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Roosevelt Elk Selection of Temperate Rain Forest Seral Stages in Western Washington

Abstract

We studied habitat selection by Roosevelt elk (*Cervus elaphus roosevelti*) in a temperate rain forest in the lower Queets River Valley of the western Olympic Peninsula, Washington from June 1986-June 1987. Elk annual home ranges included predominantly unlogged forests protected within Olympic National Park and logged, regenerating forests adjacent to the park. Radio-collared elk selected valley floors during all seasons except winter, when elk frequently used an adjoining plateau 60 m above the floodplain. In winter, radio-collared elk selected 6-15 year-old clearcuts, which were available on the plateau. Elk selected mature deciduous forests of the valley floor during spring, summer, and autumn, and generally they selected old-age Sitka spruce forests during autumn and winter. Young clearcuts (1-5 years old) and even-aged, regenerating stands (16-150 years old) generally were avoided during all seasons. Management practices that retain preferred habitats of elk, such as deciduous forests, 6-15 yr-old coniferous stands, and old-age coniferous bottomland forests will benefit elk, particularly on elk ranges managed for short-rotation, even-aged stands. Silvicultural alternatives to typical even-aged stand management, such as uneven-aged management and commercial thinning, should also be considered for improving and maintaining interspersion of forage and cover.

Introduction

Logging has altered habitats of Roosevelt elk *Cervus elephus roosevelti* throughout the Pacific Northwest. Since the turn of the century, most low-elevation old-age forests (>150 years) within the range of Roosevelt elk in Oregon and Washington have been cut for wood products and converted to even-aged stands harvested in 60-90 year cutting cycles (Juday 1977, Meslow *et al.* 1981). For example, low elevation Douglas-fir (*Pseudotsuga menziesii*) forests greater than 200 years old cover about 10 percent of their original distribution (Franklin *et al.* 1981, Franklin and Spies 1984).

Extensive conversion of old-age forests to even-aged stands in short-term harvest rotations may have significant long-term effects on elk populations. These effects include reduced availability of preferred elk habitats and forage (Harris *et al.* 1982, Witmer and deCalesta 1983, Schroer *et al.* 1988); reduced plant species richness and diversity, particularly in pole-sized stands (Franklin and Pechanec 1968, Alaback 1982); and increased disturbance caused by roads (Witmer and deCalesta 1985, Schroer 1987). Greater understanding of elk habitat preferences relative to forest successional stages would be useful for long range planning of forest harvesting in the Pacific Northwest.

Previous studies of habitat use indicated that old-age coniferous forests, deciduous forests, and some young age-classes of logged coniferous forests are important habitats for Roosevelt elk (Witmer and deCalesta 1983, Jenkins and Starkey 1984, Schroer 1987, Brunt *et al.* 1989). Those studies, however, did not include a broad array of successional ages of forest which permit an assessment of all stages of forest succession. The purpose of this study, therefore, was to determine habitat use patterns of Roosevelt elk whose home ranges included unlogged forests protected within Olympic National Park (ONP) and a variety of successional forests resulting from logging adjoining the park.

Study Area

The study was conducted along 15 km of the lower Queets River Valley in and adjacent to the Queets Corridor of Olympic National Park. The corridor is a strip of national park land (1-3 km-wide) that extends along both sides of the Queets River for approximately 20 km, from the interior core of ONP west to the Quinault Indian Reservation. The Queets corridor was added to ONP in 1945 to protect riparian communities and adjoining areas on the broad floor of Queets River Valley.

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The principal landform in the study area is a broad, glacial outwash plain that is predominant along the southwestern edge of the Olympic Mountain Range (Tabor 1975). The Queets River has cut into this plain and created a 1-2.5 km wide valley floor. The valley floor is about 60 m in elevation with at least 4 levels of alluvial terraces (Fonda 1974). Valley walls extend approximately 60 m from either side of the valley floor up to the broad glacial outwash terrace (plateau). A majority of the valley floor and valley walls are within the ONP Queets corridor, whereas the plateaus are within Washington Department of Natural Resources (DNR) and Olympic National Forest (ONF) lands.

