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Source: *The Journal of Wildlife Management*, Vol. 48, No. 2 (Apr., 1984), pp. 642-646
Published by: Wiley on behalf of the Wildlife Society
Stable URL: http://www.jstor.org/stable/3801209
Accessed: 21/08/2013 17:52

HABITAT USE BY ROOSEVELT ELK IN UNMANAGED FORESTS OF THE HOH VALLEY, WASHINGTON

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Primevally, Roosevelt elk (*Cervus elaphus roosevelti*) inhabited humid, coastal forests from northern California to Vancouver Island, British Columbia. During the 1890's and early 1900's populations declined or were eliminated under pressures of settlement and intensive market hunting (Rasmussen 1949). Today Roosevelt elk occupy much of their former range, but proliferation of agriculture, urbanization, and roads have altered many productive riverine habitats. Thus, Roosevelt elk are limited largely to forested uplands, which are managed predominantly for timber production. Additionally, Roosevelt elk are hunted throughout most of the range. A notable exception is Olympic National Park in northwest Washington, which is a major population center of unhunted Roosevelt elk and contains nearly 3,600 km^2 of unharvested forest. Because so little was known of primeval distribution patterns of elk in north-coastal temperate forests, our objective was to describe habitat use by Roosevelt elk in an unmanaged riverine ecosystem with a significant old-growth forest component.

STUDY AREA

The study area was 53.6 km^2 of the Hoh River Valley in Olympic National Park (47°51'N, 124°00'W) from the west boundary of the park upriver 12 km. The Hoh Valley has a typical glacial configuration with steep side slopes and broad lowland terraces of glacial and alluvial derivation. Elevations range from 150 m on the valley floodplain to 910 m on adjoining ridges. Climate is maritime with mild, wet winters and cool, dry summers. Precipitation averages 345 cm annually, with most occurring as rain, although ephemeral snows fall on the valley floor each winter.

Vegetation of alluvial terraces was representative of the *Picea sitchensis* vegetation zone of the Olympic Peninsula (Franklin and Dyrness 1973). A shrub community of red alder (*Alnus rubra*) and willows (*Salix* spp.) pioneered gravel substrates adjoining the Hoh River. Forest communities of increasing age occupied successive river terraces (Fonda 1974). Red alder and Sitka spruce (*Picea sitchensis*)–black cottonwood (*Populus trichocarpa*) communities occurred on alluvial terraces 70–80 and 400 years old, respectively. A climax community of spruce and western hemlock (*Tsuga heterophylla*) occupied old-aged alluvial and glacial deposits >700 years old. The seral forests were characterized by well-developed deciduous or mixed overstories and grass or forb-dominated understories. Grasses dominated the understory of red alder communities, with the cumulative ground cover averaging 120%. Forbs were also abundant in alder stands but dominated the understory of spruce-cottonwood stands with ground cover averaging 110%. With progression to climax, overstories were increasingly dominated by coniferous species, with understories of ferns, shrubs, and mosses. Tree densities ranged from approximately 800 trees/ha for alder communities to 200–300 trees/ha for spruce-cottonwood and spruce-hemlock communities (Fonda 1974).

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A bigleaf maple (*Acer macrophyllum*) vegetation type was superimposed on the terrace mosaic and occurred on shallow rocky soils deposited by fluvial or colluvial action at the base of the valley side slopes (Fonda 1974). Understories were a patchy mosaic of vine maple (*Acer circinatum*) and grassy clearings. A western hemlock vegetation type occurred on the forested uplands and valley side slopes (Fonda 1974).

Except for a single road and relatively minor visitor development north of the river, forest communities of the Hoh Valley were virtually undisturbed. Additionally, the population of elk has been legally protected from hunting since the creation of Olympic National Park in 1938.

METHODS

Nine free-ranging cow elk were immobilized in February and March 1979, each with 28 mg of succinylcholine chloride, and were equipped with radio collars. Three elk were collared from each of three distinct groups of elk totaling approximately 150 individuals (Jenkins and Starkey 1982). Movements of collared elk were monitored in three seasonal periods: summer (6 Jun–10 Sep 1978), winter (1 Jan–28 Feb 1979), and late winter (1 Mar–20 Mar 1978 and 1979).

Six vegetation types were mapped on orthographically corrected aerial photographs to determine the relative availabilities of each and to facilitate the recognition of vegetation types occupied by elk. Mapping was accomplished using supplementary vertical, color aerial photographs and ground reconnaissance of community boundaries.

