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Author(s): Kurt J. Jenkins and Edward E. Starkey

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KATHLEEN A. FAGERSTONE AND OLWEN WILLIAMS, *Denver Wildlife Research Center, Bldg. 16, Denver Federal Center, Denver, CO 80225, and Department of Environmental, Population, and Organismic Biology, Univ. Colorado, Boulder, CO 80309. Submitted 18 March 1980. Accepted 6 August 1981.*

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SOCIAL ORGANIZATION OF ROOSEVELT ELK IN AN OLD-GROWTH FOREST

Previous studies have suggested that social organization of Roosevelt elk (*Cervus elaphus roosevelti*) is variable. Harper (1964) reported that non-migratory herds of Roosevelt elk in silviculturally managed forests of southwest Oregon changed composition continuously, that marked members of adjacent groups interchanged freely, and that herds generally were unstable. In contrast, non-migratory and unhunted elk in the unmanaged Prairie Creek Redwoods State Park in north-coastal California formed stable assemblages of adult females and immature offspring during most of the year (Franklin et al., 1975). Franklin and Lieb (1979) suggested that open and snow-free meadows of north-coastal California provided stable habitat and forage which favored long-term social bonding of elk and development of cohesive social groups. Conversely, they postulated that early successional forests of southwest Oregon provided transitory habitats which precluded development and maintenance of stable groups. While conducting studies of home range and habitat preferences of non-migratory Roosevelt elk in Olympic National Park, Washington, we evaluated grouping behavior of adult cow elk by examining home ranges of elk, association of elk within social groups, and monthly mean sizes of elk groups. Social organizations of elk in stable old-growth forests in Olympic National Park, stable meadow habitats in north-coastal California, and silviculturally managed forests in southwestern Oregon also were compared.

The study area was in the rain forest valley of the Hoh River in western Olympic National Park, Washington (47°50'N, 123°55'W). The valley has a broad U-shaped configuration with steep densely forested sideslopes and broad river bottoms of alluvial and glacial derivation. Elevations range from 150 m on the valley floor to 910 m on the ridge tops. Climax spruce-hemlock forests were predominant in the valley bottom as were western hemlock forests on valley sideslopes (Franklin and Dyrness, 1973); distinctive features of forested bottomlands included presence of Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), groves of vine maple (*Acer circinatum*) and bigleaf maple (*A. macrophyllum*), and high coverage of mosses and lichens on the forest floor, fallen logs, and limbs of living trees. Climate is maritime with mild, wet winters and cool dry summers. Precipitation averaged 345 cm annually with most occurring as rainfall, although temporary snow cover of 1-18 cm existed in February of each year.

Home ranges and association of elk were described by radio-tracking nine non-migratory cow elk, of an estimated population of 150, from 5 June to 15 September 1978 and 1 January to 20 March 1979. Three mature cows were radio-collared in each of three cow groups in the study area. Home ranges of elk were

