BROWSE PRODUCTION AND ITS USE BY MOOSE AND SNOWSHOE HARES AT THE KENAI MOOSE RESEARCH CENTER, ALASKA

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Abstract: A 4-year study conducted at the Moose Research Center (MRC) on the Kenai National Wildlife Refuge, Alaska evaluated the effect of different densities of moose (*Alces alces*) on paper birch (*Betula papyrifera*) production and use. Production and use of quaking aspen (*Populus tremuloides*) and willow (*Salix* spp.) were also estimated and the impact of snowshoe hares (*Lepus americanus*) on paper birch was evaluated. The study was conducted in 4 2.6-km^2 enclosures at the MRC where moose densities ranged from 1,237 to 5,851 moose-days/pen/winter period. Paper birch produced an average of 102 kg/ha in the 4 enclosures whereas willow and aspen together produced only 3.7 kg/ha. During the 1st 3 years there was a significant difference in per-plant production among 5 important vegetative types. Use by moose at higher densities affected mean plant production the 3rd and 4th years. Birch use ranged from 31.8 to 83.3% of current annual production. During the 4 years, snowshoe hares browsed a greater percentage of tagged plants than did moose. Sixty-five percent of the birch plants browsed by hares were less than 1.5 m tall and 62% of those browsed by moose were taller than 1.5 m. Birch plants browsed in a given year were shorter on the average the following growing season. Seventy percent of the willow and 58.7% of the aspen plants were browsed during winter.

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I evaluated the effects of forage use by moose at the Moose Research Center (MRC) on the Kenai National Wildlife Refuge (KNWR), Alaska from October 1971 through May 1975. The primary objective was to evaluate the effect of different moose densities on production and use of paper birch. Although quaking aspen and willow occur at the MRC, paper birch was the most abundant forage species and LeResche and Davis (1973) found that it composed the bulk of the moose's year-round diet. Snowshoe hares were near a cycle high when the study began and were having an obvious effect on the vegetation. Secondary objectives were to estimate production of aspen and willow and their use by herbivores, and to evaluate the impact of snowshoe hares on paper birch.

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STUDY AREA

The MRC is in the northern portion of the Kenai lowlands on the western side of the Kenai Peninsula. Vegetation in the lowlands consists of plants associated with the northern boreal forest where white spruce (*Picea glauca*) is the climax tree and seral communities contain paper birch

Table 1. Days of use by moose (number of moose) in 4 pens at the Kenai Moose Research Center during winters 1 October 1971–1 May 1974 (from A. W. Franzmann and P. D. Arneson, unpubl. rep., Alaska Dep. Fish and Game Fed. Aid Proj. W-17-7, 1975).

	Pen			
Winter	1	2	3	4
1971	3,625 (17)	4,183 (20)	2,486 (12)	5,851 (28)
1972	2,515 (12)	2,956 (14)	1,484 (7)	4,084 (19)
1973	1,662 (8)	3,015 (14)	1,816 (9)	3,910 (18)
1974	1,237 (6)	2,590 (12)	1,600 (8)	3,213 (15)

and aspen mixed with white spruce. Black spruce (*Picea mariana*) occurs in wetter and disturbed sites. The MRC consists of 4 enclosures, each 2.59 km^2, within a 125,500-ha area that was burned in 1947. This fire had a beneficial effect on moose populations because it created seral ranges containing an abundance of browse species (Spencer and Hakala 1964).

Vegetation in the pens at MRC was not disturbed following 1947 other than minimal clearing when the fences were built during 1968–70. The moose populations (Table 1) were managed to maintain 3 levels: a normal level comparable to outside the MRC (pen 3); an unrestricted level allowed to fluctuate naturally (pens 1 and 2); and a high level that severely overused the vegetation (pen 4). During the last 2 years of the study, production and use of browse outside the enclosures was evaluated.

