Abstract: Two clear-cuts in the Dog River area of Thunder Bay District were studied to examine the relationship between browse utilization by moose and distance from cover. Utilization was determined by the presence of browsed stems on sample plots 4m² in area. In order to isolate the influence of cutover width, other factors such as browse availability and browse quality had to be held constant. Two statistical methods were used to examine the data from both cutovers: a frequency analysis and a regression analysis. In the larger of the two cuts, utilization declined significantly with increased distance from the edge, reaching zero at about 100m. In the smaller cutover, there were no significant changes in use with respect to distance from cover.
INTRODUCTION

It has long been recognized that moose populations are strongly influenced by forestry practices (Bergerud and Mauel 1968, Telfer 1974) through a direct manipulation of habitat and therefore that sound moose management requires a thorough understanding of the relationships involved.

Past studies along this line have mainly been aimed at describing known favourable winter habitats for moose. (Vozeh and Cumming 1960, Prescott 1968, Le Resche et. al. 1973). Most of these studies indicate moose prefer disturbed areas offering a wide variety of interspersed stand types and age classes which provide both mature conifers for cover and open disturbed areas for food.

Past logging operations have generally been valuable in producing this type of moose range. In recent years in Ontario however, increased demand for wood and greater mechanization have resulted in the development of extensive clear-cuts whose value as moose range has long been open to debate. Telfer (1974) suggests clear-cuts up to 0.5 square miles may be used by moose but clear-cuts larger than this are probably not heavily utilized until the stand has grown sufficiently to provide shelter (10 to 15 years). The Manual of Forest Aesthetics (Hough, Stansbury and Assoc. 1972) suggests no part of a clear-cut be further than 300 yards from coniferous cover.

If we are to be successful in working with foresters to manage our timber resources for wildlife as well as wood products, we must first be able to make biologically sound recommendations on the habitat needs of wildlife and how they can be best achieved in conjunction with forest cutting. This study was aimed at examining one aspect of this problem by determining how far moose will wander from cover to utilize browse in open clear-cuts.

STUDY AREAS

Two cutovers about 5 miles apart (designated as Dog River - 5 and Dog River - 2) were selected from the Great Lakes Paper Company's Dog River Limits, about 100 miles north-west of Thunder Bay (Figure 1). The areas have a rolling topography consisting of unmodified moraines of deep glacial till. Both contain residual "islands" of trembling aspen (Populus tremuloides) and are bordered by jack pine (Pinus banksiana), aspen and black spruce (Picea mariana). Both exhibited adequate browse and significant utilization by moose.
The Dog River - 5 study area (cut in 1968-69) consists of about 80 cleared hectares (200 acres) and is part of a larger cut-over complex (Figs. 2 and 3). Originally a spruce stand, it was scarified in 1969 and planted to jack pine in 1973. A significant portion of the area was partially cut, leaving scattered residual hardwood edges as well as scattered residual "islands" ranging from 0.2 to 4 hectares (0.5 to 10 acres). In parts of the cut-over, distances from cover exceeded 200m.

The Dog River - 2 study area is a former jack pine stand, cut in 1969-70 and scarified in 1971 (Figs. 4 and 5). It is about 30 hectares in size (75 acres) and contains a few aspen "islands" ranging from 9.2 to 1.2 hectares (0.5 to 3 acres). Both the islands and the cut boundary are of a solid residual type. In this cut-over, maximum distance from cover was slightly less than 100m.

METHOD
(a) General

The degree of utilization of a cutover is presumably influenced by at least six factors: moose density, hunting pressure, browse preference and abundance, snow depth and distance from cover. By holding the other factors constant, it was hoped that any effect of distance from cover on use patterns could be isolated. For the two study cutovers, moose densities, hunting pressure and snow depths were assumed to be the same. Densities are approximately 0.3 moose/km² (0.8 moose/mi²), harvest levels are about 0.08 moose/km² (0.2 moose/mi²) and snow reached about 75 cm during the previous winter. Browse preference and abundance will be discussed later.

(b) Sampling

Sampling was done on 2m by 2m plots spaced at 25m intervals along lines which were deliberately chosen to pass through selected site and cover types. All stems over 75 cm in height were tallied on each plot and browsing judged to have taken place during the previous winter was recorded. Descriptive notes were made regarding site types and plot location. Counting pellet groups proved to be useless as only one group was found on over 400 plots.

