SUMMER FORAGE AND FEEDING SITE SELECTION BY ELK

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Abstract: The mechanisms involved in selecting forage and feeding sites by elk (*Cervus elaphus*) are poorly understood but have important implications for habitat management. During the summers of 1982 and 1983, we conducted a study in western Montana to determine the levels at which feeding site selection occurs by elk. We used stepwise discriminant analysis to test the hypothesis that availability of 16 forage species, used in ≥10% of the feeding sites, did not differ between feeding and random sites. Availability differed between feeding sites and random locations during early and late summer ($P < 0.01$); however, elk showed a preference for forage species at a feeding site only during late summer. Similar studies, stratified by habitat, may allow managers to identify potential elk habitat based upon the abundance of forage species at a site.

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Elk diets have been studied and reviewed (Kufeld 1973, Collins et al. 1978, Nelson and Leege 1982). The nutritional quality of elk summer diets has also been reported (McReynolds 1977, Schommer 1978, Baker and Hobbs 1982). Elk diets vary seasonally, from year to year, and from area to area, which makes site or area-specific recommendations for habitat modifications difficult.

Irwin and Peek (1983*a*) suggested that more information is needed about the mechanisms that lead to habitat and food patch selection by elk. This is particularly important because of evidence suggesting that forage on winter ranges rarely meets maintenance requirements (Scotter 1980, Hobbs et al. 1981, Baker and Hobbs 1982). Habitat selection occurs on several levels (Johnson 1980) and food habits may be the result of ≥3 levels of selection. Herbivores may select feeding sites from the available habitat based on abundance of preferred forage species (third-order selection). They may demonstrate fourth-order selection through preference for particular forage species at a feeding site, and fifth-order selection through preference for individual plants or particular portions of a plant. Our study was designed to determine if elk choose between feeding sites on the basis of forage species abundance, and if individual forage species are selected at feeding sites.

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STUDY AREA

The study area was in the northern Garnet Mountains, 56 km east of Missoula, Montana. Approximately 85% of the area was Douglas-fir (*Pseudotsuga menziesii*) and subalpine fir (*Abies lasiocarpa*) forests (Pfister et al. 1977). The remainder of the study area was pasture, hayfields, natural meadows, clearcuts and associated roads, and brushy riparian areas. Elevations ranged from 1,160 to 2,090 m and included year-round range for local elk herds. The Blackfoot River bordered the study area to the north and west. Scott (1978) and Lehmkuhl (1981) described the study area.

Timber harvest was the principal land use; much of the area at low to mid-elevations had been logged, primarily as partial cuts, within the past 50 years. Horses and cattle grazed the area from June to October.

METHODS

We captured elk in corral-type traps baited with alfalfa during the winter, and salt during spring and summer. We placed a radio transmitter, encased in a polyvinyl chloride collar (Pedersen 1977) on each captured adult female. We located elk 1 time/week from an airplane (Denton 1973), marked these locations on aerial photographs (1:12,000), and transferred these marks to U.S. Geological Survey 7.5-minute maps. We saw the elk, and therefore located them on the ground, in 52% of the radio loca-

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tions. We determined nonvisual locations on the ground by searching approximately 1 ha until fresh pellet groups or tracks were found.

We used the location of elk or fresh sign as the center of a 375-m^2 circular plot. We visually estimated percent ground cover of species for all understory vegetation within reach of an elk. To increase precision, all estimates were made by the same observer. Identification of all grass species followed Hitchcock (1950), and nomenclature of all other plants followed Hitchcock and Cronquist (1973). We also sampled a series of plots distributed randomly throughout the study area. We sampled the majority of these during mid-summer, prior to forb senescence.