METHODS

Twenty stands of vegetation, ranging from 0.18 to 1.25 ha, were randomly selected for study in each pen except for pen 4, which contained 21 stands. A stand was described for this study as being of 1 vegetative type and relatively uniform topography. Seven upland vegetative types occur in the MRC; however, only 5 were of importance as browse-producing types (dense, medium, and thin birch-spruce regrowth; spruce-birch regrowth; and thin, mature hardwoods). The number of stands sampled in each of the 5 vegetative types was determined by a combination of the size of the vegetative type in the pen and the relative importance of the type for producing moose forage (Oldemeyer 1981). Twenty stands sampled outside the MRC were allocated proportionately to vegetative types of the 81 stands within the pens and were no closer than 400 m to any fenceline.

In each stand, I estimated density of woody plants using a sample of 25 randomly located 1 × 5-m quadrats. I randomly selected and tagged 24 individual birch saplings in each stand to study birch production and use. Saplings more than 50 cm tall and less than 4.2 cm dbh were considered available browse. Production and use were estimated in pens 3 and 4 in 1971–75, pen 2 in 1972–75, and pen 1 and outside in 1973–75.

Regression equations of the form:

$$\text{production} = a + b_1(\text{circumference}) + b_2(\text{circumference})^2 + b_3\sqrt{\text{number of current annual growth (CAG) twigs}}$$

were developed from clipped plant measurements and weights each fall and were used to estimate current annual growth production of each tagged sapling (Oldemeyer 1982). Diameters of browsed twigs on the tagged saplings were measured each spring and regression equations of the form:

$$\text{twig weight} = a + b_1(\text{twig diameter}) + b_2(\text{twig diameter})^2$$

were used to estimate current growth removed from each tagged sapling. I also recorded whether the plant had been browsed by moose or snowshoe hares.

Willow and aspen saplings were sampled for production and use only during 1974–75 due to their scarcity. Of the 20 stands in each enclosure, the 2 with the greatest density of aspen or willow were selected for study. Twenty-four aspen or willow were selected and tagged in the same manner as birch except there was no minimum size restriction. Regression estimation of production did not work well because of the reduced vigor of the plants. Therefore, only CAG and height were used to describe production, and percentage of tagged plants browsed was used to describe use.

RESULTS

Woody-plant Density

Most of the study stands were in the birch-spruce regrowth types because they produced the most browse (Oldemeyer 1981). Dense, mature hardwoods composed a large proportion of the MRC; however, so little browse was produced in this type that it was not given enough weight, compared with other types, to warrant establishment of study stands.

Fifty-four percent of the area of the MRC was regrowth vegetation, the result of the 1947 fire. In regrowth stands, black spruce and paper birch were the dominant species. Of the browse species (paper birch, willow, aspen), paper birch had a relative density of 90% in all vegetative types except thin, mature hardwoods. Willow had a relative density in regrowth types of 7%. Aspen was most important in thin, mature hardwood types, where its relative density was 49%.

Average birch density ranged from 3,813 plants/ha in the thin mature hardwood type to 24,983 plants/ha in the dense birch regrowth type. Birch density in dense, birch regrowth types was somewhat higher than browse density at 1 of the highest browse-producing areas on the KNWR studied by Oldemeyer and Regelin (1980*a*) and was higher than in regrowth stands measured in other parts of Alaska (Milke 1969, Wolff and Zasada 1979). However, Wolff (1980) estimated densities of 20,512 plants/ha in black spruce thickets in interior Alaska.

Birch Production

Average birch production was compared among types and among pens for each of the 4 years by analysis of variance. Significant differences ($P \geq 0.95$) occurred each year (Table 2). During the first 2 years, these differences were among types, and the type means maintained the same relative order each year. Average birch production was greatest in spruce-birch regrowth stands (4.3 and 9.0 g/plant in 1971 and 1972, respectively) whereas thin, mature hardwood stands produced only 1.4 and 1.7 g/plant, respectively.

By 1973 the different moose densities were having detectable influence on plant production (Table 2). Plant production in pen 1 was highest at 6.9 g/plant whereas pen 3 was lowest at 3.7 g/plant. During 1973 there was also a significant difference in plant production among types, with a ranking order similar to that in previous years. The order of production among pens was similar in 1974, except the average production per plant was lowest in pen 4 rather than in pen 3.

