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Browse Evaluation and Survey Techniques for the Uinta North Slope Moose Herd

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BROWSE EVALUATION AND SURVEY TECHNIQUES FOR

THE UINTA NORTH SLOPE MOOSE HERD

by

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of the requirements for the degree

of

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William H. Babcock

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ABSTRACT

Browse Evaluation and Survey Techniques for

The Uinta North Slope Moose Herd

by

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Utah State University, 1977

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Department: Wildlife Science

A study was conducted on the North Slope of the Uinta Mountains from January, 1972 through June, 1974, to determine the effects of three simulated levels of moose utilization on the crude protein content, phosphorus content, digestibility and vigor of willow plants. A comparison was also made on the crude protein content, phosphorus content and digestibility of current year's versus past years' willow growth. Finally, the validity of direct and indirect population enumeration methods was compared for the possible development of a standardized moose survey technique.

Clipping caused a highly significant increase in crude protein and phosphorus content between treatment levels. There was also a highly significant increase in digestibility between years. Plant vigor comparisons were confounded by additional sources of mortality and the effects of environmental variables.

A comparison of the nutrient content and digestibility of 1 to 5 year-old willow growth showed that crude protein content, phosphorus content and digestibility decreased with increasing twig age. Additional factors are discussed which indicate that the carrying capacity of the winter range is larger than previously described.

A poor correlation was found between direct aerial moose observations and indirect population estimates from pellet-group counts.

(48 pages)

INTRODUCTION

Moose have been dispersing from their original range in North America since the last glacial period (Kelsall and Telfer, 1974). Changing vegetation types, resulting from climatic warming trends and human influences, have created suitable habitat in many new areas.

In 1875, the Shiras moose (Alces alces shirasi) occupied northern Idaho, southwestern Montana and northwestern Wyoming (Peterson, 1974). The present range of the Shiras moose extends from Alberta and southeastern British Columbia, south through northern and eastern Idaho, western Montana, western Wyoming and into northeastern Utah (Figure 1), thus affording Utah the southernmost moose population in North America.

The Uinta North Slope moose herd developed slowly from its beginnings in the early 1900's. In 1957, the Utah State Division of Wildlife Resources conducted the first aerial moose survey over the area and 59 moose were counted. Counts ranged from 57 to 100 animals from 1957 to 1965, but began increasing rapidly in 1966. By 1971, the herd had increased to more than 371 animals, an increase of 500 percent during the previous five-year period (Wilson, 1971).

In 1969, the Utah Cooperative Wildlife Research Unit initiated a study to determine the key browse species for moose on the Uinta North Slope, its acreage on the winter range, the caloric requirements of moose, and the carrying capacity of the key browse species. Wilson (1971) determined that Drummond's willow (Salix drummondiana) and Geyer's willow (Salix geyeriana) were the key browse species on the winter range for the Uinta North Slope, accounting for 92 and 4.7

Figure 1. Shiras moose distribution: 1875 and present. (adopted from Peterson, 1955).

percent, respectively, of all observed feeding occurrences. He further determined that Drummond's willow comprised 59 percent of the vegetation on the study area and Geyer's willow 31 percent. The carrying capacity of the key browse species on the winter range was calculated to be 80,030 moose days or 445 animals for six months.

Ungulate populations must be managed within the limits of the carrying capacity of the preferred browse species to prevent range deterioration and maintain a healthy herd. Since the Uinta North Slope moose population appeared to be rapidly approaching the limits of its theoretical winter carrying capacity, it was decided that more precise information was needed as to what level of browsing pressure these willow species would withstand while continuing to maintain production and adequate nutrient levels for moose. This information, when combined with data on the availability of key browse species, digestibility, and a more reliable population estimate, would allow a more precise estimate of the carrying capacity of the winter range.

The study was conducted from January, 1972, through June, 1974. The primary objectives of the study were:

1. to determine the effects of various simulated levels of moose utilization on the crude protein content, phosphorus content, digestibility and vigor of willow plants;
2. to compare the crude protein content, phosphorus content, and digestibility of current year's versus past years' willow growth;
3. to compare the validity of direct and indirect population enumeration methods for possible development of a standardized moose survey technique.

LITERATURE REVIEW

Effects of utilization on shrubs

Clipping studies are subject to numerous biases. Culley et al. (1933) found that: (1) animals tend to pull and break off vegetation at random, without uniformity, (2) litter accumulation from clipping is different than from grazing and (3) there is no trampling effect. Jameson (1962) maintained that clipping is often more severe than grazing because more herbage is removed from individual plants. Furthermore, clipping often does not accurately simulate grazing because grazing animals select specific plant parts rather than utilizing the plant uniformly. However, in comparing the effects of grazing and clipping by removing duplicate amounts and types of forage, Gossett (1961) determined that grazing may be more harmful to plants than clipping. Despite these inconsistencies, clipping studies are often the only practical means by which researchers can compare the effects of various levels of utilization on plant species.

Clipping studies have been conducted on many browse species important to North American ungulates. Julander (1937) found that quaking aspen (*Populus tremuloides*) reproduction on the Kaibab National Forest was adversely affected when subjected to 75 percent or more utilization. Cliffrose (*Cowania stansburiana*) was able to withstand a maximum of 70 to 75 percent utilization without deteriorating, but browsing up to 65 percent was found to stimulate growth.

Young and Payne (1948) found that for spring and summer sheep grazing in northern Idaho, 60 to 65 percent utilization of the current annual growth was allowable for Utah honeysuckle (Lonicera utahensis), serviceberry (Amelanchier alnifolia) and rose (Rosa jonesii), while 60 percent utilization was allowable on redstem ceanothus (Ceanothus sanguineus) if taken in late summer or early fall.

Aldous (1952), working in Michigan and Minnesota, found that white birch (Betula papyrifera), mountain maple (Acer spicatum), pin cherry (Prunus pennsylvanica), beaked hazelnut (Corylus cornuta) and black ash (Fraxinus nigra) were able to withstand moderate to heavy use and he concluded that all should be used at least moderately to keep plant growth within the reach of deer. Redosier dogwood (Cornus stolonifera), mountain ash (Sorbus americanus) and red-berried elder (Sambucus racemosa) could not tolerate heavy use, but moderate use was necessary to maintain continued availability for deer.

After clipping all of the current year's growth from one side of big sagebrush (Artemisia tridentata) plants for three years during late winter or early spring, Cook and Stoddart (1960) found that this treatment caused death to the clipped side of the plants, while the unclipped side almost doubled production. They also found that clipping half of all of the current annual growth from the entire plant for the same period caused reduced plant vigor, but few twigs or branches were killed. They concluded that clipping browse from one side of the plant caused greater lignin and cellulose content in the remaining forage, while clipping half of the current annual growth over the entire plant caused increased protein, carbohydrate and ether extract levels.