Climate is maritime with mild, wet winters and cool, dry summers. Annual rainfall averages approximately 300 cm, with the majority falling between October and May. Snowfall occurs infrequently and accumulation rarely exceeds 30 cm. Abundant rainfall, moderate temperatures, and coastal fog have created a temperate rain forest ecosystem in the Queets Valley and the three other major river drainages on the west side of the Olympic Mountains (Franklin and Dyrness 1973). Winter temperatures from 1 January-10 February, 1987 in forested and nonforested habitats of the plateau were not significantly different than those on the valley floor.

Vegetation of the valley floor represents seral stages of the *Picea sitchensis* vegetation zone (Franklin and Dyrness 1973), which are associated with the age of alluvial terraces, soil moisture, and soil profile (Fonda 1974). Active river channels that receive frequent fluvial disturbance support pioneer deciduous forests (< 10 years old) dominated by red alder (*Alnus rubra*) and willows (*Salix* spp.). The youngest alluvial terraces above the active channels support mature deciduous forests (> 10 years old) dominated by red alder, black cottonwood (*Populus trichocarpa*) and bigleaf maple (*Acer macrophyllum*). Mid-seral coniferous/deciduous forests occur on mid-aged alluvial terraces and are dominated by spruce, black cottonwood (*Populus tremuloides*) and bigleaf maple (*Acer macrophyllum*) (Fonda 1974). Old-age coniferous forests (> 150 years old), dominated by Sitka spruce and western hemlock (*Tsuga heterophylla*), occur commonly on the oldest alluvial terraces of the valley floor. Approximately 30 percent of mature forests was selectively logged between 1910 and 1945. The corridor now consists of dense, coniferous forests (30-150 years old) comprised predominantly of Sitka spruce and western hemlock. Vegetation of the valley floor also includes 55 abandoned homestead clearings that range in size from 2 to 16 ha and are composed primarily of non-native grasses.

Vegetation of the adjoining glacial plateau is characteristic of the *Tsuga heterophylla* forest zone of western Washington (Franklin and Dyrness 1973). Unharvested old-age stands of western hemlock (> 150 years old) cover approximately 11 percent of their original distribution on the glacial plateau. The remaining forests have been converted to 1-150 year-old, even-aged forests by clear-cutting and planting of nursery seedlings, or by wildfire. One to 15 year-old clearcuts are dominated by non-native grasses and forbs, as well as shrubs, including huckleberries and *Rubus* spp., and regenerating conifers. The majority of clear-cuts were planted with Douglas-fir (*Pseudotsuga menziesii*) or western hemlock seedlings, with some areas containing dense stands of naturally seeded western hemlock. The percent cover of coniferous trees in stands 16-30 years old is 100 percent, and the coniferous cover in stands 31-150 years old is 94 percent (G. L. Schroer, Nat. Park Serv., unpubl. data).

No hunting is allowed within ONP, but hunting for elk, deer, bear, and other species is permitted on other federal, state, and private lands adjacent to the park. Annual legal elk harvests from the western Olympic Peninsula averaged 0.22 + 0.03 (SE) elk/km^2 from 1983 to 1987 (Houston *et al.* 1990).

Methods

We placed radio-collars on 1-2 adult female elk in 4 of 5 herds inhabiting the study area. Elk were immobilized with mixtures of Carfentanil or M99 (etorphine) and Rompun (xylazine). Movements of adult females and calves within a herd are highly interdependent on the Olympic Peninsula (Jenkins and Starkey 1982, Schroer 1987); therefore, locational data from only 1 adult female in each of the 4 herds was used in the analysis.

The 4 herds monitored were referenced according to regional features in each area: Kelly (K), Streater (S), Tacoma (T), and Higley (H)). The herd sizes were approximately 30 (K); 45 (S); 70 (T) and 35 (H). The elk were studied during 5 seasons: summer (27 June-14 September 1986); autumn (15 September-3 December 1986); winter (7 December 1986-15 February 1987); spring (25 February-19 May 1987); and calving (20 May-

20 June 1987). An adult female of the Streater herd was not radio-collared until early summer; therefore, it was not included in the summer data.