Radio-collared elk were located one to three times daily in morning (0600–1000), midday (1100–1400), and evening (1600–2000) periods using a combination of remote telemetry procedures and direct observations. Locations of all collared elk were determined before any elk was located twice in a day, thus assuring that elk in poor transmitting locations were sampled equally. Locations were determined remotely by triangulating from three receiving stations, several of which were located on gravel bars along the length of the river. Azimuths were plotted on vegetation maps and a circle was inscribed within the triangle formed by the three intersecting azimuths; the center represented the estimated elk location. Vegetation type of the location was recorded if the circle included only one vegetation type. If not, the vegetation was recorded after tracking the collared elk and verifying its location. Accuracy of the remote habitat determinations using this acceptance criterion was tested by triangulating on radio collars which were distributed by hand at known locations.

Patterns of habitat use by cow elk were evaluated by comparing use of vegetation types to availability of types within the composite home range of collared elk. This corresponded to analysis of third-order habitat selection, aimed at identifying important habitat components of the home range (Johnson 1980). Individual home ranges were delineated using 95% confidence ellipses (Koepple et al. 1975), and the composite home range was delimited by elevational contours that included individual home ranges of all collared elk. Use was measured as the proportion of relocations of elk in each vegetation type, and availability was defined as the percentage of composite home range covered by each vegetation type as determined using an electronic digital planimeter. Chi-square statistics were used to test the hypotheses that vegetation types were used in proportion to availability. If the null

Table 1. Percent availability and use of physiographic locations and vegetation types by cow elk in the Hoh Valley, Olympic National Park.

Physiographic location	Vegetation type	Availability (% of composite home range)	Use[a,b] (% of radio relocations)		
			Summer	Winter	Late winter
Valley floor	Alder-willow	6	4 (0)	2 (−)	1 (−)
	Red alder	5	9 (+)	10 (+)	25 (+)
	Spruce-cottonwood	2	2 (0)	3 (0)	13 (+)
	Spruce-hemlock	35	53 (+)	44 (+)	47 (+)
	Bigleaf maple	4	13 (+)	10 (+)	5 (0)
	Combined	52	81 (+)	69 (+)	91 (+)
South-facing slope	Western hemlock	23	10 (−)	20 (0)	7 (−)
North-facing slope	Western hemlock	25	9 (−)	11 (−)	2 (−)

[a] Symbols indicate significant habitat selection (+), avoidance (−), and neutrality (0) based on family confidence intervals using Bonferroni Z-statistics (Neu et al. 1974).
[b] N = 683, 759, and 541 radio relocations for summer, winter, and late winter, respectively.

hypothesis was rejected ($P < 0.05$), family confidence intervals were employed using the Bonferroni Z-statistic as adapted by Neu et al. (1974) to determine which vegetation types were used in proportions greater or less than availability ($P < 0.10$).

RESULTS AND DISCUSSION

Thirty-four field trials of the telemetry procedure were conducted on hand-placed radio collars. The error of 136 individual azimuths averaged 6.8° (SE = 5.9°). Habitat determinations were 97% accurate on the valley floor, although the error of the estimated locations averaged 23% of their distance from the telemetry receiving posts. Average distances of the radio-collared elk from the receiving stations ranged from 278 m (SE = 211 m) in late winter to 540.6 m (SE = 390.8 m) in midwinter and were similar to distances used in the field trials.

Side slopes of the Hoh Valley were farther from the receiving stations than was the valley floor; thus detection of habitats used by elk on side slopes may have been more prone to error. However, only one vegetation type was recognized on the slopes, and telemetry signals originating there were distinct from those on the valley floor. Thus, errors in determining habitat occupied by the monitored elk were considered minimal.

Fifty percent of the 1,983 relocations obtained on the radio-collared elk were confirmed visually or aurally. Home range ellipses of individual elk encompassed the entire valley floor and lower one-third of the adjoining side slopes, indicating distribution of elk was closely aligned to the valley lowlands (Jenkins and Starkey 1982). The composite home range, or principal area of elk use, was bounded by the 425 m elevational contour on side slopes north and south of the valley. The resulting area of 25.5 km² represented 47% of the watershed segment within the study area and encompassed 98.8% of the relocations of radio-collared elk.

Vegetation types within the composite range were used in disproportion to availability (Table 1). Vegetation types on the valley floor were selected as a group over the upland western hemlock type. Selection of floodplain vegetation types was similar in summer and winter seasons when hardwood stands of red alder and bigleaf maple and the coniferous spruce-hemlock were favored.