Total birch production was greatest in pens 1 and 2 (Table 3). The difference in production between pens 3 and 4 increased each year for the 4-year period as did the difference between pens 2 and 4 for 1972–74. Production varied annually due to precipitation and growing season, but the trend indicates that the heavy stocking rate of moose in pen 4 reduced production.

Dense birch regrowth stands produced,

Table 2. Birch production (g) on a per-plant basis by habitat types and years at the Kenai Moose Research Center. Sample sizes are in parentheses. Type means with the same letters were not different ($P < 0.9$).

		Cover type					
Year	Pen	Dense birch-spruce regrowth	Medium birch-spruce regrowth	Thin birch-spruce regrowth	Spruce-birch regrowth	Thin mature hardwoods	Pen average
1971	3	3.5 (192)	2.1 (120)	3.2 (96)		1.6 (72)	2.8 (480) a
	4	3.7 (72)	3.2 (144)	2.5 (120)	4.3 (96)	1.2 (72)	3.0 (504) a
	Type mean	3.5 (264) a	2.7 (264) a	2.9 (216) a	4.3 (96) a	1.4 (144) a	2.9 (984)
1972	2	6.4 (120)	6.4 (144)	4.9 (120)	13.8 (48)	2.1 (48)	6.3 (480) a
	3	5.3 (192)	3.8 (120)	5.2 (96)		2.1 (72)	4.4 (480) a
	4	7.1 (72)	4.0 (144)	4.8 (120)	6.6 (96)	1.1 (72)	4.7 (504) a
	Type mean	6.1 (384) ab	4.8 (408) b	5.1 (336) b	9.0 (144) a	1.7 (192) c	5.2 (1,464)
1973	1	6.2 (240)	8.8 (120)	3.1 (72)	11.5 (48)		6.9 (480) a
	2	5.5 (120)	5.3 (144)	5.7 (120)	10.8 (48)	1.4 (48)	5.6 (480) ab
	3	4.5 (192)	2.8 (120)	4.7 (96)		1.5 (72)	3.7 (480) b
	4	5.5 (72)	2.9 (144)	4.4 (120)	6.2 (96)	0.8 (72)	3.9 (504) b
	Outside	4.3 (120)	6.8 (144)	3.1 (48)	6.6 (96)	2.0 (72)	5.1 (480) ab
	Type mean	5.3 (744) ab	5.3 (672) ab	4.5 (456) b	8.0 (288) a	1.4 (264) c	5.0 (2,464)
1974	1	9.1 (240)	12.7 (120)	4.2 (72)	15.2 (48)		9.8 (480) a
	2	8.0 (120)	7.6 (144)	8.1 (120)	15.0 (48)	2.6 (48)	8.0 (480) ab
	3	6.5 (192)	3.9 (120)	7.8 (96)		3.0 (72)	5.6 (480) b
	4	7.5 (72)	5.4 (144)	5.8 (120)	6.2 (96)	1.5 (72)	5.4 (504) b
	Outside	6.6 (120)	8.2 (144)	6.2 (48)	8.6 (96)	4.1 (72)	7.1 (480) a,b
	Type mean	7.7 (744) ab	7.5 (672) ab	6.6 (456) b	10.0 (288) a	2.8 (264) c	7.2 (2,424)

on the average, as much as 223 kg/ha whereas thin mature hardwood stands produced only a maximum of 32.5 kg/ha. Much of the difference is undoubtedly due to birch density in those habitat types; however, birch production was consistently low on a per-plant basis in the thin, mature hardwoods type.

Table 3. Birch production (kg/ha) by cover type, pen, and year at the Kenai Moose Research Center.