We relocated elk by first obtaining a general location by using radio-telemetry and then by approaching to confirm a visual sighting or aural location. Locations were not recorded if elk were disturbed prior to detection. In 7 percent of the relocations, we used remote triangulation procedures to locate elk from distances of 150-1,000 m. Average location errors derived from field tests at those distances were 110 meters. All locations were recorded according to 100 m coordinates of the Universal Transverse Mercator System. Data from remote triangulation were used in assessing vegetation selection patterns only if the error polygon was completely within a single vegetation class.

Vegetation selection patterns were determined by locating each elk once or twice daily on random days and at random times between dawn and dusk 3-5 days per week. To help ensure that locations from the same day were independent, successive locations were separated by a minimum of three hours. A minimum of three hours was a sufficient period for the elk to change activity or vegetation class in greater than 50 percent of consecutive locations within a day.

Individual patterns of vegetation selection were examined by comparing proportional use of vegetation classes to proportional availabilities of vegetation classes within annual home ranges of individual elk. Annual home ranges were delineated using 100 percent contour intervals of the harmonic mean utilization distribution (Dixon and Chapman 1980) using the computer program McPAAL (Stuwe and Blohawiak 1985). Vegetation classes were mapped within home ranges on 1:24,000 scale base maps using aerial photographs, DNR and ONF timber management maps, orthophotographs, and field verification. Availabilities of vegetation classes were measured using a digital planimeter.

We tested null hypotheses that elk used vegetation classes in proportion to availability using Chi-square tests and family confidence intervals based on Bonferroni Z-statistics (Neu *et al.* 1974). A vegetation class was considered selected when proportional use exceeded availability (family-level $P \leq 0.05$), and was considered avoided when use was less than availability. Statistical tests could not be conducted when there was no documented use of an available habitat type or topographic area, although those types or areas were considered avoided. Vegetation habitat use could not be statistically determined for calving season due to the small sample size and large number (12) of habitat types (Koehler and Larntz 1980).

Results

Radio-collared elk selected the valley floor during all seasons except winter (Table 1). During winter, elk generally used valley floor and plateau regions in proportion to availability.

During summer all radio-collared elk selected mature deciduous forests (>10 years old, Table 1). Additionally, collared elk tended to select coniferous/deciduous forests and old homestead fields, although those trends were significant for only one of three collared elk. All collared elk avoided 31-150 year-old conifer stands on the valley floor, and also 1-5 and 16-150 year-old conifer stands on the plateau. Old-age (>150 years old) Sitka spruce forests on the valley floor were used in proportion to availability, but old-age western hemlock forests on the plateau were avoided during summer.

Each of the radio-collared elk continued to select mature deciduous forests (>10 years old) throughout autumn (Table 1). Additionally, 3 of 4 elk selected conifer/deciduous and old-age spruce forests on the valley floor. All seral stages available to elk on the plateau were generally avoided during autumn.

During winter, all radio-collared elk selected 6-15 year-old conifer stands on the plateau (Table 1). Increased use of 6-15 year-old stands corresponded with decreased use of mature deciduous forests (>10 years old) and conifer/deciduous forests on the valley floor. Two of four elk continued to select old-age spruce forests on the valley floor during winter. Elk tended to avoid 1-5 and 16-150 year-old coniferous stands on the valley plateau, and they generally used old-age western hemlock forests in proportion to availability.

During spring, elk use of 6-15 year-old forests diminished while use of mature deciduous forests (>10 years old), conifer/deciduous forests, and old homestead fields increased on the valley floor (Table 1). Elk used old-age spruce forests on the valley floor in proportion to availability during spring, and avoided 1-5 and 16-150 year-old conifers on the plateau.

Although selection patterns could not be evaluated statistically during the short calving season, use of conifer/deciduous forests on the valley floor

TABLE 1. Percent availability and use of physiographic zones and vegetation classes by adult female Roosevelt elk from 4 herds in the Queets River Valley, Washington.