Ferguson and Basile (1966) studied the effects of topping decadent bitterbrush (Purshia tridentata) shrubs on deer winter range in Idaho. After one treatment, twig production increased nearly ninefold over that produced by control plants. Twig production on the treated plants remained higher than control plants in subsequent years, but at a decling rate.

Shepherd (1971) conducted a clipping study in southwestern Colorado to determine the effects of various clipping intensities on antelope bitterbrush, big sagebrush, oakbrush (Quercus gambelii), mountain mahogany (Cercocarpus montanus) and serviceberry. Chemical analyses were made to determine differences in any of the five species. Serviceberry appeared to be most resistant to clipping of all species studied. Annual use of up to 60 percent of the current annual growth (CAG) stems was found to be beneficial, but prolonged use of 80 percent or more would kill the plants. One hundred percent clips increased the proportion of suckers but no plants died as a result of the treatments. Oakbrush was found to withstand 60 percent utilization of CAG on summer and fall ranges with an occasional allowable use of from 80 to 100 percent. Mountain mahogany was resistant to clipping intensities of up to 80 percent, with 70 percent being near optimum. Allowable summer and fall use of up to 50 percent was determined for bitterbrush, with somewhat higher levels of from 50 to 65 percent permissible on winter ranges. Big sagebrush was able to maintain good browse production under clipping intensities up to 80 percent during summer and fall, but use in excess of 50 percent could not be tolerated for indefinite periods. Slightly higher winter use would be acceptable.

Garrison (1953) studied the effects of fall and winter clipping on snowbrush ceanothus (Ceanothus velutinus), creambush rockspirea (Holodiscus discolor), antelope bitterbrush, rubber rabbitbrush (Crysothamnus nauseosus) and curlleaf mountain mahogany (Cercocarpus ledifolius) in eastern Oregon and Washington. Antelope bitterbrush was found to withstand 60 to 65 percent clipping on the best sites and 50 percent on the poorer sites. Snowbrush ceanothus tolerated 35 to 40 percent; rubber rabbitbrush, 50 percent; and creambush rockspirea, 50 to 60 percent. Curlleaf mountain mahogany plants, completely within reach of grazing animals, were recommended to be used 50 to 60 percent, thus controlling their height.

Jensen et al. (1972), working in northern Utah, found that bitterbrush plants browsed by sheep in late May and late June or by big game in winter, were characterized by numerous shoots and large volumes of forage by the end of the growing season. Plants used heavily by sheep in late July did not produce regrowth and appeared to lack vigor. They concluded that sheep grazing could be compatible with big game use in the area if grazing was restricted to the early part of the growing season and that sheep use should be terminated by the time bitterbrush seeds set.

Nutritional requirements

Although little information on moose nutritional requirements is available, a fair amount of research has been done on other species of wild and domestic animals.

Adequate protein levels are requisite for body maintenance and production. Protein deficiencies affect growth, reproduction and lactation (Morrison, 1957). Murphy and Coates (1966) found that white-tailed deer (*Odocoileus virginianus*) fed low protein (7 percent) diets throughout the year manifested retarded growth characteristics. Productivity of does consuming diets of 7 to 11 percent protein was less than that for deer on an adequate diet. French et al. (1955) stated that 13 to 16 percent dietary protein levels were necessary for optimum growth and 6 to 7 percent was necessary for maintenance in white-tailed deer. Dietz (1967) found that deer rumen functions were impaired when crude protein levels in forage were below 6 to 7 percent.

Phosphorus is essential for herbivore metabolism as well as being a major component of bones, antlers and tissues (Short, 1969). Moen (1973) stated that the effect of diet on metabolism may not be limited to individual animals alone, but may also carry over into their newborn offspring. Phosphorus deficiencies are detrimental to the processes of lactation and reproduction (Maynard and Loosli, 1969).

Halls (1970) found that the phosphorus requirements of white-tailed deer approximate those for domestic livestock and are probably similar to those of other antler-producing big game. Magruder et al. (1957) estimated that phosphorus levels of 0.25 to 0.30 percent were necessary for maintenance, while 0.56 percent was necessary for optimum growth.

Survey methods

The problem of obtaining accurate estimates of animal numbers has long plagued game managers. Pellet group counts have been used to determine trends and survey animal populations since the late 1930s. The technique and its biases have been reviewed in general by Neff (1968), and with specific reference to enumeration of moose numbers, by Timmerman (1974). Problems incurred with the pellet group method as it applies to moose population estimation according to Timmerman (1974) include: (1) inadequate sampling area; (2) missed groups due to plot size and shape; (3) observer bias and fatigue in counting groups; (4) decreased visibility of pellet groups due to vegetation growth; (5) loss of pellet groups from insects and flooding; and (6) determination of daily defecation rates.

Aerial surveying is considered by many to be the best enumeration method for large ungulates (Evans et al, 1966; Bergerud and Manuel, 1969). LeResche and Rausch (1974) found that accuracy of aerial counts is affected by: (1) observer experience and topicality; (2) the number of observers used; (3) by snow and weather conditions; (4) by habitat type and terrain relief; and (5) by time of day. The type of aircraft used also affects the results obtained due to stall speed and visibility afforded (Wolfe and Jordan, Unpub. manuscript).

The Utah State Division of Wildlife Resources has conducted annual aerial surveys of the Uinta North Slope moose herd since 1957. Fixed wing aircraft were used for this purpose through 1969 when it was determined that a helicopter provided more accurate survey results, both in number of animals counted and in herd classification.

Little research has been done in comparing direct and indirect population enumeration methods to obtain a greater degree of accuracy. The limited winter range on the Uinta North Slope offers a good opportunity to compare these two methods of population enumeration.

STUDY AREA

The Uinta Mountains are the only major east-west mountain range in the United States. With an overall length of approximately 240 km and a mean width of about 55 km, they lie along the northeast border of Utah, extending into northwestern Colorado.

The study area (Figure 2) is bounded on the east by Burnt Fork, on the south by the mountain peaks forming the drainage divide, on the west by the Bear River and its tributaries, and on the north by the major portion of the moose winter range which extends approximately 25 km into Wyoming.

Altitudes vary from approximately 2,250 meters above sea level at the base of the mountain range to over 3,900 meters, with 26 peaks within the range exceeding this elevation. Timberline is at an altitude of about 3,300 meters (Hansen, 1969).

Short, cool summers and long, cold winters are characteristic of the area. The coldest and warmest months are January and July, with temperatures for those months averaging -7 C and 17 C, respectively (Van Wormer, 1967). Snow depths range from approximately 75 to 125 cm at the lower and upper limits, respectively, of the moose winter range (Wilson, 1971). Average annual precipitation ranges from 40 to 100 cm, with 50 to 75 percent of this falling between October and April, mostly in the form of snow (Anonymous, 1971).

Lodgepole pine (*Pinus contorta*) represents the dominant vegetation type over much of the Uinta North Slope, with quaking aspen (*Populus tremuloides*) interspersed from 2,100 to 2,850 meters elevation.