		Cover type					
		Regrowth					
Year	Pen	Dense birch-spruce	Medium birch-spruce	Thin birch-spruce	Spruce-birch	Thin mature hardwoods	kg/pen
1971	3	172.7	91.0	82.8		6.0	11,619
	4	101.8	105.2	97.2	76.2	6.7	10,295
1972	2	131.0	136.2	63.0	93.5	11.1	12,357
	3	166.0	85.6	86.9		6.3	11,347
	4	97.2	71.9	109.0	77.4	4.3	9,115
1973	1	141.5	115.9	51.4	41.4		13,033
	2	127.8	139.5	64.3	77.8	8.1	11,867
	3	151.2	80.1	74.7		4.7	10,226
	4	86.3	52.4	100.8	64.0	3.9	7,681
	Outside	125.0	120.7	85.5	63.8	17.9	
1974	1	223.1	179.0	97.0	62.2		20,866
	2	186.5	190.0	101.1	104.4	14.1	17,318
	3	217.0	109.5	124.0		8.0	15,058
	4	116.5	100.5	159.4	74.1	7.3	12,292
	Outside	187.6	159.3	158.6	92.0	32.4	

Table 4. Use of birch at the Kenai Moose Research Center by moose and snowshoe hares. Use is expressed as percentage of production, CAG, and plants browsed.

	Pen 1			Pen 2			Pen 3			Pen 4			Outside		
Year	Production	CAG	Plants	Production	CAG	Plants	Production	CAG	Plants	Production	CAG	Plants	Production	CAG	Plants
1971							31.8	31.1	64.4	61.8	62.9	87.1			
1972				58.2	60.6	81.7	55.4	58.8	77.9	75.2	79.0	94.4			
1973	46.2	43.7	66.3	75.5	73.0	91.3	72.8	71.7	89.0	83.3	83.2	94.4	65.1	63.6	87.3
1974	43.2	43.3	67.1	51.8	54.0	77.1	39.6	40.6	60.0	62.1	63.6	81.7	44.6	47.7	75.4

Aspen and Willow Production

Production of willow and aspen was considerably less than birch for both species in all pens and vegetation types. Birch produced an average of 102 kg/ha in the 4 pens whereas willow and aspen combined produced an estimated 3.7 kg/ha, or 3.5% of the total browse production in 1974. Production of willow and aspen was lower than on ranges examined by Wolff (1978) and Milke (1969), where up to 204 kg/ha of willow was produced. Birch production was similar to production of mountain maple (*Acer spicatum*) and beaked filbert (*Corylus cornuta*), individually, on the Gaspé Peninsula (Bedard et al. 1978). Total browse production at that study location included balsam fir (*Abies balsamea*) and exceeded 600 kg/ha on browsed range 8 years postlogging. On a 20–25-year-old clear-cut in New Brunswick, Telfer (1972) reported deciduous browse production of 112 kg/ha, similar to that at the MRC.

Birch Use

Birch use by both moose and snowshoe hares (Table 4) ranged from 31.8 to 83.3% of current annual production. Pen 3 had the lightest use except in 1973–74. During each year, pen 4 had the heaviest use, ranging from 61.8 to 83.3% of the production.

Percentage of plants and CAG browsed was high (Table 4). Up to 94.4% of the plants and 83.2% of CAG in pen 4 were browsed. Of the 5 habitat types, average percentage of birch production browsed was lowest in the thin, mature hardwood type (50.9%). This was probably due to a combination of low density of food in that type, the short height of plants that made them unavailable for part of the winter, and the availability of an alternate food, aspen. Average use was highest in the dense, birch regrowth types over the 4 years (62.1%).

Birch plants were subdivided into those browsed only by moose, those browsed only by snowshoe hares, and those browsed by both (Table 5). Hares browsed a greater percentage of plants than did moose in most years, pens, and types. Of those plants browsed only by moose, percentage of production browsed ranged from a low of 47.0% outside the MRC during 1974–75 to a high of 76.2% in pen 4 during 1973–74. During each year, use was highest in pen 4. Percentage of all plants browsed by moose ranged from a low of 25.0% in pen 3 in 1974–75 to a high of 56.0% outside during 1973–74, and was consistently highest in pen 4 and outside.

Snowshoe hare browsing was greatest (89.6% of production) during 1973–74, the year I considered to be the peak of the population cycle. Use among types was similar, except for the spruce-birch type, in which use was considerably lower than the others. Browsing intensity of the plants browsed only by hares was greater than

Table 5. Use of plants browsed by moose or hares by year and pen, Kenai Moose Research Center.