"Cover" was not defined quantitatively in terms of basal area or another such measure, but was simply taken to be any aggregation of deciduous or coniferous trees that had a noticeable "edge" and which produced the feeling of being "inside" a residual stand, as opposed to being "in the open" or among a few widely-spaced trees. A quantitative understanding of what constitutes cover remains an important area of moose habitat research, but was considered to be outside the scope of the present investigation.
Fig. 2 - Cutover pattern and cruise lines for Dog River #5 cutover
Fig. 3—Forest cover and site types for Dog River #5 cutover
Fig. 4—Cutover pattern and cruise lines for Dog River #2 cutover
Fig. 5 - Forest cover and site types for Dog River #2 cutover
Cover types were separated into "solid" and "scattered" residual stands. Scattered residuals were invariably hardwood stands which had been partially cut (softwoods removed), resulting in a significantly opened canopy and a disturbed ground surface which was usually very productive of deciduous browse. The solid residuals were undisturbed hardwood and softwood stands with closed canopies.

(c) Mapping

A basic requirement of this study was that each plot could be mapped accurately so that a distance from cover value could be determined. It was therefore necessary to produce detailed, large scale field maps with the use of aerial photos, base maps, a sketchmaster and a pentagraph. Figures 2 and 3, showing Dog River – 5, were drawn to 1:3960, while Figs. 4 and 5, showing Dog River – 2, were drawn to 1:7920. Careful compassing and chaining and the recording of significant landmarks in the field, helped to accurately establish the position of the cruise lines.

Distance from cover values for each plot (in 20m categories) were calculated from the maps with the use of calipers, measuring from the nearest edge including edges of scattered residual and island areas. It was felt that categories smaller than these could not be used due to inherent inaccuracies in mapping the cruise lines and in determining an exact position for the edge.

(d) Site Types

In the course of the field study, it was noted that subtle differences in site type were marked by significant changes in browse abundance. Since it was assumed that the abundance of browse might influence the degree of utilization by moose, plots were stratified into general site type categories. These groupings could be analyzed separately, if desired, keeping the abundance factor relatively constant. These categories were as follows:

Type A - well-drained upland sites - characterized by good browse abundance.

Type B1 - lowland sites, often adjacent to black spruce stands, not necessarily wet but characterized by very little browse.

Type B2 - upland sites, often with poor drainage or another factor not readily apparent, characterized by low browse abundance.

Subsequent to sampling, abundance and browsing levels were calculated for each category. As was suspected, browsing pressure was strongly influenced by browse abundance. Average abundance and use for each type both cutovers combined was as follows:
Type A - 5.0 stems/plot and 24.0% use.
Type B₁ - 1.0 stems/plot and 4.7% use.
Type B₂ - 0.7 stems/plot and 1.9% use.

For the purposes of this study, Types B₁ and B₂ could be combined into a "low abundance" grouping. Boundaries of these site types were mapped and plots were consequently assigned to a site type category within a particular zone regardless of individual stem numbers.

e) Browse Species

Although all woody stems over 75 cm in height were tallied in the field, only 4 indicator plants were used in the statistical analysis. This was an attempt to keep the preferred browse species constant and it removed the extraneous variability caused by the inclusion of large numbers of little-used stems such as green alder (*Alnus crispa*) and hazel (*Corylus cornuta*). The four indicator plants used were willow (*Salix spp.*), cherry (*Prunus spp.*), juneberry (*Amelanchier spp.*), and aspen. They accounted for 88.0% of all browsed stems on Dog River - 5 and 89.3% on Dog River - 2, and were the four most preferred species on both areas (Tables 1 and 2). Although hazel made a modest contribution to the diet of the moose, the fact that it was distributed very unevenly (found almost exclusively in and around the edge) was considered to be an adequate reason for its exclusion.