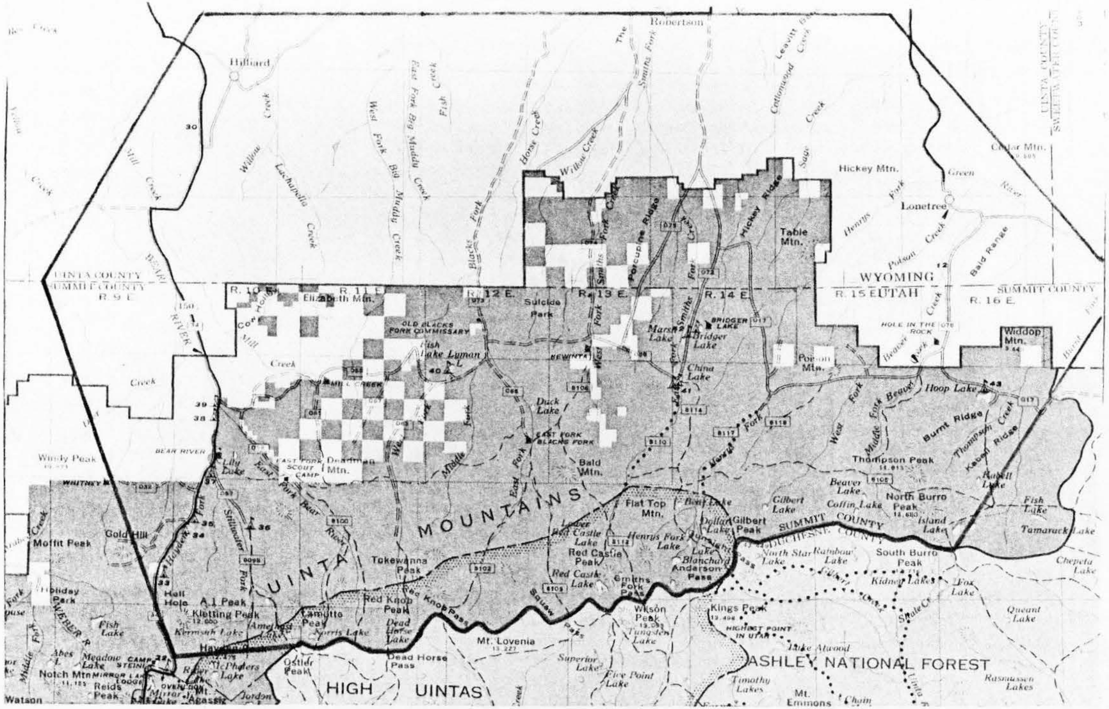

Figure 2. Uinta North Slope Study Area.

Lodgepole pine and aspen stands give way to sagebrush (*Artemisia spp.*) and grasslands at lower elevations, while areas above 3,000 meters are characterized by Engelmann spruce (*Picea engelmanii*)-lodgepole pine mixtures.

Numerous lakes, ponds and grass-sedge (*Carex spp.*) meadows are found throughout the area. Stream gradient decreases slowly and creek channels widen to form large willow bottoms. Wilson (1971) determined that six species of willow occur throughout the study area: Drummond's (*Salix drummondiana*), Geyer's (*S. geyeriana*), Wolf's (*S. wolfii*), lasiolepis (*S. lasiolepis*), subcoerulia (*S. subcoerulia*) and exigua (*S. exigua*). Drummond's willow was found to occur with the greatest frequency, followed by Geyer's and Wolf's, the frequency of these varying from one drainage to the next.

METHODS

Determination of the effects of simulated utilization on the nutrient content, vigor and digestibility of willow plants

The following arbitrary definitions were used for various plant parts during the study.

1. Stem--the major supporting structure to which branches are attached at regular intervals.

2. Branch--a major woody extension growing from the stem.

3. Twig--a minor woody extension growing from a branch.

4. Whip--a dead stem.

5. Sucker--a long, slender current annual growth stem arising at ground level from clustered willow stems.

Wilson (1971) found that Drummond's willow twigs utilized by moose on the Uinta North Slope averaged 0.5 cm in diameter, with frequent observations of twigs nipped to 2.0 cm in diameter and occasionally up to 2.5 cm. Bassett (1951) found that about 15 percent of the willows in the Snake and Buffalo River bottoms of Wyoming showed utilization of 2 year-old wood. Denniston (1956) reported moose using willow twigs up to 1.27 cm in diameter near Jackson, Wyoming.

In this study, 10 plants were selected at random and 10 stems were cut from each plant and separated into various years' growth increments (Table 1). The following diameters were determined for the various age classes of twigs:

Table 1. Average diameters for 1 to 5 year-old Drummond's willow twigs.

Age in years	Diameter in centimeters
1*	0.16 - 0.32
2*	0.33 - 0.50
3	0.51 - 1.03
4	1.04 - 1.12
5	1.13 - 1.44

*From unpublished data of David E. Wilson

Data from previously established browse transects indicate that moose utilization of willow on the Uinta North Slope remains below the estimated carrying capacity of the winter range. Browse utilization for the period 1966-1971 averaged 26 percent (Wilson, 1971: Table 9) in the study area. However, in view of the observations of the investigators cited above, it was decided to clip up to and including 3 year-old growth, instead of only CAG, to better simulate the browsing habits of moose.

A 0.4 ha. exclosure, with a 4.5 meter fence, was constructed in the Henry's Fork drainage (Figure 3). Forty Drummond's willow plants within the exclosure were selected as subjects for the clipping study. Samples from each plant were taken to Professor Arthur Holmgren of the Utah State University Botany Department for species verification.

Plants selected for treatment were subjected to clipping intensities of 30, 60 and 90 percent (by number of stems) of the cumulative 1, 2 and 3 year-old growth (Figure 4). Ten replications of each treatment were performed, with plants from each treatment level located randomly throughout the exclosure to reduce possible biases from

Figure 3. Henry's Fork moose exclosure, Uinta North Slope, 1973.

Figure 4. Drummond's willow plants subjected to 30, 60 and 90 percent clipping of the cumulative 1, 2 and 3 year-old growth.

differences in exposure, moisture and microclimate. Ten additional representative plants were randomly selected and used as controls.

Clipping treatments were performed in late December or early January each year while plants were in a dormant state. Plants were clipped with pruning shears, one branch at a time, starting from snow level (approximately 1 meter above ground) and moving upward, systematically removing the stipulated percentage of branches.

Data collected from each treated plant included: (1) height, (2) total stems and branches present, (3) total dead stems (whips), (4) total suckers produced, (5) green and air-dried weight of clipped forage, and (6) total branches removed. All but the last parameter were used as indicators of plant vigor. Data collected from control plants included: (1) height, (2) total stems and branches produced, (3) total dead whips, (4) total suckers produced, and (5) general observations on plant vigor.