		Percent browsed by moose				Percent browsed by hares			
				Plants by				Plants by	
Year	Pen	Current annual production	CAG twigs	Moose	Moose and hares	Current annual production	CAG twigs	Hares	Moose and hares
1972	2	51.3	52.5	12.9	36.3	79.8	81.2	45.4	68.8
	3	57.4	61.7	18.8	34.1	81.2	84.6	42.1	59.2
	4	67.2	71.0	20.0	50.8	87.2	88.9	43.6	78.1
1973	1	53.0	47.9	32.5	39.8	88.7	87.6	26.4	33.8
	2	70.2	65.0	25.8	41.0	90.6	88.8	50.6	67.9
	3	68.3	62.2	14.4	33.8	89.2	88.5	55.2	74.6
	4	76.2	79.0	14.3	42.3	92.2	90.7	52.2	80.2
	Outside	63.1	59.0	32.1	56.7	85.1	84.0	30.6	55.2
1974	1	58.4	55.4	15.0	26.5	68.2	69.0	40.6	52.1
	2	54.9	58.5	19.6	39.0	75.6	77.6	38.1	57.5
	3	54.6	51.3	16.0	25.0	72.6	74.3	35.0	44.0
	4	64.5	66.2	28.0	53.4	82.6	83.2	28.4	53.8
	Outside	47.0	49.8	30.4	46.7	70.4	73.0	28.8	45.0

on the plants browsed only by moose (Table 5).

Lower levels of hare browsing were observed by Telfer (1972) in New Brunswick, where snowshoe hares browsed up to 4.9% of the available forage in a 15–18-year-old cutover. Pease et al. (1979) determined that in about half of the woody stems sampled, over 50% of the terminal twig or the lateral twigs had been clipped off by snowshoe hares. They considered this level of use to be heavy to severe browsing.

Birch Response to Browsing

I evaluated plant response to different browsing intensities using differences in production and height (Figs. 1, 2). A production ratio was calculated for each of 11 use categories (0 to 100% in 10% increments) by summing the production estimates of the plants in a given use category and dividing that sum by the summed production of those same plants the previous year. The ratio behaved erratically each of the 3 years (Fig. 1). In 1972 the ratio peaked at 30 and 70%. In 1973 the ratio dropped below the level of the 0% browsed plants and continued this decrease to the point that the 1973 plants only produced about 65% as much forage at the 100% use level as they did in 1972. In 1974 the ratio peaked at 30% use followed by a drop to below the 0% ratio that continued to the 100% level.

A height ratio using fall height measurements was calculated in a manner similar to the production ratio (Fig. 2). In 1972 and 1973, the ratio decreased to a level below the 0% browsed-plant ratio. In 1974 the ratio peaked at 10%, gradually decreased, and went below the ratio of the 0% browsed plants when use was at the 50% level.

The response in birch production contrasts to what Aldous (1952) observed for birch in the Great Lakes region and to what Garrison (1953), Ferguson and Basile (1966), Willard and McKell (1978), and Wolff (1978) observed. The Kenai lowlands are at a western extreme of the boreal forest and the range of paper birch in Alaska. This growing location may affect the response of birch to browsing. During 1973, when May–September precipitation was lowest and when degree

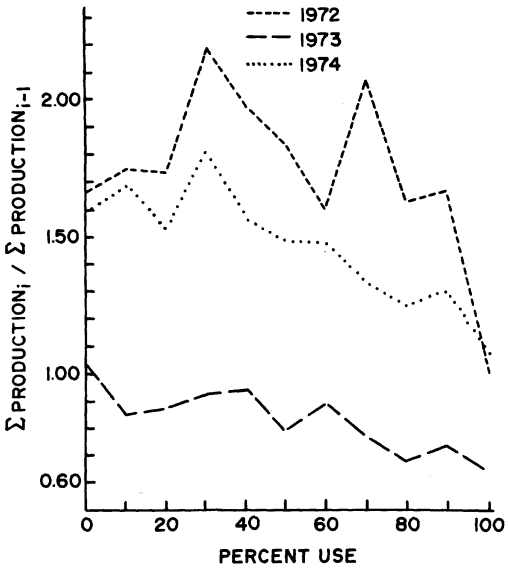

Fig. 1. Response of birch production to different intensities of browsing (*i* refers to year).

