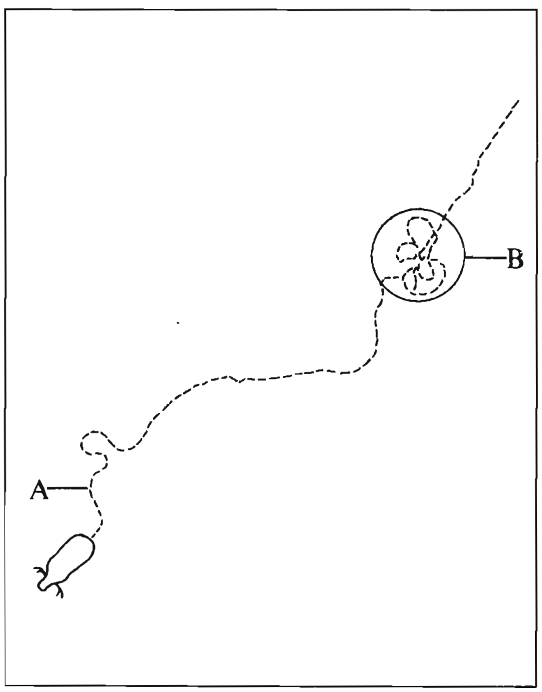

Figure 2. Examples of a moose track (A) and a moose track aggregate (B).

Observations of pellet groups per hectare, as well as available and utilized biomass were also denoted by the time period since treatment. Pre-spray data arose from the surveys that took place in areas 3 and 4 during the spring of 1986. Data for the 21 months post-spray period (1 growing season) were made on areas 1 and 2 during the spring of 1987. Data for the 9 month post-spray (0 growing seasons) analysis were obtained by grouping the data from the surveys in area 1 and 2, spring 1986, with the data from areas 3 and 4, spring 1987.

The number of tracks and number of aggregate areas were analyzed using a chi-square goodness-of-fit test and a Bonferroni z test to determine utilization (Neu *et al.* 1974, Byers *et al.* 1984). The total track aggregate area, average track aggregate size, browse available and utilized, and pellet groups per hectare were analyzed using an analysis of variance. All testing was carried out at $P < 0.05$.

RESULTS AND DISCUSSION

Snow depths in both winters were < 60 cm with minimal crusting. Such conditions, according to Coady (1974), do not hinder free movement of moose. We, therefore, concluded that snow conditions during our study were not a factor influencing an animal's ability to select feeding sites.

The data from the 15 flights indicated no significant differences between the treated and control areas for the number of moose tracks, moose track aggregates, mean total track aggregate (MTTA) area, or the mean track aggregate (MTA) size at 7 months post-spray for areas 3 and 4 (Table 2). The data for this analysis was gathered over the winter immediately following the late summer treatment in 1986. Connor (1986) found no difference in moose usage of glyphosate-treated cutovers for a similar 7 to 8 month post-spray period. Similarly, Sullivan (1985) observed that black-tailed deer (*Odocoileus hemionus columbianis*), in British Columbia, did not avoid glyphosate-treated cutovers in the year immediately following application. The similar use of the treated and control portions in our study at 7 months post-spray, therefore, would be expected.

After one full growing season post-treatment, 17 flights determined that the number of tracks on treated and control areas was similar, while the number of track aggregates indicated a preference for the control areas (Table 3). The MTTA area and the MTA size were also similar for this post-spray period.

At 31 months post-spray, the number of tracks, and the number of track aggregates were greater on the control than on the treated areas (Table 4). The MTTA area and the MTA size, however, were similar. The 31-month post-spray data indicated that moose visited and browsed more often on control areas and less on the treated areas than expected. The MTA size was apparently greater (although not significantly) on the control areas. This pattern was similar to that observed after one full growing season post-spray.