Clipped forage samples from each treated plant were subjected to proximate analysis in the Plant Analysis Laboratory at Utah State University to determine percent dry matter, percent ash, percent crude protein (N x 6.25) and percent phosphorus. Dry matter digestibility was determined by the Tilley and Terry (1963) "two-stage" technique. No moose rumen liquor could be obtained during the course of the study, so domestic goats were used as an inoculum source. These animals were all maintained on a 100 percent Drummond's willow diet for a period of 15 days prior to collection of the inoculum to allow the rumen microflora an opportunity to adjust in terms of species present to efficiently digest the willow forage. After reviewing the literature on both domestic and wild ruminants, Moen (1973) suggested that rumen fluid obtained from animals on the same diet, despite the fact that the animals may be of two different species, would probably produce similar in vitro digestibility results.

Statistical analysis of data

The effects of clipping on nutrient content, plant vigor and digestibility of willow browse were determined by an analysis of variance to test differences among treatment levels and between the two years.

An analysis of variance incorporating a randomized block design, where plants were used as blocks, was used to analyze the comparison of crude protein content, phosphorus content and digestibility of current year's versus past years' growth. Standard F tests were also performed on each variable and least significant difference confidence intervals (Ostle, 1969) were used to further define differences among various years' growth.

Comparison of crude protein content, phosphorus content and digestibility of current year's versus past years' willow growth

Ten Drummond's willow plants were selected during the dormant period and 10 stems were cut from each plant. The stems from each plant were bundled separately and taken to the laboratory to separate the various years' growth. This was accomplished by starting at the terminal end and following the growth rings back, clipping off each years' growth through the fifth year. The clipped samples were then subjected to an in vitro digestibility analysis and proximate chemical analysis to determine differences between digestibility and nutrient content among the various years.

Sparse information on moose nutritional requirements is available. Studies by LeResche et al. (1974) suggest that Alces and Odocoileus are closely related genera. Deer are also primarily browsers, occasionally utilizing the same forage species used by moose, and researchers have determined many of their nutritional requirements. Thus, for the purpose of this research, and pending appropriate nutrition studies, the nutritional requirements of deer were used as guidelines for comparison.

Comparison of direct and indirect population enumeration methods

A study area of approximately 4,200 ha. was selected in an area of high winter moose concentration in the west fork of Smith's Fork drainage. Four pellet group transects containing 132 individual (9.2 m^2) plots, spaced at intervals of 10 paces, were established in the willow bottom portion of the study area in 1973. In 1974 it was decided that additional sampling was needed in areas of lower moose density so 10 additional pellet group transects were established in upland areas, composed primarily of mixed lodgepole-aspen vegetation types. All plots were cleared of old fecal pellets in early September before the moose moved to the winter range.

Fixed-wing aerial and ground observations were scheduled weekly, starting in November, to determine the relative increase of moose on the winter range. When population levels in the study area leveled off, it was assumed that the full wintering complement was on the winter range. The study area was then surveyed with a helicopter to obtain a more accurate population estimate. Fixed-wing observations continued throughout spring until the majority of the moose population had moved off the study area.

Pellet group transects were read after the snow melted and moose days use for the area was determined. A defecation rate of 17.9

pellet groups per day was calculated by dividing the total number of pellet groups found in the study area by the total days moose inhabited the area. Various moose defecation rates found in the literature were used to determine the theoretical wintering population for the study area at the time of maximum concentration. These population estimates were then compared to the results obtained by the aerial survey to determine if any correlation existed.

RESULTS AND DISCUSSION

Effects of clipping on nutrient content of willow browse

The values obtained for nutrient content and digestibility of browse samples collected during the two years of the study from plants subjected to different clipping intensities are given in Table 2. The F values for the various nutritional parameters derived from analysis of variance are summarized in Table 3. The observed increases in crude protein and phosphorus between treatment levels were highly significant ($F = 16.5$; $df = 2/48$; $p < 0.01$ and $F = 11.36$; $df = 2/48$; $p < 0.01$, respectively), thus indicating a higher degree of protein and phosphorus content in response to the increased percentage of current annual growth due to clipping.

Table 2. Nutrient content and digestibility of Drummond's willow browse in response to clipping (values given are percentages).

Year	Percent Clip	Phosphorus	Crude Protein	Digestibility
1973	30	0.10	6.32	30.43
1974	30	0.12	6.38	35.48
1973	60	0.10	6.16	30.88
1974	60	0.12	6.60	36.09
1973	90	0.10	6.40	32.25
1974	90	0.14	7.86	35.37

Table 3. F values obtained from analysis of variance of nutrient content and digestibility of Drummond's willow browse in response to various levels of clipping.

Source of variation	P	Crude Protein	Digestibility
Treatment (A)	11.36**	16.50**	00.75
Year (B)	34.67**	21.31**	46.60**
Interaction (AxB)	9.49**	13.00**	00.93

**Significant: $p < 0.01$.

Digestibility

A highly significant ($F = 46.6$; $df = 1/48$; $p < 0.01$) increase in digestibility was observed between years (Tables 2 and 3). This was probably caused by the increased percentage of current annual growth in the second year resulting from clipping. Knox et al. (1958) found that repeated clipping tends to reduce lignin content and improve forage digestibility.

Plant vigor

The parameters used to describe plant vigor were: the number of live stems, branches, suckers and dead stems (whips) per plant. There was a significant ($F = 7.43$; $df = 1/48$; $p < 0.01$) decrease in the average number of stems per plant between years and a significant decrease ($F = 4.98$; $df = 2/48$; $p < 0.05$) between treatment levels (Tables 4 and 5). The greatest decrease in stems was found in the 60 and 90 percent clipping levels which may indicate that these levels of utilization are detrimental to plant vigor.

Spencer and Chatelain (1953) found that current years' growth was reduced, crude protein content decreased and forage quality declined from the effects of continued heavy browsing on willow plants.

Aldous (1952) found that moderate to heavy use of the annual growth of willow (Salix spp.) stimulated growth, increasing the weight of annual production every year until the fifth year when it had increased 855 percent. Larger but fewer stems were produced each year until the final clipping when the total number of stems was reduced by 41 percent.

A substantial decrease in stems was also observed in the control plants in the present study. Since these plants were not subjected to clipping, this suggests that some other factor was partially responsible for the mortality observed during the study. Some of the stem mortality on the taller willow plants appeared to have been caused by the yellow-bellied sapsucker (Sphyrapicus varius). These birds drill parallel rows of small holes in the stems, then feed on the sap and small insects which are attracted to the area (Figure 5). A large proportion of these stems died above the affected area. Although many species of insects and fungi are known to attack willows in the western United States (Furniss and Krebill, 1971, and Furniss and Barr, 1975), no significant damage of this kind was noted in the study area. The central stems of willow plants have been observed to die frequently because of decadence and possibly other unknown reasons. Perhaps one or more of these factors would account for the stem mortality observed in control plants.