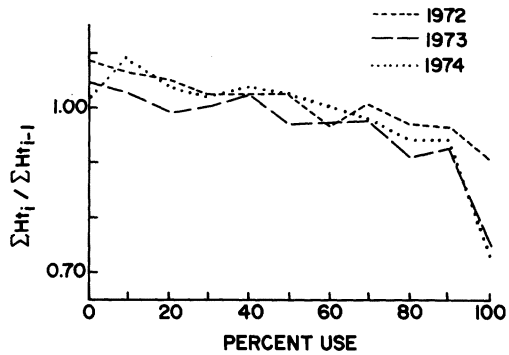

Fig. 2. Response in height growth of birch to different intensities of browsing (*i* refers to year).

days were the highest of the 4 years of the study, the response curves showed no stimulation effect of browsing (Figs. 1, 2). A slight stimulation in production at low use levels was observed when weather was warmer and wetter in 1972 and 1974. Near Aldous' (1952) study sites in the Great Lakes region, both temperature and precipitation are normally greater than on the Kenai lowlands, perhaps inducing the response reported by Aldous (1952).

Broken Stems of Birch

Telfer and Cairns (1978) found that moose broke stems up to 3.5 cm dbh. I found larger stems broken and set the maximum size limit for browse as 4.2 cm dbh. As a result, some tagged plants exceeded 4 m in height. In many other studies, 2.5 m is considered an upper limit for moose browse; my data indicate that 2.5 m is not a realistic maximum height for moose browse studies.

Stem breakage averaged only 0.4% of the marked plants per year in pen 4 and 2.1% in pen 1. Height of broken plants in 1974 ranged from 1.7 to 5.0 m and averaged 2.4 m. Plants of this height averaged over 15 g of forage production but composed only 5% of the browse population (Fig. 3). None of the marked plants that were broken died.

Birch Mortality

Hare browsing caused birch mortality in 9% of the 2,424 tagged plants during winter 1973–74. Clipping the stem below the lowest external bud was generally the cause of mortality. This high mortality followed the peak in the hare population cycle at the MRC. The previous fall, 5% of the tagged plant population was replaced because of mortality.

Although no mortality was attributed to moose in this study, early investigations (unpubl. annu. rep., Kenai Natl. Moose Range, Kenai, Alaska, 1965:46*a*) showed mortality of tagged browse plants over a 12-year period. At the end of 12 years, 75% of the willow, 65% of the aspen, and 44% of the birch plants had died. This mortality was attributed to heavy browsing by moose.