We determined forage use by elk by feeding-site analysis (Knowlton 1960). One instance of use was defined as a bite of a stem or leaf from forbs, grass or grass-like plants, or of a twig or leaf from shrubs or trees. Where leaves were stripped from twigs, 1 stripped twig was recorded as 1 instance of use. We defined a feeding site as a site with ≥50 instances of use. Significant biases with feeding-site analyses may result because of co-use by other herbivores and regrowth of used plant parts (Cook and Stoddart 1953, Holechek et al. 1982). We reduced these biases by measuring plots within 4 days of use, and removing plots from consideration if other herbivores were present during the observation or if their sign was found in the plot.

We pooled data for 1982 and 1983, and defined 2 seasons: early summer (15 Jun–30 Jul) and late summer (Aug). The random sample was stratified based on the range of elevations used by elk during each season (Edge et al. 1987). Because a large sample size: variable ratio is needed for multivariate methods (Johnson 1981, Magnusson 1983), only 16 forage species were used for analysis. Instances of use for these species were recorded in ≥10% of all feeding sites. We calculated relative use for these species by dividing percent seasonal use of each species by the sum of percent seasonal use for all 16 species. Percent availability was based on percent ground cover, and relative availability was calculated in the same manner as relative use. We considered a species preferred when relative use exceeded ($P < 0.05$) relative availability based upon a Bonferroni Z-test (Miller 1966:67). We used stepwise discriminant function analysis to test the hypothesis of equal mean species availability between random sites and seasonal feeding sites. The criterion for maximizing the Mahalanobis distance between groups was used to select the independent variables for the stepwise procedure (Morrison 1976:241). A variable was considered for entry into, or removal from, the model if the probability of its partial multivariate F-ratio was ≤0.05 or ≥0.10, respectively. The assumption of equal variance–covariance matrices was not met; thus, our analysis and interpretation of canonical variates must be considered data-exploratory and not confirmatory in nature (Williams 1983).

RESULTS

We sampled circular plots surrounding 268 radio locations from 22 female elk between 15 June and 31 August, 1982 and 1983. Feeding sites were found at 121 of these locations. During the same period, we sampled 172 randomly located plots. We recorded use of 18 species of shrubs, 17 graminoids, and 58 forbs. Elk consumed 86 and 76 forage species during early and late summer, respectively. Graminoids accounted for <10% of total use each season. Forbs accounted for 43 and 56% of the diet during early and late summer, respectively. Shrubs accounted for about 30% of the diet during both seasons.

Sixteen species were used at ≥10% of the feeding sites. These 16 species accounted for 39 and 80% of the diet during early and late summer, respectively. During early summer, serviceberry (*Amelanchier alnifolia*), snowberry (*Symphoricarpos albus*), and mountain arnica (*Arnica latifolia*) were the most frequently and heavily used forage species, but they were not preferred (Table 1). Mountain arnica accounted for 40% of the use during August and was a preferred species.

Percent availability of primary forage species differed ($P < 0.001$) between elk feeding sites and random sites for both seasons (Table 2). Serviceberry, prickly currant (*Ribes lacustre*), and beargrass (*Xerophyllum tenax*) aided in discriminating between early summer elk feeding sites and random locations. During late summer, serviceberry, globe huckleberry (*Vaccinium globulare*), pinegrass (*Calamagrostis rubescens*), mountain arnica, and beargrass were used in the discriminant model to separate elk feeding sites from random locations.

DISCUSSION

Elk in the Chamberlain Creek study area consumed many forage species during summer.

Table 1. Seasonal use and availability of major forage species within elk feeding plots, and availability of those species at random plots, Chamberlain Creek, Montana, 1982 and 1983.