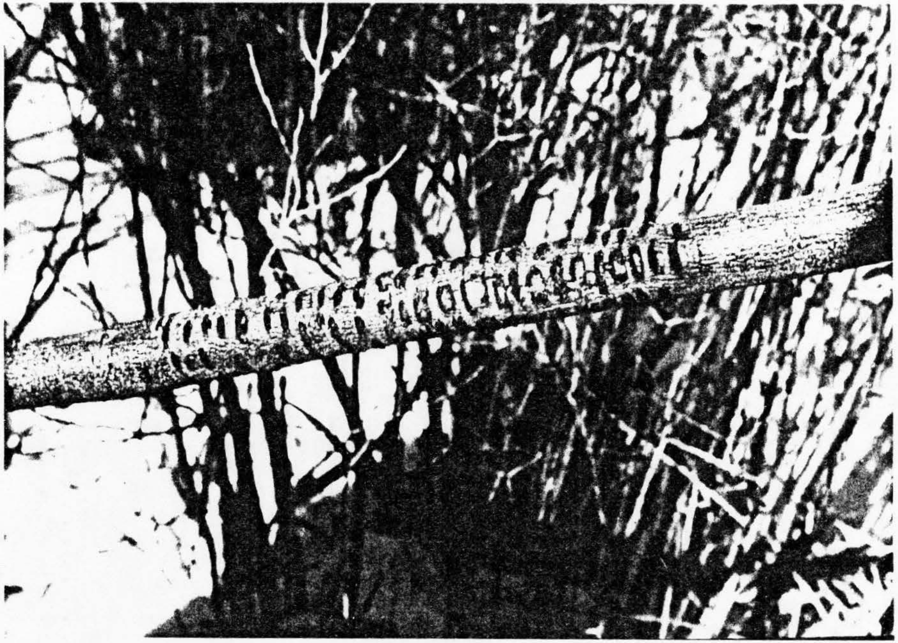

Figure 5. Damage to willow stems caused by yellow-bellied sapsuckers.

Table 4. Comparison of stem, branch and sucker production in response to treatment.

Year	Treatment percent clip	Mean no. per treatment level: Stems	Branches	Suckers	Percent decrease of stems	Percent increase of branches	Percent increase of suckers
1973	Control	104	431	27	--	---	--
1974	Control	92	576	52	12	34	93
1973	30	66	209	25	--	---	--
1974	30	57	330	31	14	58	24
1973	60	62	230	28	--	---	--
1974	60	46	366	35	26	59	25
1973	90	86	362	37	--	---	--
1974	90	64	740	39	26	104	5

Table 5. F values obtained from analysis of variance for plant vigor parameters in response to clipping.

Source of variation	Stems	Branches	Suckers	Whips
Treatment (A)	4.98*	16.52**	1.15	0.02
Year (B)	7.43**	17.10**	0.47	1.30
Interaction (AxB)	0.36	4.98*	0.08	4.51*

*Significant: $p < 0.05$.
**Significant: $p < 0.01$.

Branch production (Tables 4 and 5) increased significantly between years ($F = 17.1$; df = 1/48; $p < 0.01$) and in all treatment levels ($F = 16.52$; df = 2/48; $p < 0.01$). Although plant response seemed to increase proportionately to clipping intensity, other factors would have to be partially responsible to explain the observed increase in branch production among control plants. Some of this response might be accounted for by the removal of dead whips which would decrease the shading effect on the plants and stimulate new growth. Probably the most influential factor, however, was the increased precipitation during the spring of 1974 (Figure 6). Precipitation during the months of July through September, 1972, averaged approximately 2.35 cm. Precipitation for the same time period in 1973 averaged 7.7 cm, an increase of approximately 328 percent. Precipitation for the month of April, 1974, was approximately 48 percent higher than the mean for that month for the preceding two years. The combination of these two factors probably had the greatest influence on vegetation growth. It is, therefore, difficult to separate treatment response from the effects of differential environmental conditions during the growing season.

Average sucker production increased among all treatment levels and between years (Table 4) but the increases were not statistically significant, largely due to variation in production among individual plants. The greatest increase in sucker production was found in the control plants and the smallest increase in the 90 percent treatment level. Although some of the response of the control plants is probably due to more favorable growing conditions as discussed above, it would also seem to indicate that all clipping, as performed in this study, is somewhat detrimental to Drummond's willow. Reduction in photosynthetic tissue causes a decrease in nitrogen and carbohydrate reserves, which leads to a decreased rate of root and forage production (Stoddart and Smith, 1955).

Neither the differences in the number of dead whips (Table 6) observed between treatment levels nor between years were statistically significant. All dead whips were removed in the first year of the study, therefore, all whips present in the second year died during the

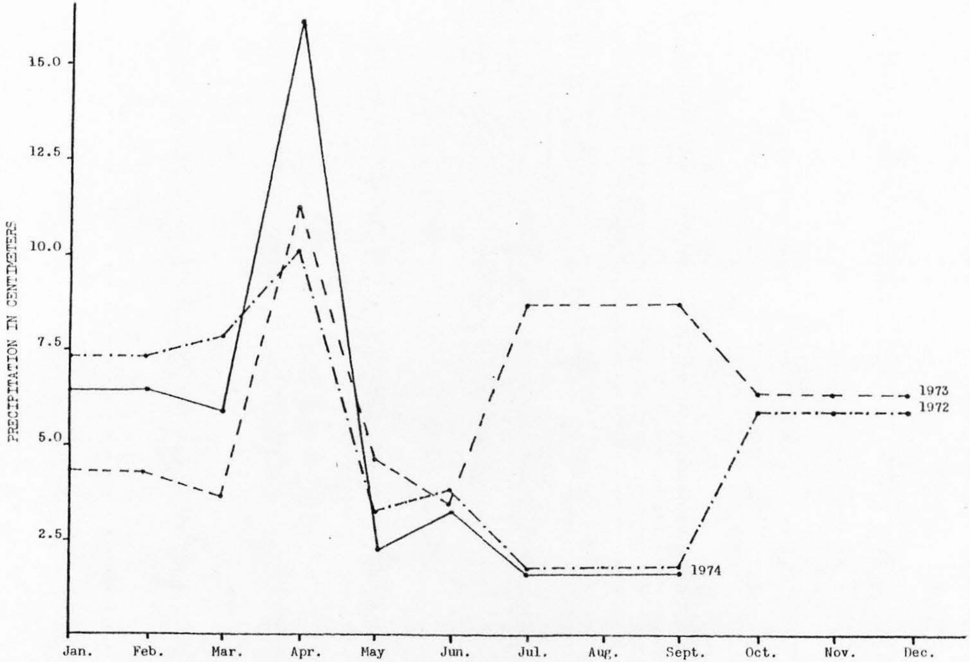

Figure 6. Approximate average monthly precipitation for the Henry's Fork clipping study area, 1972 - 1974. (Source: River Forecast Center, Salt Lake City, Utah).

study. Control plants and plants in the 90 percent treatment level showed a substantial reduction in stem mortality while mortality was observed to increase in the 30 and 60 percent treatment levels. The reason for this is not clear. The study must be continued for a longer period before more definitive conclusions can be drawn.