Aspen and Willow Use

Browsing levels of willow and aspen were high. Fall production surveys re-

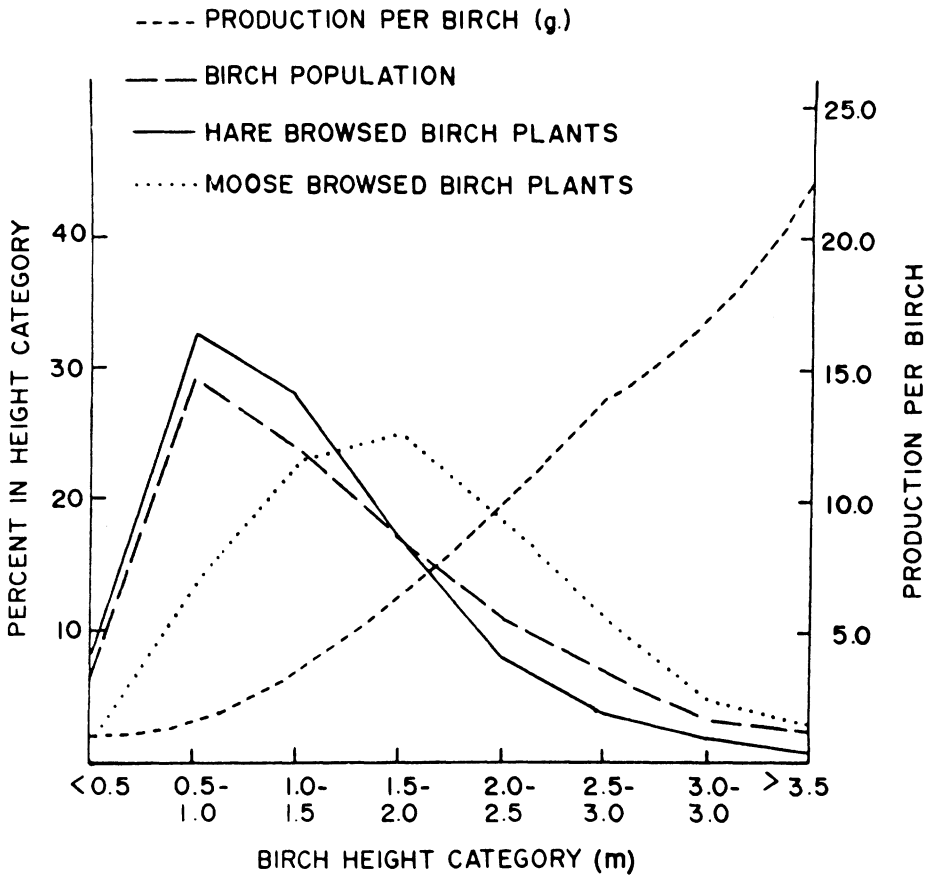

Fig. 3. Birch heights as related to production, browsing by moose and hares, and the normal birch population at the Kenai Moose Research Center and outside study sites.

vealed an average of 40.7% of the aspen plants in the 10 study stands had been browsed. By spring, use had increased to 57.8%. Willow use was higher than aspen use both in the fall and spring surveys; 55 and 70%, respectively, of the willow plants were browsed.

In regrowth stands, willow and aspen were generally found growing between 2 or more close-growing spruces, and were therefore protected from moose. Height distribution and production of these species are indicative of intense browsing. In lightly browsed stands, both species would have been considerably more productive. Peek et al. (1976), for example, estimated use levels of 11–48% of leaders browsed on willow and aspen and believed that this use was not excessive with respect to plant vigor and production.

Allocation of Birch to Browsers

A record of which species browsed each twig was not kept; thus, only a range of use by species can be made. Over 65% of the plants browsed by hares were less than 1.5 m tall (Fig. 3). These plants averaged less than 3.5 g production each. On the other hand, 62% of the birch plants browsed by moose were over 1.5 m tall.

These plants averaged at least 6.4 g production. Whereas hares browsed the shorter plants, they also browsed birch proportionately to its occurrence.

The plants browsed only by moose were larger than those browsed only by hares. Using the data available (Table 6) and the moose density in each pen, I calculated the kilograms of birch browsed by moose in each pen. For those plants browsed only by moose, this value ranged from 0.18 kg/moose-day in pen 4 to 1.94 kg/moose-day in pen 1. This represents a minimum consumption, because it is composed only of birch production of the plants browsed only by moose. Ignoring the plants browsed only by hares and assuming (incorrectly) that moose consumed all the forage browsed on the remaining browsed plants, the maximum daily consumption could have ranged from 1.2 to 3.8 kg/day of birch. LeResche and Davis (1973) estimated that moose consumed 1.3 kg/day of forage during winter 1970–71 on normal ranges in the MRC. Almost 15% of that was cranberry (*Vaccinium vitis-idaea*). Birch composed 77% of the diet and a significant, but undetermined, portion was older-growth twigs.

Conroy et al. (1979) and Wolff (1980) have shown that hares are closely associated with habitats containing a high density of cover. The combined density of all woody plants at the MRC approaches the density in preferred winter habitat (Type III) near Fairbanks, Alaska (Wolff 1980), where total shrub density exceeded 21,000 plants/ha. In the MRC, the only vegetative type with plant densities not approaching 20,000/ha was the thin, mature hardwoods type. Thin and dense birch-spruce types were particularly dense, with >30,000 stems/ha. Assuming all vegetative types with fewer than 20,000 plants/ha were not preferred winter habitats for snowshoe hare, then about 43% of the

Table 6. Use of birch browsed by only moose, only hares, and both moose and hares at the Kenai Moose Research Center.