Physiographic Zone/ Vegetation Class	Availability (% of annual home range)				Use[1,2,3] (% of locations) Summer 27 Jun–14 Sep			Autumn 15 Sep–3 Dec				Winter 7 Dec–15 Feb				Spring 25 Feb–19 May				Calving[4] 20 May–20 Jun			
	K	S	T	H	K (58)	T (60)	H (61)	K (67)	S (69)	T (69)	H (70)	K (64)	S (63)	T (63)	H (64)	K (58)	S (59)	T (57)	H (58)	K (27)	S (31)	T (27)	H (31)
Valley Floor[5]																							
Deciduous Forest < 10 yrs	1	1	1	1	0-	2-[3]	0-	3	0-	3	0-	0-	0-	0-	0-	0-	2	0-	0-	0	14	0	0
Deciduous Forest > 10 yrs	3	19	7	8	38+	44+	32+	32+	50+	40+	31+	18+	17	12	0-	47+	44+	58+	31+	12	5	44	5
Coniferous/Deciduous Forests	10	8	11	8	26+	23	21	28+	10	28+	29+	14	11	13	13	16	10	28+	32+	39	24	17	25
Coniferous Forest 31-150 yrs	19	11	13	10	7-	5-	7-	10-	7	9	3-	6-	10	6	6	5-	0-	0-	5	0	0	3	0
Coniferous Forest > 150 yrs	2	9	7	1	12	10	13	20+	23+	13	15+	5	22+	10	14+	3	12	2	3	27	47	11	19
Old Homestead Field	1	1	1	1	16+	0-	0-	7	10	7	7	5	5	3	0-	29+	29+	5	5	22	5	11	9
Other	3	3	1	1	2	0-	0-	0-	0-	0-	0-	0-	0-	2	0-	0-	0-	0-	2-	0	0	0	0
Habitats on the Plateau[6]																							
Coniferous Forest 1-5 yrs	10	4	11	20	0-	0-	0-	0-	0-	0-	3-	0-	0-	5	3-	0-	0-	0-	5-	0	0	0	0
Coniferous Forest 6-15 yrs	9	12	15	7	0-	15	23+	0-	0-	0-	9	43+	32+	38+	56+	0-	3-	7	17	0	0	0	0
Coniferous Forest 16-30 yrs	17	12	4	12	0-	0-	3-	0-	0-	0-	3-	3-	0-	3	0-	0-	0-	0-	0-	0	5	14	42
Coniferous Forest 31-150 yrs	19	9	11	19	0-	0-	0-	0-	0-	0-	0-	2-	0-	2-	0-	0-	0-	0-	0-	0	0	0	0
Coniferous Forest > 150 yrs	5	11	19	14	0-	0-	2-	0-	0-	0-	0-	3	3-	6	8	0-	0-	0-	0-	0	0	0	0

[1] Herds designated by (K) Kelly; (S) Streater; (T) Tacoma and (H) Higley.

[2] Total number of locations are indicated in parentheses.

[3] "+" and "–" indicate use significantly greater or less than availability, respectively, based on family confidence intervals using Bonferroni Z statistics, $P < 0.05$ (Neu *et al.* 1974).

[4] Percentages of use were not statistically compared with percentages of availability during calving season due to the small sample size.

[5] Coniferous forests on valley floor are predominantly the sitka spruce (*Picea sitchensis*) vegetation zone (Franklin and Dyrness 1973).

[6] Coniferous forests on plateaus are predominantly the western hemlock (*Tsuga heterophylla*) vegetation zone (Franklin and Dyrness 1973).

and 16-30 year-old conifer stands on the plateau appeared to increase during calving (Table 1). Use of old-homestead fields and old-age spruce forests remained high during calving, whereas use of mature deciduous forests (>10 years old) decreased. Use of 1-5 year-old, 16-150 year-old, and old-age conifer stands on the plateau remained low during calving.

Discussion

Valley bottoms and riparian areas along the Queets River were key habitats selected by elk year around. Mature deciduous forests and coniferous/deciduous stands appeared to be important foraging areas of elk during all seasons except winter. In general, deciduous forests contain abundant forage for elk in comparison to coniferous forests of similar ages (Franklin and Pechenac 1968). Mature deciduous forests in our study area contained >95 percent ground cover (G. L. Schroer, Nat. Park Serv. unpubl. data) of important elk forages in the region (Leslie 1982). Research of other elk populations in western Washington and Oregon and Vancouver Island, B.C. also documented elk selection of deciduous forests and riparian areas (Brunt *et al.* 1989, Cooper 1988, Schroer 1987, Jenkins and Starkey 1984, Witmer and deCalesta 1983).