	Early summer					Late summer				
	Feeding plots (n = 58)				Random plots (n = 166)	Feeding plots (n = 63)				Random plots (n = 159)
Life form Species	% use	Relative use	% availability	Relative availability	% availability	% use	Relative use	% availability	Relative availability	% availability
Shrubs										
Sitka alder (*Alnus sinuata*)	0.5	1.3	2.0	4.0	2.0	6.0	7.2	6.0	10.5	3.0
Serviceberry	8.0	20.3	3.0	6.0	1.0	1.0	1.2	0.5	0.9	1.0
Utah honeysuckle (*Lonicera utahensis*)	2.0	5.1	1.0	2.0	1.0	4.0	5.0	1.0	1.8	1.0
Rusty mensiesia (*Menziesia ferruginea*)	1.0	2.5	0.5	1.0	3.0	4.0	5.0	7.0	12.3	3.0
Prickly currant	1.0	2.5	1.0	2.0	0.5	3.0	3.7	1.0	1.8	0.5
Scouler willow (*Salix scouleriana*)	2.0	5.1	1.0	2.0	1.0	0.5	0.6	0.5	0.9	1.0
Birchleaf spirea (*Spiraea betulifolia*)	2.0	5.1	4.0	8.0	4.0	2.0	2.4	2.0	3.5	4.0
Common snowberry	8.0	20.3	8.0	16.0	5.0	3.0	3.7	1.0	1.8	5.0
Globe huckleberry	1.0	2.5	2.0	4.0	7.0	4.0	5.0	6.0	10.5	7.0
Graminoids										
Pinegrass	1.0	2.5*[a]	13.0	26.0	15.0	1.0	1.2	4.0	7.0	16.0
Elk sedge (*Carex geyeri*)	1.0	2.5	5.0	10.0	2.0	1.0	1.2	2.0	3.2	2.0
Forbs										
Mountain arnica	5.0	12.7	6.0	12.0	7.0	40.9	49.7*	14.0	24.6	7.0
White hawkweed (*Hieracium albiflorum*)	2.0	5.1	1.0	2.0	1.0	3.0	3.7	1.0	1.8	1.0
Mountain sweetroot (*Osmorhiza chilensis*)	2.0	5.1	1.0	2.0	0.5	1.0	1.2	1.0	1.8	0.5
Meadow rue (*Thalictrum occidentale*)	1.0	2.5	1.0	2.0	1.0	1.0	1.2	1.0	1.8	1.0
Beargrass	2.0	5.1	0.5	1.0	4.0	6.0	7.5	9.0	15.8	4.0

[a] Relative use differed from relative availability ($P \leq 0.05$).

Forbs and shrubs were the predominant forage classes used; grasses and grass-like plants were used <10%. A similar use of forbs and shrubs during the summer has been reported (Marcum 1975, Collins et al. 1978, Irwin and Peek 1983*a*). Other studies, however, have reported the importance of graminoids in the summer diet of elk (Morris and Schwartz 1957, Boyd 1970, Mackie 1970, Wydeven and Dahlgren 1983). Elk diets vary from area to area because of differences in forage availability, plant phenology, plant species diversity, and habitat type (Miller et al. 1981, Irwin and Peek 1983*b*, Nietfeld 1983).

Elk in Chamberlain Creek did not select feeding sites or forage species at those sites during early summer. Elk foraging behavior during early summer reflected the abundance and succulence of forage throughout the study area. The discriminant model identified 3 species that differed in availability between feeding sites and random sites, but none of these species were preferred at feeding sites. Elk at Chamberlain Creek consumed more species during early summer, and feeding sites contained more species than during late summer. Irwin and Peek (1983*b*) reported that elk used habitats with the greatest amount of succulent forbs or shrubs and found that elk did not select individual forage species during the summer.

During late summer, we found evidence of strong selection for feeding sites by elk, and for 1 forage species at those sites. Mountain arnica received 40% use during late summer, and was

Table 2. Standardized canonical discriminant function coefficients and classification rates for species availability in analysis of monthly elk feeding sites versus randomly located sites, Chamberlain Creek, Montana, 1982 and 1983.