	Pen 1			Pen 2			Pen 3			Pen 4			Outside		
Year and category	Moose	Hares	Moose and hares	Moose	Hares	Moose and hares	Moose	Hares	Moose and hares	Moose	Hares	Moose and hares	Moose	Hares	Moose and hares
1972															
g/plant				11.0	3.5	10.8	5.2	2.8	7.7	2.6	2.9	8.9			
g browsed/plant				5.5	2.1	6.0	2.6	1.7	4.1	1.7	2.2	6.4			
Percent use				49.7	59.5	55.8	49.6	60.3	53.9	65.4	77.7	72.3			
1973															
g/plant	9.4	1.7	9.3	10.5	2.0	8.7	5.7	1.9	7.3	3.9	1.7	7.4	6.8	1.8	6.9
g browsed/plant	4.5	1.4	7.0	7.2	1.6	6.0	3.3	0.9	4.8	3.2	0.9	6.3	3.9	0.9	4.9
Percent use	48.4	80.3	74.9	68.8	82.3	68.6	58.0	47.4	64.8	8.2	53.6	85.6	56.6	47.3	70.7
1974															
g/plant	14.0	6.2	17.7	11.4	5.1	13.4	7.6	3.8	10.7	4.8	3.3	9.8	8.0	4.5	13.0
g browsed/plant	7.3	2.8	9.0	6.1	3.0	7.4	4.1	2.0	5.4	3.3	2.9	8.3	3.5	2.4	7.4
Percent use	52.0	44.9	50.6	53.5	58.6	54.9	54.0	52.5	50.2	68.7	87.2	84.3	43.3	53.0	56.8

MRC area was preferred winter habitat for hares.

DISCUSSION

Spencer and Chatelain (1953) described the preburn forests in 1 section of the 1947 burn as black spruce forest with scattered aspen. After the fire, abundant aspen root-sprouting occurred. Five years after the burn, unbrowsed aspen reached a height of nearly 3 m. By this time increased numbers of black spruce, paper birch, willow, and aspen seedlings occurred throughout the burn. Spencer and Chatelain's (1953) description was probably for an area to the southeast of the MRC where aspen is the dominant hardwood. However, their description of the successional pattern is similar to what probably occurred at the MRC (Viereck 1973). LeResche et al. (1974) described the 1947 burn as one of the "most productive large areas of moose habitat known to them." They attributed this productivity to the combination of high forage production, generally mild winters, abundant alternative food (cranberry), edge effect, and adjoining upland ranges.

My study occurred 25 years after the fire and at a time when over 4 moose/km^2 wintered in the vicinity of MRC. The browse population was certain to be affected by moose populations of this size. Bergerud and Manuel (1968) showed that height growth of birch was severely retarded with high moose populations. Spencer and Chatelain (1953) thought that aspen had low browsing resistance on the Kenai and that overuse would cause lowered productivity of willow. I found many more dead than live aspen and willow plants during the density surveys of my study areas. The high use of those 2 species is probably the reason for their short heights and low production and density.

At the time of my study (when there was only a single important browse species), the moose stocking rate had little effect on birch production except in pen 4. In that pen the difference in production, compared with pen 3, increased from 1971 through 1974 (Table 3). Height decreased slightly in pen 4 from 121 to 113 cm/plant over the 4-year period whereas it increased slightly in pen 3 from 133 to 135 cm/plant. If willow and aspen are less tolerant of browsing than birch, as indicated, then moose population management should be directed at retaining these species in productive condition. However, because of uncontrollable factors such as cyclic snowshoe hare populations and the effects of varying winter conditions on year-to-year moose distributions, maintaining a productive browse population cannot be achieved solely through herd management.

Moose are a product of early stages of forest succession and benefit from the effects on habitat of fire (Spencer and Hakala 1964, LeResche et al. 1974), logging (Peek et al. 1976), and tree crushing (Oldemeyer and Regelin 1980*b*). If management is devoted to developing and maintaining a healthy moose population, then an active habitat management program is required. The benefits of such a program are an abundant supply of food and cover for moose, reduction in habitat deterioration through overuse, and an increase over the total ecosystem in habitat diversity and thus wildlife diversity.

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