Table 1. Browse preference and abundance, Dog River 5.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>% USE</th>
<th>AVERAGE #/PLOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>cherry (<em>Prunus</em> spp.)</td>
<td>43.2</td>
<td>0.5</td>
</tr>
<tr>
<td>willow (<em>Salix</em> spp.)</td>
<td>40.3</td>
<td>2.0</td>
</tr>
<tr>
<td>aspen (<em>Populus tremuloides</em>)</td>
<td>22.4</td>
<td>1.2</td>
</tr>
<tr>
<td>juneberry (<em>Amelanchier</em> spp.)</td>
<td>18.5</td>
<td>0.5</td>
</tr>
<tr>
<td>hazel (<em>Corylus cornuta</em>)</td>
<td>5.8</td>
<td>2.7</td>
</tr>
<tr>
<td>green alder (<em>Alnus crispae</em>)</td>
<td>1.3</td>
<td>2.7</td>
</tr>
<tr>
<td>mountain maple (<em>Acer spicatum</em>)</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>white birch (<em>Betula papyrifera</em>)</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>jack pine (<em>Pinus banksiana</em>)</td>
<td>0.0</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Average use of 4 indicator plants (cherry, willow, aspen, juneberry) was 33.1%. These stems accounted for 88.0% of all browsing on this area.
Table 2. Browse preference and abundance: Dog River - 2.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>% USE</th>
<th>AVERAGE #/PLOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>willow (Salix spp.)</td>
<td>42.5</td>
<td>1.6</td>
</tr>
<tr>
<td>cherry (Prunus spp.)</td>
<td>21.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Juneberry (Amelanchier spp.)</td>
<td>8.3</td>
<td>0.2</td>
</tr>
<tr>
<td>aspen (Populus Tremuloides)</td>
<td>7.3</td>
<td>1.4</td>
</tr>
<tr>
<td>hazel (Corylus cornuta)</td>
<td>6.7</td>
<td>1.5</td>
</tr>
<tr>
<td>white birch (Betula papyrifera)</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>mountain maple (Acer spicatum)</td>
<td>0.0</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Average use of 4 indicator plants (willow, cherry, juneberry, aspen) was 24.3%. These stems accounted for 89.3% of all browsing in this area.

(f) Analysis

Two methods of analyzing the data were used: a frequency approach and a regression analysis.

The first method is often used by foresters for conducting regeneration surveys and involves looking at the data in terms of percent stocking. This eliminates the large amount of variability inherent in counting actual stem numbers per plot and focuses instead on stem distribution. Under this approach, a plot was considered to be either available or not available depending on whether or not it had one or more stems of any of the 4 preferred browse plants. The availability of browse in an area was therefore expressed as the proportion of its plots that were available, as opposed to those having no available stems.

The minimum number of stems required for a plot to be considered available was set at 1 on the basis of the following data from Dog River - 5.

Table 3. Number of preferred stems on 58 used plots.

<table>
<thead>
<tr>
<th># OF PREFERRED STEMS PER PLOT (X)</th>
<th># OF USED PLOTS HAVING &quot;X&quot; STEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>6 – 32</td>
<td>31</td>
</tr>
</tbody>
</table>
Although the average number of available stems on browsed plots was 7.9, a significant proportion (10.3%) had only one preferred stem. It was concluded, therefore, that these plots should be considered to be available for browsing by moose.

Similarly, the degree of utilization was expressed in terms of browsing frequency, i.e. the proportion of available plots in a given area that were used. Plots with no preferred stems could not be considered available and therefore were not included in the calculations of browsing frequency.

For the regression analysis, availability and use were compared with distance from cover on an individual plot basis using actual stem numbers.

(g) Roads

Plots that fell on or within about 3m of useable roads were excluded from all calculations in an effort to minimize two types of bias. First, bare road surfaces are unproductive of browse and their inclusion in the data reduces the average availability of the surrounding areas. Secondly, plots adjacent to roads were excluded on the grounds that browsing activity is often concentrated along road edges due to the easy access that they afford to moose.

RESULTS

Dog River - 5: Frequency Analysis

Figure 6 is a graphic representation of the availability and use frequencies of all plots from Dog River - 5. Although plots up to 140m from cover were encountered, they showed no significant departure from the pattern seen in Fig. 6, which combines all plots beyond 60m for the sake of simplicity and to provide an adequate sample in the last grouping.

Comparison of availability and use levels for the various categories was by means of Chi-square testing (Alder and Roessler, 1968). Yates' correction for continuity was used in all cases where there was only one degree of freedom.

A comparison of all 20-metre categories in the open part of the cut-over (from 0 to 140 metres from cover) revealed no significant differences in availability ($P=.25$). Since the requirement of relatively uniform availability with respect to distance appears to be satisfied by combining plots of all three site types ($A_3$, $B_2$, and $B_3$), it was not considered necessary to treat them separately.