Species and Statistics	Early summer vs. random	Late summer vs. random
Serviceberry	0.4825	0.3524
Prickly currant	0.5248	
Globe huckleberry		0.4584
Pinegrass		0.5621
Mountain arnica		−0.3696
Beargrass	−0.6741	−0.3759
F-value	8.539	8.620
df	3,220	5,216
P-value	<0.001	<0.001
% correctly classified	77.2	73.4

twice as abundant at feeding sites as in random locations. Also, during this period, elk habitat use in Chamberlain Creek shifted to more closed-canopy stands (Edge et al. 1987), probably in response to decreased palatability of forage in open areas. Mackie (1970) reported that availability of preferred forage appeared to be a primary determinant of seasonal distributions of elk in the Missouri River Breaks of central Montana. Habitat selection on a summer range in Utah was strongly influenced by forage availability and associated grazing values (Collins et al. 1978).

Factors other than abundance, diversity, or palatability of forage species also influence feeding site selection. Grover and Thompson (1986) reported that forage use by elk during spring was positively correlated with cattle use, distance from the nearest visible road, and density of bunchgrasses, and negatively correlated with distance from cover. Except for slope, elk at Chamberlain Creek did not strongly select habitat factors during summer and fall (Edge et al. 1987). However, human disturbance was low during this study, and elk are expected to be less specific in selecting habitats under such conditions (Marcum 1975). Thus, during early summer, elk showed little selection for either feeding sites or forage species within a feeding site. During late summer, as the diversity and abundance of succulent species decreased, elk became more selective of feeding sites and the forage species at these sites. Data for this study were pooled across habitats and undoubtedly masked some of the relationships in selection of feeding sites and forage species. These relationships need further research if management is to be directed at improving elk summer range. Additional studies need to address feeding site and forage species selection within habitats. Similar models for specific habitats may allow prediction of elk use based upon the abundance of forage species at a site.

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IMMOBILIZATION OF ELK WITH A-3080

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Abstract: We evaluated the reliability and safety of A-3080 (1-[2-{2-thienyl}ethyl]-4-methoxycarbonyl-4-[N-phenylmethoxy-acetamido]-piperidinium oxalate), a new opioid analgesic, as an immobilizing agent in elk (*Cervus elaphus*). The analgesic rapidly immobilized elk after intramuscular (IM) injection (6.5 ± 3.6 [SE] min after 2 μg/kg body wt [BW] and 2.3 ± 1.2 min after 10 μg/kg BW) at doses that are about 2 and 10× the syringe-injection dose required to immobilize 50% (ED_{50}) of the animals (i.e., ED_{50} = 0.88 μg/kg BW). Injections of A-3080 from Paxarms darts (Paxarms, Ltd., Timaru, N.Z.) immobilized elk in 8.5 ± 0.7 and 6.8 ± 3.1 minutes after 4 and 5 mg, respectively. Heartrate remained unchanged and respiratory rate decreased slightly after doses between 10 and 50 μg/kg BW of drug. Twenty elk immobilized with syringe injections recovered without a reversal agent. Recovery was directly related to the dose of A-3080 used (range = 10 min after 0.5 μg/kg BW–3 hr after 10 μg/kg BW). Fifteen elk immobilized with syringe-injected drugs and 11 of 16 elk immobilized with dart-injected drugs received diprenorphine (M50-50) (Lemon Co., Sellersville, Pa.) (n = 10), naltrexone (Dupont Pharmaceuticals, Wilmington, Del.) (n = 5), or a mixture of M50-50 and naltrexone (n = 11) for reversal. Reversal was rapid and elk did not show evidence of renarcotization or stress hyperthermia.

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Potent opioid analgesic compounds such as etorphine hydrochloride (HCl) (M99) (Lemon Co., Sellersville, Pa.), carfentanil HCl (Wildl. Labs Inc., Fort Collins, Colo.), and fentanyl chloride (Janssen Pharmaceutica, New Brunswick, N.J.) are frequently used alone or in combination with a sedative or tranquilizer (e.g., xylazine HCl, Haver-Lockhart, Shawnee, Kans.; acepromazine maleate, Tech America, Elwood, Kans.) for immobilization of free-ranging ungulates, bears (*Ursus* spp.), and other mammals (Woolf 1970, Roussel 1975, DeVos 1978, Meule-