Table 6. Effect of treatment as determined by the average number of dead whips per plant.

Year	Percent clip	Average no. whips per plant	Percent difference between years
1973	Control	48	---
1974	Control	16	-67
1973	30	26	---
1974	30	28	+08
1973	60	22	---
1974	60	30	+36
1973	90	38	---
1974	90	13	-66

The mean yield of air-dried forage (Table 7) decreased at a highly significant ($F = 22.96$; $df = 1/48$; $p < 0.01$) rate between years and among all treatment levels ($F = 14.12$; $df = 2/48$; $p < 0.01$), the primary reason for this being the method of clipping employed. Plants can not maintain their rate of forage production when older age wood is harvested.

Table 7. Mean yield of air-dried forage by treatment and year.

Year	Treatment percent clip	Average yield per treatment level (gm.)	Percent reduction
1973	30	477	--
1974	30	353	26
1973	60	888	--
1974	60	436	51
1973	90	1,543	--
1974	90	591	62

In summary, it appears that plant vigor was adversely affected to some extent by all clipping intensities due to the method of clipping employed. However, some of the stem mortality was caused by injury from other sources or decadence, so it is difficult to determine at this time how much of the decreased plant vigor can be attributed to clipping and how much can be attributed to other causes. The study must be continued before more definitive conclusions can be drawn.

Comparison of crude protein content, phosphorus content and digestibility of current year's versus past years' growth

Crude protein and phosphorus content were found to decrease significantly (Table 8) with increasing twig age. The least significant difference (LSD) confidence interval test for percent crude protein content showed that years 1, 2 and 3 were significantly different, while years 4 and 5 were similar (Table 9). The LSD test for percent phosphorus content showed significance among all years' growth.

As plants mature, soluble carbohydrates are converted to structural carbohydrates with a resultant increase in cellulose, hemicellulose and lignin. Cell walls thicken and crude protein and phosphorus content decrease (Cook and Harris, 1950a, 1950b).

Houston (1968) noted a pronounced decrease in forage quality and digestibility between 6 and 18 month-old blueberry willow (S. pseudocardata) twigs due to significant differences in the chemical composition and increased lignification of older stems. He further hypothesized that poor quality diets, composed of larger amounts of 18 month-old willow twigs, might be largely responsible for decreased calf production by adversely affecting the physical condition of pregnant cows.

Ash content in this study was found to decrease significantly (Tables 8 and 9) with increasing twig age. The LSD test, however, showed that the only significant differences were among years 1, 4 and 5. Ash content is a measurement of all of the minerals contained in plants. As structural carbohydrates increase in older age stems, the mineral content decreases. A similar phenomenon also occurs as the growing season progresses. Dietz et al. (1962) found that willow browse samples contained high ash percentages in the spring, but the values decreased as the growing season progressed.

Table 8. F test values for comparison of nutrient content and digestibility of current year's versus past years' willow growth.

Percent ash	Percent crude protein	Percent Phosphorus	Percent digestibility
16.2	215.7	201.1	26.1

$F4/36 = 3.89$, $\alpha = .01$

The crude protein content of current annual Drummond's willow growth collected during the month of March in this study ranged from 6.69 to 7.94 percent, with an average of 7.36 percent. Milke (1969) found crude protein values of 7.0, 5.5, 6.4 and 6.1 percent for S. alaxensis, S. interior, S. myrtillifolia and S. niphoclada, respectively, during the month of March in Alaska. Gasaway and Coady (1974) found protein levels of 6.0 percent in washed rumen contents from winter moose diets in interior Alaska. Houston (1968) observed crude protein values of 6.8, 5.0 and 6.0 percent for S. geyeriana, S. interior and S. pseudocordata, respectively, during November in Wyoming. Low protein diets such as these are probably near the minimum required protein level for deer and other ruminants (Corbett, 1969; French et al., 1955; and Urness, 1973).

Phosphorus levels found in current annual growth in this study ranged from 0.13 to 0.16 percent with an average of 0.14 percent. This is well below the levels of 0.25 to 0.30 percent that Magruder et al. (1957) estimated were necessary for maintenance of white-tailed deer.

There was a highly significant decrease in digestibility with increasing twig age (Tables 8 and 9). The LSD test showed a significant difference in digestibility between years 1 and 2. Year 3 was not significantly different from years 2 and 4, and year 4 was not significantly different from year 5. Digestibility of 1 and 2 year-old willow browse (Table 9) ranged from fair to poor (30 to 40 percent) respectively according to the criteria used for deer by Urness (1973).

Using moose rumen material as inoculum, Oldemeyer (1974) determined mean digestibilities for willow browse of 34.5 and 37.3 respectively for February and March in Alaska.

Table 9. Yearly mean comparison of nutrient content and digestibility of current year's versus past years' willow growth.

	Age of growth	Mean ± 95% CI	Range
Ash content	1	2.20 ± 0.280	1.71 - 3.02
	2	1.92 ± 0.320	1.33 - 2.73
	3	1.81 ± 0.300	1.25 - 2.51
	4	1.39 ± 0.400	0.01 - 1.98
	5	1.05 ± 0.250	0.69 - 1.78
Crude protein content	1	7.36 ± 0.300	6.69 - 7.94
	2	5.08 ± 0.310	4.38 - 5.69
	3	4.37 ± 0.370	3.50 - 5.50
	4	3.25 ± 0.310	2.31 - 3.88
	5	2.91 ± 0.360	2.31 - 3.88
Phosphorus content	1	0.14 ± 0.007	0.13 - 0.16
	2	0.10 ± 0.008	0.08 - 0.12
	3	0.08 ± 0.006	0.07 - 0.10
	4	0.06 ± 0.004	0.05 - 0.07
	5	0.05 ± 0.006	0.04 - 0.06
Digestibility	1	36.39 ± 5.890	23.01 - 50.11
	2	27.41 ± 2.780	20.81 - 31.99
	3	24.54 ± 2.560	19.32 - 30.22
	4	20.43 ± 2.680	15.28 - 26.69
	5	16.48 ± 2.640	12.19 - 25.19

Wilson (1971) used a digestibility factor of 50 percent for his calculations to estimate the carrying capacity of the key browse species on the winter range of the Uinta North Slope. The results of this study indicate that this figure is too high and would thus tend to overestimate the carrying capacity of the range. Moreover, Wilson's estimate was derived from the caloric content of current annual willow growth only. As noted previously, however, the browse consumed by moose includes considerable amounts of second and third-year's growth. Since digestibility of the browse decreases with age, this method would result in further overestimation of the carrying capacity.