A summary of other important tests of data from Figure 6 are presented in Table 4 as follows:
Fig. 6. Availability and use frequency: Dog River #5  N = 267
As can be seen from Table 4, the change in use frequency on the 4 clear-cut categories (0 - 60 + metres) was significant (P=.05), while the differences in availability were not (P=.25).

The level of use beyond 40 metres was significantly different (P=.05) from that on plots less than 40 metres from cover. At the same time, these categories exhibited a difference in availability that was not quite significant (P=.1).

The scattered residual category showed a significantly higher availability frequency (P=.005) than either the solid residual or the first two open categories (0 through 40 metres), but showed no significant difference in use frequency (P=.25).

**Dog River - 5 Regression Analysis**

Preliminary examination of the abundance data (in terms of # stems/plot) led to the acceptance of the null hypothesis, namely that there was no correlation between abundance and distance from cover. This conclusion was reached on the basis of the following observations:

1. as mentioned in the section on frequency analysis, there were no significant differences in the availability frequencies for the clear-cut categories.
2. linear regression of abundance on distance revealed a non-significant relationship (r=.08142, t=1.093, d.f.=n=2179, P=.3).
3. no other simple function appeared to conform to the data.
A number of attempts were made to find the function which best fitted the data on browsing vs. distance. A linear regression proved to be non-significant ($r=0.17390$, $t=-1.678$, d.f.=90, $P=0.1$), so quadratic and exponential functions were tried. The exponential function was selected because it had the lowest standard error of the estimate. Polynomials higher than the quadratic were rejected because the coefficient of the squared term was so small that its inclusion represented little improvement over the linear function.

The exponential function is of the form $Y = e^{bX + a}$ where $Y$ represents browsing in stems per plot, $X$ represents distance from cover, $a$ and $b$ are constants and $e$ is the base of natural logarithms. Since the logarithm of 0 is undefined it is customary to add 1 to all values before transformation, where 0 values correspond to available plots where no stems had been browsed. With the data thus transformed, the resulting linear equation was of the form $\ln(Y+1) = bX + a$.

The regression line calculated was: $\ln(Y+1) = 0.00618X + 0.65207$. The correlation coefficient $r$ was significant at the 5% level ($r=0.22943$, d.f.=90). To predict values of browsed stems per plot at a given distance requires a reverse transformation, i.e. taking antilogs and then subtracting 1. A plot of this line ($Y=(0.00618X + 0.65207) - 1$) appears in Figure 7 along with the actual arithmetic mean values for each distance category. The apparent poor fit between these arithmetic means and the fitted regression line will be discussed later.

**Dog River - 2 Frequency Analysis.**

Figure 8 is a graphic representation of the availability and use frequencies of all plots from Dog River - 2. There were only a few plots beyond 80 metres and all these were less than 100 metres from the edge. These plots have been grouped in the 60+ category.

Statistical testing (by means of Chi-square) of all plots, from within the residual stand to beyond 60 metres from cover, revealed no significant differences in availability frequencies between the various distance categories ($P=0.5$). Thus it was considered unnecessary to separate plots according to site type for further testing.
Fig. 7. Use vs. distance, Dog River #5
Fig. 8. Availability and use frequency: Dog River #2  N = 124
Table 5. Results of Chi-square tests performed on categories shown in Figure 8 for Dog River - 2.

<table>
<thead>
<tr>
<th>ATTRIBUTE BEING COMPARED</th>
<th>CATEGORIES COMPARED</th>
<th>DEGREES OF FREEDOM (n-1)</th>
<th>CHI-SQUARE (CALCULATED)</th>
<th>PROBABILITY (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>availability</td>
<td>solid residual</td>
<td>4</td>
<td>3.957</td>
<td>.5</td>
</tr>
<tr>
<td></td>
<td>through 60+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>use</td>
<td>solid residual</td>
<td>4</td>
<td>4.511</td>
<td>.5</td>
</tr>
<tr>
<td></td>
<td>through 60+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>use</td>
<td>0 to 40</td>
<td>1</td>
<td>2.333</td>
<td>.25</td>
</tr>
<tr>
<td></td>
<td>vs. 40+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to these results, there are no significant differences in use frequencies with respect to distance from cover.