The pellet group and browse surveys in areas 3 and 4 during the spring of 1986 were carried out prior to treatment (Table 1). The pellet group data for areas 3 and 4 prior to spray were not normally distributed, consequently, they were transformed to the normal distribution by adding 1 and taking the natural logarithm. Analysis of the transformed data indicated that moose preferred the areas scheduled to be treated to the areas that were to remain as controls. The available browse and the amount of browse utilized by moose, however, were statistically similar between the areas to be treated and the control areas (Table 5).

Post-spray data collected before the next growing season (9 months) indicated that there were significantly more pellet groups per hectare on the controls than treated areas (Table 6). This pattern was similar to that

Table 2. Numbers of moose tracks, moose track aggregates, mean total track aggregate (MTTA) area, and mean track aggregate (MTA) size for cutover areas 3 and 4, seven months post-spray.

Observation	Control	SD	Treated	SD
Number of tracks	42		62	
Number of aggregates	11		8	
MTTA area (ha)	1.427	1.411	0.939	1.329
MTA size (ha)	0.242	0.038	0.117	0.166

Table 3. Number of moose tracks, moose track aggregates, mean total track aggregate (MTTA) area, and mean track aggregate (MTA) size for cutover areas 1 to 4, combined, 19 months post-spray.

Observation	Control	SD	Treated	SD
Number of tracks	168		178	
Number of aggregates	46		30*	
MTTA area (ha)	2.639	1.647	2.484	2.189
MTA size (ha)	0.230	0.120	0.270	0.210

* - Significant ($P<0.05$)

Table 4. Numbers of moose tracks, moose track aggregates, mean total track aggregate (MTTA) area, and mean track aggregate (MTA) size for cutover areas 1 and 2, 31 months post-spray.

Observation	Control	SD	Treated	SD
Number of tracks	111		58*	
Number of aggregates	55		29*	
MTTA area (ha)	4.096	4.963	3.336	3.537
MTA size (ha)	0.114	0.078	0.214	0.213

* - Significant (P<0.05)

Table 5. Numbers of pellet groups per hectare (PG/ha), available biomass, and utilized biomass for cutover areas 3 and 4, three months pre-spray.

Observation	Control	SD	Treated	SD
PG/ha	2.90	1.93	28.08	2.00*
Available biomass (kg/ha)	71.15	10.54	64.35	23.41
Utilized biomass (kg/ha)	0.025	0.035	0.065	0.092

* - Significant (P<0.05)

observed by Hjeljord and Gronvold (1988) on control and glyphosate-treated plantations in Norway. Available and utilized biomass were similar for this time period post-spray (Table 6).

At 9 months post spray the similarity in available biomass was expected since glyphosate, when used for the release of young conifer plantations, is applied in the late summer, August to early September. By that time, the shoot growth on the deciduous shrubs is complete, or nearly so. Consequently, the only noticeable effect of the herbicide application was an early leaf fall, thus it appeared as though the deciduous

Table 6. Numbers of pellet groups per hectare (PG/ha), available biomass, and utilized biomass for cutover areas 1 to 4, combined, nine months post-spray.

Observation	Control	SD	Treated	SD
PG/ha	20.62	11.55	7.75*	6.28
Available biomass (kg/ha)	83.68	45.53	71.58	63.73
Utilized biomass (kg/ha)	1.26	0.84	0.38	0.59

* - Significant (P<0.05)

twigs were not initially affected to a great degree by the late herbicide application. Since glyphosate does not render forage totally unpalatable (Sullivan and Sullivan 1979, Campbell *et al.* 1981), the overwinter browse availability at 9 months post-spray and preceding the next growing season was not expected to be greatly altered by the herbicide application.

The pellet group survey at 9 months (0 growing seasons), however, indicated that moose preferred the control areas; utilized biomass was also greater on the control areas, although not significantly so. These results were not anticipated since browse availability/palatability was expected to be similar. Campbell *et al.* (1981) noted some rejection of glyphosate-treated foliage of douglas fir (*Pseudotsuga menziesii*) by black-tailed deer. They postulated that it may be due to physiological changes in the plants, brought about by the glyphosate treatment. Perhaps, in our study, translocation of glyphosate in the treatment year was sufficient to initiate a physiological change in the plants that was detectable to moose as they browsed but not to observers in the spring when browse surveys were carried out. This may have caused moose to spend more time on controls as indicated by the pellet group survey and utilized biomass. Further field trials, however, would be needed to test this hypothesis.