Even-aged coniferous stands less than 150 years old received little use by elk, except during winter, when 6-15 year-old clearcuts were selected by all elk. Stands that were 6-15 years old contained the most abundant forage (78% ground cover) of any even-aged coniferous stands less than 150 years old (G. L. Schroer, Nat. Park Serv. unpubl. data), which might have contributed to their selection. Coniferous stands approximately 10-25 years old in southeast Alaska also had the greatest abundance of forage cover of all seral stages (Alaback 1982). The habitat benefits of 6-15 year-old coniferous stands, however, are short-lived. Only 10-15 percent of a 60-90 year cutting cycle would include that age class. Succession of young coniferous stands to pole-sized and mature stands reduces forage quantity, and typically those stands persist for approximately 75 years (83%) of a 90-year cutting cycle.

The majority of radio-collared elk selected old-age spruce forests on the valley floor during autumn and winter, and generally avoided old-age western hemlock forests on the plateau except during winter. Reasons for the discrepancy among selection of these old-age habitat types are not clear from our data, but undoubtedly they stem from differences in landscape patterns and forage productivity in the two physiographic zones. Proximity of old-age Sitka spruce forests to preferred deciduous forests in the valley floor may have enhanced use of those conifer stands in bottomlands. Additionally, although we did not attempt to measure differences in forage abundance among old-age forest associations in the Queets Valley, cover of preferred forages of elk differed appreciably among climax forest associations in the nearby Hoh Valley (Smith and Henderson 1985). Other habitat benefits attributed to old-age forests include: snow interception and associated energetic benefits during winter (Jones 1974, Harestad *et al.* 1982, Parker *et al.* 1984, Zahn 1985); greater nutritional quality of browse (Happe *et al.* 1990), and abundant forage (Alaback 1982). Additional research clearly is needed to determine influences of site quality, forage production, and forest structural characteristics on elk habitat attributes and selection among old-age forest associations.

Management Implications

Conversion of old-age coniferous forests in many areas of the Pacific Northwest has created extensive even-aged stands less than 90 years old that are avoided by elk. Timber management projections indicate that by the year 2030, more than 65 percent of the total area of commercial forest lands in western Washington and Oregon will be between the ages of 30 and 90 years old (Harris 1984), and old-age coniferous forests will cover less than 10 percent of their original area (Franklin *et al.* 1981, Harris 1984).

The increasing prevalence of 16-90 year-old even-aged stands poses a significant problem for management of some elk ranges in the Pacific Northwest. Extensive even-aged coniferous forests generally do not contain the interspersion of forage and cover areas recommended by elk managers (Witmer *et al.* 1985). We recommend that comprehensive management plans be developed on a watershed or sub-watershed basis, including state, private, and federal lands, to ensure long term availability of preferred elk habitats within the managed forest.

Forest management in valley floor and riparian areas should be conducted in a manner that protects and enhances preferred vegetation habitats, especially mature deciduous forests which are key habitats for elk during most seasons. Old-age coniferous bottomland forests should also be protected on critical autumn and winter ranges. Where old-age forests cannot be retained or re-established, uneven-aged management with lengthy cutting rotations of over 150 years may be required to recreate a favorable interspersion of cover and forage.

Many additional silvicultural practices such as non-commercial and commercial thinning, shelter-wood cuts and small patch-cuts (i.e., 1-5 acres) have also been proposed as means of improving habitat interspersion and forage production in second-growth, even-aged forests (Bunnell and Eastman 1976, Hall *et al.* 1985, Witmer *et al.* 1985). Precommercial thinning, however, is typically not effective in improving forage availability for elk, because resulting slash depths often inhibit understory production and elk movements (Garrison and Smith 1974, Bunnell and Eastman 1976). Additionally, precommercial thinning of younger stands typically opens overstory canopies and increases forage cover for only relatively short periods (i.e., 5-10 years) depending on the number of trees removed (Hungerford 1969, Bunnell and Eastman 1976). Uneven-aged management and commercial thinning have been used effectively on the Olympic Peninsula to create foraging areas within the even-aged forest (M. Stoll, Olympic Nat. For., pers. comm., 1991). Additional silvicultural prescriptions that maintain partial openings in the overstory canopy in even-aged stands and produce acceptable quantities of slash debris need to be developed and implemented.

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