Other factors that should be taken into consideration include the size of the winter range and the availability of additional favored forage species such as aspen and cottonwood (*Populus angustifolia*). Wilson's caloric estimates were based on total acreage of willow vegetation as listed in Forest Service Range Allotment Analyses and aerial photographs. The area sampled, however, did not constitute the entire winter range. The greatest proportion of the lands administered by the Wasatch National Forest lie within the state of Utah. However, the major portion of the moose winter range extends 40 to 50 km. into Wyoming. This land is primarily controlled by the Bureau of Land Management and private interests. Survey figures since 1972 show that an average of 61 percent (range 37 to 75 percent) of the herd winters in Wyoming. Figure 7 shows a comparison of the size of the Uinta North Slope moose winter range as estimated by Wilson (1971) and as determined in this study by means of winter helicopter surveys. Examination of aerial photographs of the remaining portion of the winter range shows approximately 3,000 additional acres of mixed willow, aspen and cottonwood vegetation type which was heretofore not accounted for. This is an increase of 33 percent over Wilson's winter range acreage estimate.

Comparison of direct and indirect population enumeration methods

The winter of 1972-73 was characterized by numerous storms and above average snowfall. Because of this, and the inability to reschedule flights, only 10 of 23 scheduled fixed-wing flights

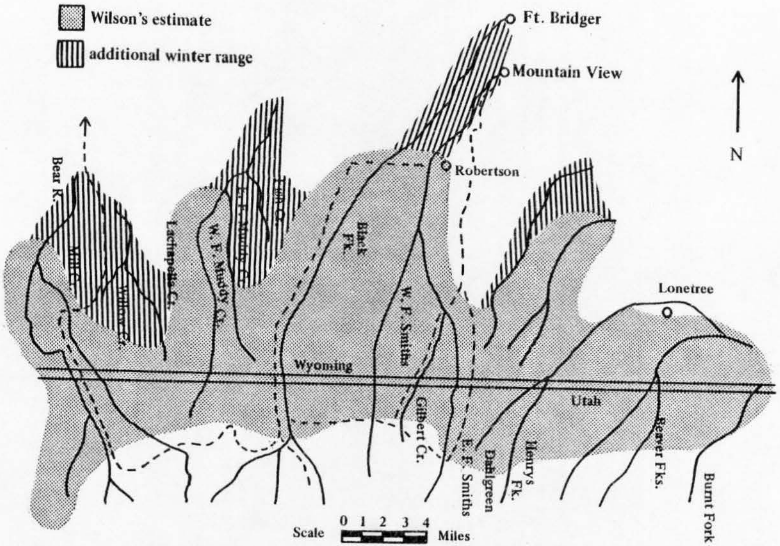

Figure 7. Comparison of the present size of the winter range of the Uinta North Slope moose herd with Wilson's (1971) estimate.

could be made (Figure 8). The pellet deposition period for the winter of 1972-73 was 253 days. A maximum count of seven animals was made by helicopter in January, 1973. Heavy snowstorms prior to the helicopter survey pushed the moose further down on the winter range. By the time the helicopter survey was made, only the lower half of the study area was inhabited by moose.

The pellet deposition period for the winter of 1973-74 was 269 days. Eighteen flights were made during this period (Figure 9), with a maximum of 23 moose counted on the study area in January. Using a daily defecation rate of 13 groups per animal per day (Vozeh and Cumming, 1960), the population estimates for the study area, calculated from the mean pellet groups per plot (Table 10) were 528 and 211 moose for the winters of 1972-73 and 1973-74, respectively.

Table 10. Pellet plot data for the west fork of Smith's Fork study area, 1973-74.

Year	Transect name	Mean pellet groups per plot ± 95% CI	Moose days use per acre
1973	Stateline	0.45 ± 0.20	3.46
	Middle	0.38 ± 0.14	2.90
	Boundary	0.30 ± 0.25	3.85
1974	Stateline	0.10 ± 0.17	3.08
	Middle	0.63 ± 0.24	4.85
	Boundary	0.58 ± 0.26	2.31

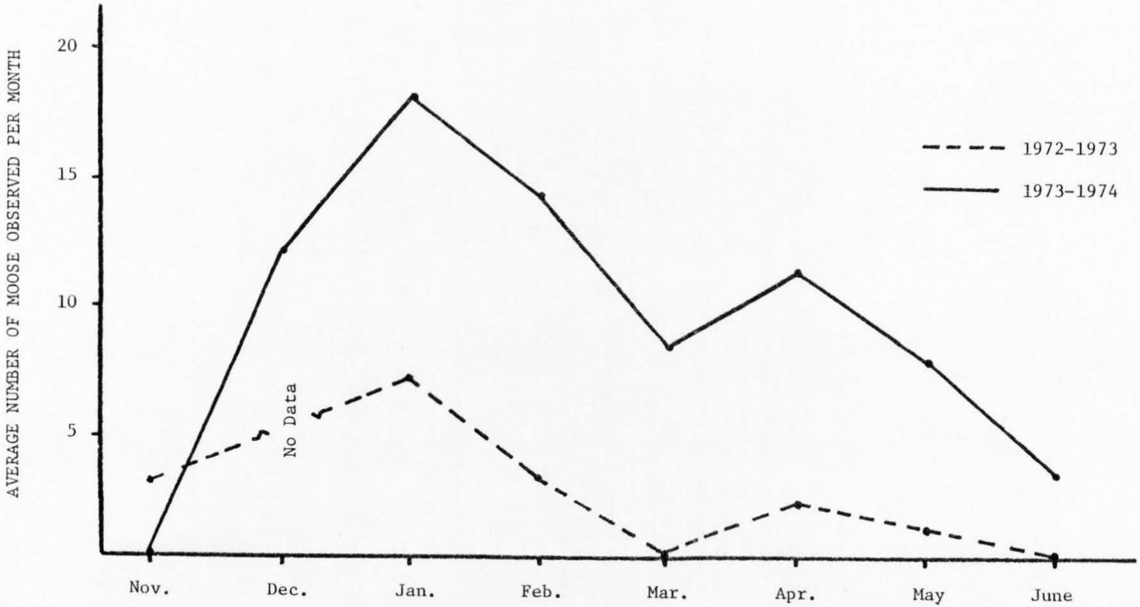

Figure 8. Results of the winter moose survey flights on the west fork of Smith's Fork study area, 1973 and 1974.

The lack of correlation between the two population estimates might be the result of a number of variables such as the flight speed of the aircraft, observer experience or weather conditions. The winters of 1973 and 1974 were typified by above average snowfall. This forced the moose which normally winter on the study area further down on the winter range, thus causing a discrepancy between numbers of moose observed and pellet group counts.

Pellet group counts indicate that some portions of the study area are used infrequently or not at all by moose during the winter. If this is true, it would cause a significant decrease in the population estimate derived from the pellet group counts. The estimate was recalculated, decreasing the acreage to allow for the areas in which no pellet groups were found. The resulting population estimates were 320 and 128 moose for 1973 and 1974, respectively.