Use of the western hemlock vegetation

was greatest in winter and on south-facing slopes, apparently in response to lower snow depths and thermal advantages. Elk were located on south-facing slopes predominantly on clear, cold winter days and when snow cover existed. After one storm, snow was deepest on parts of the valley floor (18 cm) and less on the more densely timbered side slopes (0–10 cm). Snow persisted longest in valley bottoms in the shade of the south ridge (15 days) and least on sunny, south exposures at low elevations (1–3 days). Weather was moderate during winter field seasons and thermal advantages of south-facing slopes would presumably be greater in severe winters.

In late winter, occupancy of side slopes decreased markedly whereas red alder and spruce-cottonwood types received peak use (Table 1). In synchrony with this concentration of elk, grasses and forbs in hardwood stands initiated new spring growth. Janz (1980) reported that a hunted population of Roosevelt elk also used riparian areas, including wet meadows and bogs, during spring in managed forests of Vancouver Island.

Visual observations indicated that elk followed a consistent daily pattern of habitat use governed largely by feeding behavior. In late winter, elk used red alder and spruce-cottonwood stands regularly during early morning and evening feeding periods, but often returned to spruce hemlock stands during midday. During 185 morning observations, collared elk were observed in alder flat or spruce-cottonwood habitats 98 times (53%). Of the 98, the elk moved into the spruce-hemlock habitat during midday on 61 occasions (62%); for the remaining 37, the entire day was spent in the seral stands. Similar patterns also were observed in summer and winter when elk often used bigleaf maple habitats for morning and evening feeding periods.

Our findings support the hypothesis of Raedeke and Taber (1982) that primevally, elk in coastal temperate forests were most abundant in floodplains, deltas, beaver meadows, and other areas associated with fluvial activities. In such areas, continuous forest cover is interspersed with moist, productive areas and suggests an optimum mixture of forest cover and foraging areas.

Roosevelt elk are often considered to be forest dwellers (Graf 1955) or even to require old-growth in silviculturally managed forests (Luman and Neitro 1980). The propensity of Roosevelt elk to restrict use of open habitats to a corridor near the forest edge (Harper 1971, Witmer 1982) implies that forest cover could be limiting to elk populations in extensively logged areas. Widespread use of spruce-hemlock forests by Roosevelt elk in this study suggests that old-growth bottomland forests of the Hoh Valley provided adequate cover and foraging habitats for elk over most of the year. However, seral forests associated with alluvial or colluvial substrates were also important seasonally and could be limiting to populations in extensive old-growth tracts. These hardwood communities provided the greatest biomass of herbaceous forage (Leslie 1983) and may be especially important as forage sources during spring. Intense use of red alder and spruce-cottonwood communities coincided with periods of rapid herbaceous growth, as well as the last trimester of gestation for pregnant cows. During this time, fetal nutritional requirements are great (Moen 1973:340, 354), and the availability of early herbaceous growth could be an important determinant of reproductive success.

Acknowledgments.—This research was supported by Contract No. CX-9000-7-0085 of the Pacific Northwest Reg., Natl.

Park Serv. We greatly appreciate the assistance of D. S. deCalesta, D. B. Houston, D. M. Leslie, B. B. Moorhead, R. G. Wright, and P. A. Happe.

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Received 1 November 1982.
Accepted 22 August 1983.

EVALUATION OF VAGINAL IMPLANTS FOR MULE DEER

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Information on biology of mule deer (*Odocoileus hemionus*) during the first several months of life is difficult to obtain because of the seclusive nature of fawns. Robinette et al. (1977), Steigers and Flinders (1980), and Trainer et al. (1981) successfully captured neonates by studying behavior of does and searching areas where fawns were last observed. To facilitate capturing newborn fawns in New Mexico, R. E. Lange, Jr. (unpubl. data) placed radio-transmitter implants in the vaginas of mule deer. Theoretically, implants would be expelled at parturition and enable location of neonates. Vaginal transmitters have also been implanted in white-tailed deer (*O. virginianus*) (N. S. Giessman, pers. commun.) and elk (*Cervus elaphus*) (T. K. Johnson, pers. commun.; M. W. Schlegel, pers. commun.); however, merits of the technique have not been thoroughly investigated. Objectives of this study were to assess reliability of vaginal implants for determining time and location of parturition in mule deer and to evaluate effects on dams.

METHODS

We conducted the experiment at the Colorado Division of Wildlife's Little Hills Wildlife Area in Piceance Basin, northwest Colorado. Ten mule deer does were captured 13–14 March 1982 and anes-