At 21 months post-spray, there was a 4-fold difference observed in browse availability, a 12-fold difference in browse utilized, and a 2.5-fold difference in the number of pellet groups per hectare on controls versus treated areas (Table 7). These differences were not statistically significant. However, the lack of significance was probably due to the experimental design, and not due to the lack of real differences. The experimental design for this group of data afforded only 1 degree of freedom in the error term and the resulting F-ratio needed to exceed 161 to be declared significant. Even with such a conservative test, the amount of browse utilized was nearly significant at the 95% confidence interval ($P = 0.08$). This suggested that the treatment may well have influenced where a moose browsed.

The number of pellet groups per hectare were used to estimate gross differences in overwinter moose densities. Intensity of use on the control plots suggested a density in the order of 0.80 moose/km^2, while treated areas indicated 0.30 moose/km^2, at 21 months post-spray. Inherent in these estimates are the problems associated with estimating moose densities using pellet group counts as described by Neff (1968) and Timmermann (1974). Based on the estimated densities of moose, controls appeared to be preferred areas, and moose spent relatively more time on the controls. Vivas and Saether (1987) observed that moose in Norway seemed to spend more time on plots containing high forage availability as compared to plots containing low forage availability. Considering that controls contained up to 4 times more browse than treatments, our results reflect a similar preference.

The numbers of moose tracks gave no clear indication that moose preferred either the treated areas or the control areas at 7 and 19 months post-spray. Vivas and Saether (1987) observed that moose visited plots containing low stem densities as often as they visited plots of high stem density. Therefore, the fact that the numbers of tracks did not clearly indicate a preference for either treatment suggested a random distribution of tracks. The preference for control areas at 31 months (2 growing seasons) post-spray, however, may be evidence of a treatment effect, since track numbers were expected to be in proportion to the area treated and remaining as control.

Table 7. Numbers of pellet groups per hectare (PG/ha), available biomass, and utilized biomass for cutover areas 1 and 2, 21 months post-spray.

Observation	Control	SD	Treated	SD
PG/ha	16.64	3.87	6.55	4.31
Available biomass (kg/ha)	114.10	24.61	25.65	1.46
Utilized biomass (kg/ha)	1.71	0.12	0.14	0.18

The data for track aggregate area indicated that time spent and search effort were similar between both treatments for the winter period. The search effort on the treated areas, however, was slightly greater, since the average track aggregate was larger, although not significantly so. Forage intake was much less on the treated areas as compared to the controls. Thus, the amount of forage consumed per unit of time spent in searching must be less. Consequently, net energy returns on the treated areas must also have been less. This may explain why the number of track aggregates, and the number of pellet groups per hectare were greater on the controls after treatment. It may have accounted for an almost 3-fold difference in density estimates between the treatments at 21 months post-spray. Moose may have preferred the control areas because of greater energy returns over the winter period. This may be especially important for the productive component of the population, particularly cows with calves.

The question, not addressed by this paper, or the study itself, relates to the impact on moose of a reduction in the summer browse resources. Since most winter forage species are also important summer forage species (Belovsky and Jordan 1978, Timmermann and McNicol 1988), then a reduction in winter range quality resulting from the application of glyphosate may also reduce summer range quality.

SUMMARY

Moose preferred the non-sprayed control areas to the treated areas as evidenced by the greater number of pellet groups per hectare found on the former. Also, the number of moose track aggregates was greater on the control areas than on the treated areas, and the amount of browse removed from controls was 12 times greater than that from treated areas after 1 growing season. Estimated densities of moose were nearly 3 times greater on the controls after 1 growing season, indicating that moose spent relatively more time on the control areas than on the treated areas. It is postulated that increased browse availability on the non-sprayed controls reduced search effort, and higher energy returns per unit of search time resulted in moose preferring to utilize these areas.

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