**Dog River 2 - Regression Analysis**

An examination of the abundance data (in terms of stems/plot) led to the acceptance of the null hypothesis, namely that there was no correlation between availability and distance from cover. This conclusion was reached on the basis of similar reasons to those given in the section on regression analysis for Dog River - 5. The linear regression of abundance on distance for Dog River - 2 revealed a non-significant slope ($t=1.5916$, d.f.=$102$, $P=.2$). The browsing data was treated in the same manner and the same conclusion was reached, i.e. that there was no significant correlation between browsing and distance from cover. The linear regression of browsing on distance revealed a non-significant slope ($t=1.996$, d.f.=$61$, $P=.4$). No other simple function appeared to conform to the data.

**DISCUSSION**

An examination of the availability and use frequencies of Dog River - 5 (as seen in Fig. 6 and Table 2) shows the very high availability frequency of the plots in the scattered residual category. Use also appeared to be highest in this group, although statistical significance cannot be attached to this. Attention is drawn to this category as an example of the beneficial effects of partial cutting of upland hardwoods. The disturbed ground surface and partially-opened canopy are conducive to high stem densities, while the quality of cover may be largely retained. In the clear-cut part of the cutover, there was a statistically significant decreasing trend in use frequency with increasing distance from cover, especially beyond 40 metres. There was no significant change in availability corresponding to this trend.
The calculated regression line of browsing on distance for Dog River - 5 requires some explanation. This line gives a very poor fit to the arithmetic means as seen in Fig. 7. However, it is an accurate reflection of the median values, as the following example will show. In the first distance category (0-20m), there were 28 observations, of which 17 were zeros. Thus, although the average number of stems browsed per plot was 2.1, the most likely value for any single observation would be zero.

If a large number were added to each "Y" value before transformation to natural logarithms, and then subtracted from the predicted antilog values, a regression line would be generated running much closer to the means. This line would have a greater slope but would intercept the X-axis at approximately the same point. This new line would also be mathematically valid and statistically significant and the choice to use one or the other is basically a value judgement as to whether the data is better represented by the means or the medians.

This problem could be largely avoided if the plot size were increased. This would move the median values away from zero and closer to the means. Future studies of this kind should also aim at assigning a more specific distance value to each plot. This would greatly improve the strength of the regression analysis.

In the smaller cut-over (Dog River - 2), there were no significant changes in use with respect to distance from cover in either the frequency or the regression analysis.

The difference in size between the two cutovers offers a possible explanation for the different use patterns they exhibit. In Dog River - 2, there were no plots further than 100m from cover and it is likely that at this distance a moose seeking the shortest route to safety could choose from among a number of directions. In Dog River - 5, however, plots as far as 140m were encountered and this by no means represents the maximum possible. At a distance of 100m from cover, for example, a moose finding his shortest escape route cut off might travel 300m or more to reach the next closest edge.

In other words, it is possible that the pattern exhibited by Dog River - 5 is representative of cutovers where the maximum distance from cover is limiting the degree of browse utilization. Utilization dropped to zero at around 100m. In Dog River - 2, the maximum distance from cover was less than 100m, and utilization by moose did not drop off in any significant manner with increased distance.
If the findings of this study were taken at face value and considered to be general in their application, the following conclusions could be drawn. Firstly, cutovers less than 200m in maximum width are of small enough size that distance from cover does not significantly alter use patterns by moose. Secondly, clear-cuts wider than 300m show decreasing use, especially beyond 40m, and declining to zero at around 100m from the edge. It is not suggested, however, that such significance be placed on these results, as they are based on only 2 cutovers and in only one area. This study is useful however, in showing that quantitative results can be achieved and it indicates the need for further studies of this nature in a variety of cutover types and sizes and geographic areas. Hopefully, this paper will serve as a beginning to such studies.
ACKNOWLEDGEMENTS

We would like to thank Mr. Gary Auger, a summer student who assisted in the collection of field data, Mr. R. A. Ryder, Fisheries Research and Mr. F. G. Lyons, Forest Research, for their assistance in the regression and frequency analyses and Professor L. K. Roy and Mrs. C. Otte of Lakehead University for their help in the statistical analysis and computer programming of the data.

LITERATURE CITED


NOTES: