WINTERING MOOSE VS. OIL/GAS ACTIVITY IN WESTERN WYOMING

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Abstract: We examined possible impacts to wintering moose (*Alces alces*) resulting from oil and gas related disturbances in western Wyoming. We selected 45 variables to sample repetitively in 34 timber and willow (*Salix* spp.) stands of similar habitat quality and expected to contain moose but differing in exposure to oil-and-gas-related disturbance. Discriminant analysis showed that two variables, number of shrub species and whether the stand was located next to a plowed road, accounted for 79.4% predictability of moose presence or absence. Moose using plowed roads were often forced off by vehicles (forced exits) or left at their leisure (free exits). At free exit sites moose chose significantly fewer steep and more level slopes as compared to random samples. In 80% of the forced exits, moose left the road in areas of significantly shallower snow than the roadside averages. Relative to people on snowshoes or skis and snowmobiles, trucks caused the greatest escape distance, displaced the greatest percentage of moose, and caused the most disturbance to moose. People on snowshoes or skis caused the least impact. Recommendations are given for conducting oil and gas activity in/near moose winter range.

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Western Wyoming recently has experienced extensive oil and gas development. Oil and gas related disturbances in this energy-rich area can affect wildlife directly via human activities and vehicular traffic

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(Grenier 1974) that result in increased illegal harvest and accidents. Habitat loss is another direct impact associated with construction of new access roads. Indirect effects result from increased noise, which has resulted in avoidance by elk (*Cervus elaphus*; Johnson and Lockman 1980, Knight 1980). Access roads are plowed in winter, resulting in increased recreational opportunities and subsequent increased contacts between moose and humans. Because potential effects are likely more pronounced when moose are concentrated on winter range, this study aimed to determine adverse impacts between wintering moose and oil and gas activity.

STUDY AREA

The 259 km^2 study area lay within west-central Wyoming in the Bridger-Teton National Forest. There are an estimated 0.2-0.3 moose per km^2 in the study area (B. Johnson, Wyo. Game and Fish Dept., pers. comm.). The northern boundary was 24 km southeast of Alpine, Wyoming and the area extended 40 km south following the Greys River. East-west study area boundaries were set according to winter distribution maps but never exceeded 9.6 km from the Greys River Road. Elevations ranged from 1900 to 2472 m.

Vegetation varied according to slope, aspect, and elevation. The valley bottom was typified by willow communities with some cottonwood (*Populus angustifolia*) and Engelmann spruce (*Picea engelmannii*). Adjacent to riparian areas were a variety of forest community types including quaking aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*), and Douglas fir (*Pseudotsuga menziesii*), interspersed with sagebrush (*Artemisia tridentata*)-grass meadows. As elevation increased, subalpine fir (Abies lasiocarpa) and spruce dominated (Steele et al. 1979).

Because of deep snow many shrubs used as forage were unavailable in winter. However, rose (Rosa woodsii), mallow ninebark (Physocarpus malvaceus), Saskatoon serviceberry (Amelanchier alnifolia), common snowberry (Symphoricarpos albus), and willows were most available.

Winters of 1981-82 and 1982-83 were long, with temperatures ranging from -39 C to 13 C and from -33 C to 17 C, respectively. Average monthly snow depths for February, March, and April were 168 cm, 116 cm, and 120 cm, respectively.

Employees of True Oil and Arco Oil Companies traveled the Greys River Road daily because each company operated a drilling rig. An estimated 55 trucks per day traveled the road from December through mid-April of both winters. As a result, the Greys River Road and 2 access roads leading to the rigs were plowed throughout winter. No roads in the study area were plowed in winters prior to the presence of the drilling rigs. Because of the maintained roads, weekend snowmobilers, snowshoers, coyote (Canis latrans) hunters, and cross-country skiers also used the study area.

METHODS

We examined effects of oil-related disturbance to moose by testing the hypothesis that moose would be present in acceptable habitats regardless of whether or not they were disturbed by oil and gas activity and by making measurements of snow depth, topography, and forest characteristics along the plowed road where moose freely exited the road and where they were forced to leave by an oncoming vehicle.

To determine characteristics of acceptable moose habitat, we followed moose trails during the first winter of study using snowshoes, skis, or a snowmobile. We followed trails in 17 drainages expected to contain moose, according to winter distribution maps of the Wyoming Game and Fish Department (1980). Fresh moose trails were followed until reaching randomly selected bedding and feeding sites. We randomly selected a number between 1 and 10 to determine which bedding or bedding site to sample. We then returned to the point where the track was first encountered and continued moving east or west until another trail was encountered and the selection process began again. Topographic parameters and forest characteristics were measured at each site.

Elevation and aspect were recorded using a compass and topographic maps. Slope was measured using a clinometer. Distances from each bedding and feeding site to the nearest traveled road and nearest free water were measured using a meter tape or an odometer. We visually described plant community type at each sampled bedding or feeding site. Percentage frequency of shrubs, poles (2.5-10 cm diameter at breast height [dbh]), and saplings (less than 2.5 cm dbh) at the sites was estimated using a 50 m^2 circular plot for tree stands and a 15 m^2 circular plot for shrub stands (Knight 1978, Oldemeyer and Regelin 1978). Canopy closure was measured using a spherical densiometer (Lemmon 1956, 1957). We recorded all shrubs and trees browsed by moose that we observed while following moose trails to random feeding sites.

A non-mapping technique was used to compare availability of aspect and elevation with data on use by moose (Marcum and Loftsgaarden

1980). Data taken from 20 randomly selected stands ranging from 10 to 104 ha were used to provide availability of slope, community type, and crown closure. In this paper selection for or selection against refer to deviations of use versus availability that were significant at $P <$ 0.01 unless otherwise stated. Z-tests and Chi-square analysis were used to test commonality of variables describing either bedding or feeding sites.

Habitat conditions which consistently characterized bedding and feeding sites were subsequently used to define acceptable moose winter habitat. Once this was established, we selected stands which matched the definition for repetitive sampling in 17 drainages.

During the second winter (1982-83) we sampled 34 visually "acceptable" stands, establishing transects along which we randomly selected points to obtain information on snow depth, topography, and forest habitat characteristics for a total of 45 variables that might influence use by moose. The acceptable stands were classified as disturbed (experimental) or undisturbed (control). Disturbed stands were adjacent to access roads to oil rigs. Control stands were over 800 m from access roads.

Most of the 45 habitat-related variables were measured 1 to 2 times per month in each stand throughout the winter, in addition to noting the presence or absence of fresh moose sign during each visit to the stand. Six variables were sampled as follows. We ocularly estimated total and relative percentage cover of shrubs, poles, and saplings. Both estimates were made within a 15 m^2 circular plot for lodgepole pine and lodgepole pine-subalpine fir stands (Knight 1978, Oldemeyer and Regelin 1978). We measured snow depth using a meter

stick at each randomly selected point. We used the point-centered quarter technique (Eberhardt 1967) at random points to estimate stand tree density. We also measured dbh.

Primarily using cluster analysis (Nie et al. 1975) we reduced the total number of variables from 45 to 10 which were representative of each identified cluster. These 10 were then used for analysis in a 2-group discriminant program (Nie et al. 1975). The 2 groups discriminated were stands used by moose and stands without use. A used stand was one in which moose sign was noted at least once during winter.

In addition, we compared habitat data for locations where moose freely left the Greys River Road (free exits) and where they left when followed by vehicles (forced exits). We differentiated between forced exits and free exits by observing moose leaving the road, by examining moose tracks adjacent to truck tire tracks, and by observing tracks indicating moose were running.

Distance to river (not measured in the 1981-82 winter), and percent slope were measured whenever we saw moose leaving the road, at moose tracks, and at 400 m intervals along a 16 km segment of the road where moose were known to occur. We also measured snow depth twice a month at the highest point of the roadside berm at 400 m intervals. This measurement was estimated for days when we saw moose leaving the road. Analytical comparisons consisted of z-tests and Chi-square analysis.

We recorded escape distance from snowmobiles, persons on snowshoes or skis, and trucks, as well as original and resultant behavior of moose that were not on roads. Escape distance was defined as the distance a moose traveled until reaching cover large enough to shelter a moose from sight after it was displaced. This is the minimum distance a moose could have moved from the disturbance.

Escape response of moose was determined per meter of distance between the disturbance and moose. We consider that the escape response of a moose is a function of a) mean distance traveled to reach cover, and b) mean distance to the disturbance. If the ratio, a/b, is relatively large, we hypothesized there would be no significant response. Thus, the greatest escape response was the smallest a/b ratio. Greatest percent of moose displaced was defined in a similar fashion: the smallest ratio of percent displaced/b. Greatest disturbance to moose was determined by selecting the smallest ratio of percent disturbed/b.

RESULTS

Bedding Sites Used by Moose, 1981-82 Winter

Fifty-three bedding sites were found at elevations of 1902 to 2487 m, although only 2 were found above 2287 m (Figure 1). Elevations less than 2134 m were selected for while those greater than 2285 were selected against. Elevations greater than 2133 and less than 2286 m were used in proportion to occurrence. Twenty-seven bedding sites were on level terrain. Of the 26 that were not level, 85% were on south, southwest, or southeast aspects. South and southeast aspects were used in proportion to availability. Level and southwest slopes were selected for while northeast, northwest, east, and north aspects were selected against. The average slope (and 95% confidence interval) at bedding sites, 13 ± 4%, was significantly less than the average slope

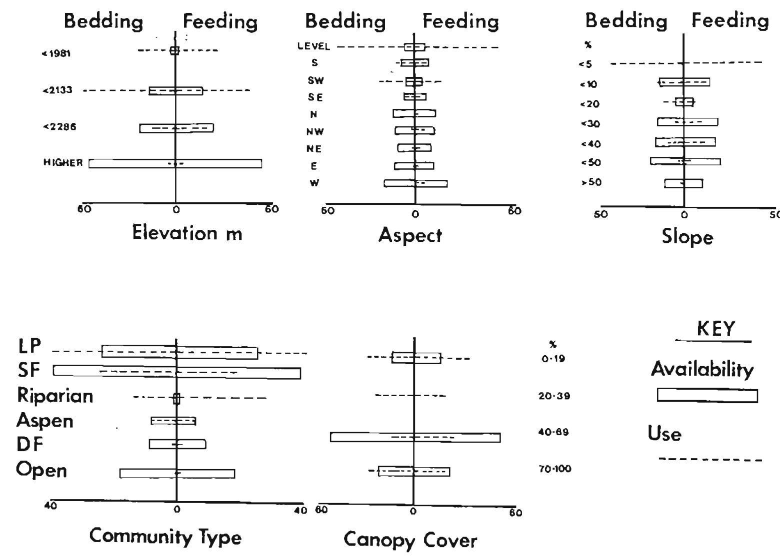

FIGURE 1. Habitat conditions selected by moose at bedding and feeding sites, 1981-1982 winter, Greys River, Wyoming. LP refers to lodgepole pine, SF refers to subalpine fir, and DF refers to Douglas fir.

available, 37 ± 6%. Sixty-four percent of all bedding sites were located on slopes less than 11%, but only 17% of the randomly located slopes were less than 11%.

The distances of bedding sites to the nearest traveled road ranged from 0 to 9230 m, averaging 1283 m. The average distance from 44 bedding sites to the nearest available, unfrozen water was 101 m, and more than 45% of the sites were within 20 m of water.

Plant community types were not selected for bedding sites in proportion to availability. Over 40% of the bedding sites were found in stands containing lodgepole pine, which comprised only 25% of the study area. About 25% were located in stands that contained subalpine fir and/or Engelmann spruce, 11% contained willows, and 8% were located in quaking aspen stands. Quaking aspen, subalpine fir and/or Engelmann spruce, and Douglas fir stands were used in proportion to availability. Eight bedding sites were found in willow and other riparian stands, which were selected for (15% use vs. 1% availability). Crown closure at bedding sites, 43%, differed significantly from that available.

Feeding Sites Used by Moose, 1981-82 Winter

Moose browsed 15 different species, of which subalpine fir was browsed most frequently (37%) throughout winter. Willows (24%) were consistently second in frequency browsed, except in April when the 2 species were equally used. For the entire winter, coniferous species comprised about 50% of the diet, with moose mostly using saplings and poles.

Forty-nine feeding sites were found at elevations ranging from 1901 to 2487 m although only 3 were found above 2286 m (Figure 1).

Elevations less than 2134 m were selected for while elevations greater than 2133 m were selected against. Of the 24 feeding sites that were not level, 65% were on south, southwest, or southeast aspects. Moose selected for level sites and southwest aspects for feeding. South and southeast aspects were used in proportion to availability. Northwest, east, northeast, north, and west slopes were selected against. The average slope (and 95% confidence interval) at feeding sites, 13 ± 4%, was less than the average slope available, 37 ± 6%. Sixty-five percent of feeding sites were located on slopes less than 11%.

Distances of feeding sites to the nearest traveled road averaged 1101 m, ranging from 0 to 7242 m. The average distance from feeding sites to the nearest available, unfrozen water was 85 m, but 39% of the sites were within 20 m of water.

Feeding site community types were not selected in proportion to availability except for quaking aspen stands. Moose selected for feeding sites in lodgepole pine stands and in riparian willow stands and selected against subalpine fir-Engelmann spruce, Douglas fir, and non-forested stands for feeding (Figure 1).

Canopy closure at feeding sites differed significantly from those available. The average canopy closure (and 95% confidence interval) at feeding sites was 37 ± 9%, ranging from 0 to 100%. Availability data showed that 16% of the stands had less than 40% canopy closure, all of which were in riparian and aspen stands. The large number of conifer stands available with at least 20% but less than 40% canopy closure and the small number of stands observed with at least 40% but less than 70% canopy closure contributed most to the Chi-square value.

Presence-absence of Moose, 1982-83 Winter

From our stand description data, we selected 34 stands for repetitive sampling from December through mid-April that matched the following description: less than 2286 m in elevation, south aspects or level; less than or equal to 10% slope; lodgepole, subalpine fir, or willow plant community; lodgepole pine or subalpine fir poles and saplings present; and less than 40% or greater than 69% crown closure for coniferous stands. Fourteen stands received no moose use, while the other 20 contained evidence of use at least 15% of the times they were examined. Fifteen stands were classified as disturbed by oil and gas activities.

There were few significant differences in habitat descriptors among selected stands receiving use by moose vs those not used by moose (Figure 2). For shrubs, poles, and saplings in stands not used by moose, the average relative percentage cover values for subalpine fir, willows, and Saskatoon serviceberry were 18%, 20%, and 0.1%, respectively. Corresponding values for stands that were used by moose were 19%, 15%, and 8%. Only Saskatoon serviceberry was significantly different from values from stands not used ($P < 0.04$). In stands not used by moose, average total shrub, pole, and sapling cover (and 95% confidence interval) was 6 ± 3%, different from the 10 ± 5% found in stands used by moose ($P < 0.04$). Average snow depth and elevation were equal in stands not used and stands that were used by moose. Tree densities were equal (180 vs 181 tree/ha), and lodgepole pine was the most prevalent conifer in each group. Average dbh (and 95% confidence interval) in stands not used was 13 ± 7 cm, compared to 13 ± 5 cm in stands that were used by moose. However, these dbh averages were

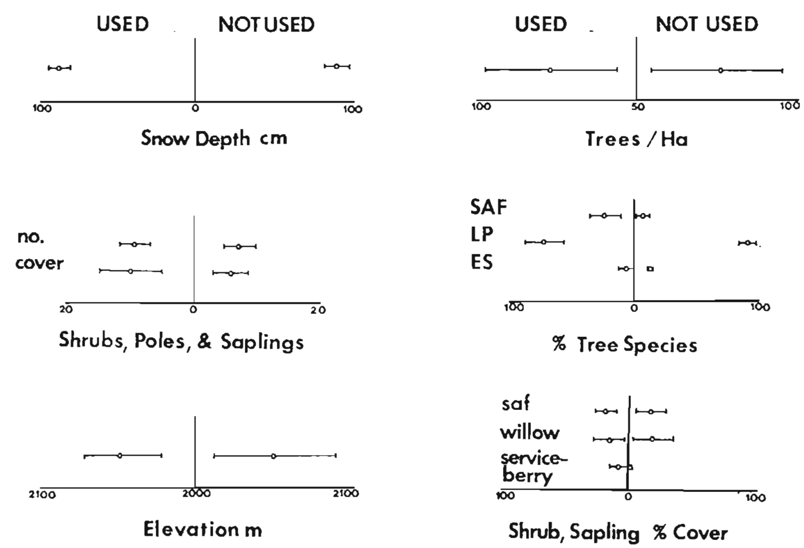

FIGURE 2. Averages and 95% confidence intervals of habitat parameters in stands used and not used by moose in winter, 1982-83, Greys River, Wyoming. SAF is subalpine fir, LP is lodgepole pine, and ES is Engelmann spruce.

significantly less than the dbh of trees available, 37 ± 4 cm. The average number (and 95% confidence interval) of shrubs available in stands not used by moose, 7 ± 3, was significantly less than the average for stands that were used (9 ± 2). Tree heights were equal (9 ± 3 m in used stands vs. 9 ± 4 m in unused stands). These values were lower than average heights in the study area (20 ± 3 m).

Cluster analysis, used to aggregate 45 habitat variables associated with the 34 selected stands, showed approximately 10 clusters of variables. Variables selected to represent each cluster were: relative percentage cover of subalpine fir, willow, and Saskatoon serviceberry, total percentage shrub cover, average snow depth, number of different shrubs present throughout winter, average tree dbh, elevation, average tree density, and status of stands relative to disturbance by oil and gas activity.

Discriminant analysis showed that total number of different shrub species and disturbance status were the best predictors of moose use of a stand. These 2 variables accounted for 43% correct classification of stands not used by moose and 95% correct stand classification of stands that were used.

Habitats Where Moose Exited Roads

When exiting roads freely, moose selected for areas with less steep uphill ($P < 0.09$) and downhill slopes than at random samples. The number of exits which had less than a 5% slope contributed most to the significant Chi-square. In 83% of the cases, moose exited at points where snow depth of the berm was less than the average depth along the Greys River Road (65 cm vs. 73 cm) although this difference

was not significant.

At forced exits, moose chose slopes in proportion to availability. Although not significant, there was a tendency for moose to exit the road at locations closer than average to the river. Forced exists were also closer to the river than free exits. The average snow depth of the berm along the Greys River Road (79 cm) was significantly greater than the average snow depth of the berm where moose were forced to leave the road (57 cm). Average canopy closure at locations where moose were forced from the road was significantly greater than random samples.

Response to Other Disturbance

The average escape distance 242 moose ran from a snowmobile was 9.7 m. The distance from snowmobiles to displaced moose averaged 54.7 m. Fifty percent of the moose were displaced, while 94% showed some type of disturbance behavior such as staring, arising from a bedded position, running, walking, and/or stopping any previous activity.

The average escape distance 18 moose moved away from a truck was 15.6 m. The average distance from trucks to displaced moose was 156 m. Only 21% of the moose were displaced while 48% displayed some type of disturbance behavior.

The average escape distance that 19 moose moved away from people on snowshoes or skis was 15.3 m. The average distance from people to moose was 74.5 m. Seventeen of the 19 moose moved to a different location and all showed signs of being disturbed.

Relative to distance to moose, trucks caused the greatest escape distance, displaced the greatest percentage of moose, and caused the greatest disturbance to moose, compared to people on snowshoes, skis, or snowmobiles. People on snowshoes or skis caused more disturbance than snowmobiles.

DISCUSSION AND CONCLUSIONS

Two variables were good predictors of presence or absence of moose in stands that appeared acceptable (by our criteria). One of these was greater number of shrub species present. Brassard et al. (1974) also found a larger number of shrub species in areas associated with higher moose densities. They also found smaller trees in these areas, characteristic of early successional stages. Preference for greater species diversity of shrubs may thus indicate selection for earlier successional stages. Doerr (1983) concluded that moose selected against old growth forests. Cowan et al. (1950) stated that, as a forest approaches climax, a reduction in quantity and quality of available browse occurs. So, a greater shrub species availability may provide a higher nutritional plane.

The other variable determining presence or absence of moose was whether or not an access road was adjacent to the stand. In selecting an appropriate area for placement of a drilling rig and access roads, management agencies should avoid preferred moose habitat. These wintering areas in the Greys River are found at elevations less than 2290 m, on level terrain, or on the south aspects. Slopes are gentle, less than or equal to 10%. The forest consists of lodgepole pine and/or subalpine fir trees with a similar understory including willow spp. and Saskatoon serviceberry. (There was no measure of availability of pole and saplings present in subalpine fir stands although subalpine

fir-Engelmann spruce community types were selected against. However, subalpine fir was frequently used for feeding.) Total percent shrub cover is about 10% with a shrub variety of at least 9 different shrub species browsed by moose per forest stand. These stands preferred by moose also possess characteristics of early forest succession: small dbh, small tree height, and low crown closure (0-39%). Locating and avoiding these areas would aid in mitigating impacts to wintering moose in the Greys River area.

Moose wintering in an area free of disturbance would have fewer encounters with recreationists and would not get trapped on traveled roads by vehicles. Ferguson and Keith (1983) found that cross-country skiing influenced the general, over-winter distribution of moose and caused moose to stay away from heavily used trails during the ski season. Mytton and Keith (1981) found that moose were located farther from human disturbance than expected in a random distribution. Also, Rolley and Keith (1980) found evidence that 4-wheel-drive vehicles, snowmobiles, and trail bike activity within 250 m of moose may cause them to leave an area.

Our data also suggested a disturbance to moose was created by trucks. The available literature and our data show that disturbances cause moose to avoid preferred areas, so roads should not be placed near moose winter habitat. If this is impossible, disturbances associated with oil and gas activity should be located where they will cause the least impact to moose. In areas where mitigation is necessary, habitat improvement might include creating early successional stages to provide an increase in the quality and quantity of existing shrubs beneficial to moose. This may also serve a dual purpose in luring moose away from disturbances. When possible, moose populations should be monitored before, during, and after disturbances. In addition, educational programs should be provided for employees of oil companies concerning moose winter ecology, stressing the need to avoid human contact with wintering wildlife. Winter recreation and use of recreational vehicles should be restricted in and near winter ranges to reduce stress. Research should be conducted to find more efficient means to allow moose to leave the road.

Beak Consultants (1979) observed that moose and elk continued to use habitat within 1 km of a drilling rig, apparently habituating to activities and sounds of drilling operations. On plowed roads, this habituation could prove detrimental. Grenier (1974) documented that increased traffic produced an increase in vehicle-related moose mortality in Laurentide Park, Quebec when moose use of the road increased. Therefore, we suggest that the speed of all vehicles using access roads be limited to 30 kmph and enforced.

Reduced snow depth consistently characterized sites where moose selectively exited from roads. Penner and Duncan (1983) found that the average berm height at the point of crossing was less than the average berm height at 3 m to either side of the point of crossing. Horjesi (1979) found snow berms to be a barrier to normal animal movement. Therefore, berms of plowed roads should be kept under 50 cm. (This would also allow deer (Odocoileus hemionus) to enter and exit the roads.) All data suggested moose attempt to conserve energy. Providing escape ramps on level areas with trees adjacent to the road may facilitate escape and minimize energy expenditures.

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