Average daily moose defecation rates vary widely from area to area and between sex and age classes. Diet may also affect defecation rates as documented by Smith (1964) with mule deer (Odocoileus hemionus). Vozeh and Cumming (1960) reported a defecation rate of 13 moose pellet groups per day from data collected by R.Y. Edwards in Wells Grey Park, British Columbia. DesMeules (1968) found an average defecation rate of 21.5 groups per day for two moose (11.9 by a cow and 9.6 by a calf) over a period of 11.3 days in Laurentides Provincial Park, Quebec. LeResche and Davis (1971) determined a rate of 32.2 groups per day from cleared plots in a 2.6 km^2 pen in Alaska. A daily defecation rate of 17.9 pellet groups per day was calculated during this study for the Uinta North Slope moose herd. This corresponds closely to the combined mean defecation rate of 17.6 groups per day for adult moose of both sexes reported by Franzmann et al. (1976) in Alaska. Table 11 shows a comparison of population estimates derived for the study area using various defecation rates.

Table 11. Population estimates for the west fork of Smith's Fork study area (1973-74) derived by using various defecation rates.

Defecation rate	Population estimates 1973	1974
13.0[a]	320	128
17.6[b]	230	77
21.5[c]	186	64
32.2[d]	128	45

[a]Vozeh and Cumming (1960)
[b]Franzmann et al. (1975)
[c]DesMeules (1968)
[d]LeResche and Davis (1971)

The results of this study indicate that aerial population estimates tend to be less than those derived from pellet group counts. This agrees with the findings of Timmerman (1974) and others. Simkin (1959) and Gustin (1973) estimated 200 and 400 percent, respectively, more moose by pellet group counts than by aerial surveys. LeResche and Davis (1971) suggested that up to 31 percent of the animals may be missed by aerial counts. LeResche and Rausch (1974) found that with experienced observers and under ideal conditions they were able to count only 68 percent of the moose present. Franzmann et al. (1975) found that differences in defecation rates between sexes in adult moose made knowledge of the sex structure of a population mandatory when the pellet group census technique was used. The results of this study agree with those of Simkin (1959) who found that the pellet group count provides a useful index to moose population numbers rather than a reliable estimate.

Management recommendations

The results of the clipping study were inconclusive due to extreme variations in precipitation, multiple mortality factors and insufficient time to determine the long term effects of treatment levels on plants. The study should be continued until more definitive conclusions can be drawn.

Food habits for the Uinta North Slope moose herd should be determined for all seasons of the year and a range inventory should be conducted to determine the relative abundance of the favored forage species. Digestibility and proximate analysis studies should be carried out during all seasons of the year to determine the nutritional value of these species. After these objectives have been completed a better estimate of the carrying capacity of the range can be made.

The pellet group method, as it is now being used for moose in Utah, has proven to be inadequate for reliable population estimates. If this technique is to be used for more than just an index of population trends further refinements such as determining the variability of deposition rates between sex and age classes should be determined.

As mentioned earlier, moose defecation rates have been shown to vary widely, even within the same geographic area. Although a defecation rate of 17.9 pellet groups per day was calculated in this study, additional research should be conducted to determine if this figure is truly representative for the Uinta North Slope herd before incorporating it into future management programs.

Aerial surveying continues to be the only practical means of estimating moose numbers on the Uinta North Slope. In the past, survey efforts have been restricted mainly to the willow bottoms. During open winters moose are not restricted to these areas, however, and survey results have not been reliable. Since most of the North Slope vegetation is comprised of lodgepole or lodgepole-aspen types it is impossible to conduct a reliable aerial survey over the entire area. Investigations should be made into the possibility of conducting a random stratified quadrat survey which would allow a more representative sample to be made.

SUMMARY

The primary objectives of the study were: (1) to determine the effects of various simulated levels of moose utilization on the crude protein content, phosphorus content, digestibility and vigor of willow plants; (2) to compare the crude protein content, phosphorus content and digestibility of current year's versus past years' willow growth and (3) to compare the validity of direct and indirect population enumeration methods for development of a standardized moose census technique.

A 0.40 ha. exclosure was constructed and willow plants within the exclosure were subjected to clipping intensities of 30, 60 and 90 percent of the cumulative 1, 2 and 3 year-old growth. Ten replications of each treatment were performed and 10 additional plants were left untreated to serve as controls.

An analysis of variance of the crude protein and phosphorus content showed highly significant increases between treatment levels, indicating a greater concentration of these nutrients in response to the increased percentage of current annual growth due to clipping.

Dry matter content did not change significantly between treatment levels, but there was a significant decrease between years. There was a highly significant increase in digestibility between years.

Plant vigor determinations were confounded by additional sources of mortality and above average precipitation in the spring of 1974. When all factors are considered, it is difficult to separate treatment response from the effects of differential environmental conditions during the growing season.

A number of Drummond's willow plants were selected during the dormant period and 10 stems were cut from each plant. The various year's growth from each plant, through the fifth year, were separated and analyzed to compare nutrient content and digestibility. Crude protein, phosphorus and ash content, as well as digestibility, were found to decrease significantly with increasing twig age.

A comparison of the results of this study with the data from Wilson's (1971) study indicates that a digestibility factor of 50 percent, which was used to determine the carrying capacity, is probably too high. This would tend to decrease Wilson's carrying capacity estimate. Other factors that should be taken into consideration, however, include a much larger winter range than Wilson estimated and the availability of additional favored browse species. These factors, in combination, should increase the carrying capacity estimate considerably.

A study area of approximately 4,200 ha. was selected in an area of high winter moose concentration to compare direct and indirect population enumeration methods. Swept pellet-group transects were established and stratified according to moose concentration and vegetation type. Weekly fixed-wing flights were scheduled, beginning in early November, to determine the relative increase of moose on the winter range. When population levels in the study area leveled off, it was assumed that the full wintering population was on the winter range. The study area was then surveyed with a helicopter to obtain a more accurate population estimate. Fixed-wing observations were continued throughout spring until the majority of the moose population had moved off the study area.

Pellet-group transects were read after the snow melted and moose days use for the area was determined. A defecation rate of 17.9 pellet groups per day was determined in this study. Various moose defecation rates found in the literature were used to determine the wintering population at the time of maximum concentration. The population estimates were then compared to the results obtained by the aerial surveys to determine if any correlation existed. None of the estimates showed close correlation with the aerial surveys.

The lack of correlation found between the two population estimation methods might be caused by a number of variables such as flight speed of the aircraft, observer experience or weather conditions. Above average snowfall during the winters of 1973 and 1974 forced moose, which normally winter on the study area, further down on the winter range, thus causing a discrepancy between numbers of moose observed and pellet group counts. Present data indicate that the pellet group count method provides a useful index to moose population numbers rather than a true estimate.

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