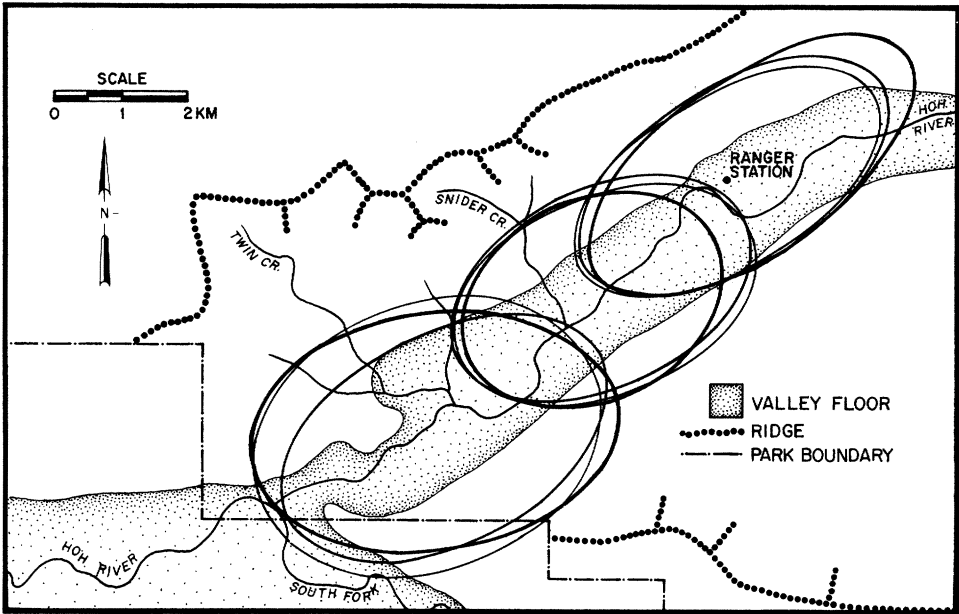


FIG. 1—Home range probability ellipses ($P = 0.05$) of radio-collared elk in each of three cow groups in the Hoh Valley, Olympic National Park, Washington. Line widths distinguish home ranges of three individuals in each group.

delimited using probability ellipses which encompassed 95% of the space utilized by each animal (Koeppel et al., 1975).

Association was defined as the incidence of two collared elk inhabiting the same social group, within 200 m of each other. Coefficients, corresponding to the frequency of association of pairs of elk, were calculated according to Cole's (1949) procedure; values ranged linearly from 0.0 to 1.0, reflecting a gradient from no association to perfect association.

A total of 1,935 relocations was obtained, 801 and 1,134 in summer and winter periods respectively. Annual home ranges averaged 1,064 ha ($SD = 219$) with no differences between paired summer and winter estimates ($t = 1.2$, $P > 0.05$). Franklin and Lieb (1979) reported home ranges of 300 ha in open meadow habitats and Graf (1955) and Witmer (1981) reported home ranges of 259–518 ha ($1\text{--}2\text{ mi}^2$) and less than 400 ha, respectively, in silviculturally managed forests of western Oregon.

Home ranges of individual elk in each group were nearly identical, which allowed delineation of three discrete home range groups (Fig. 1). Home ranges of adjacent groups overlapped peripherally, but use of the central areas was exclusive and association of elk from adjacent groups was rare. Elk from adjoining groups associated on eight occasions, but associations were temporary, lasting 3 days or less ($\bar{X} = 1.4$ days), and the original sets of three collared elk were preserved in each group. Franklin and Lieb (1979) reported similar patterns of overlap and interchange of elk in north-coastal California.

Coefficients of association of pairs of collared elk indicated that cohesiveness of individuals in cow groups was high. Coefficients of elk pairs within groups averaged 0.84 ($SD = 0.22$) and 0.79 ($SD = 0.21$) in summer and winter seasons, respectively ($t = 0.8$, $P > 0.05$). The lack of perfect association within groups indicated that sub-groups of individuals periodically were absent from the main herd. The duration of absentee periods averaged 5.4 days ($n = 42$) but was highly variable ($SD = 6.2$). Although coefficients were high in the summer overall, coefficients of two cow pairs with calves were 0.26 and 0.11 in June, which suggested that groups were least stable during calving. Association of elk pairs in silviculturally managed forests in southwestern Oregon averaged 0.33 and 0.50 in summer and winter, respectively (Witmer, 1981), and indicated lower constancy of association.

Franklin and Lieb (1979) documented seasonal changes in cohesiveness of elk groups by monitoring sizes of known herds and absence of marked individuals. Three annual periods were identified, a period of winter-spring stability marked by large group size (ca. 25) and low absenteeism and less stable periods of

TABLE 1.—Summary of habitat features and social parameters of cow elk groups in old-growth forests in Olympic National Park, open meadows in north-coastal California and silviculturally managed forests in western Oregon.

Habitat	Forage supply	Size of home range	Overlap of adjacent home ranges	Transfer of individuals between groups	Cohesion of groups	Size of groups
Old-growth forest	Dispersed stable	Large	Peripheral	Rare temporary	High	Large
Open ¹ meadow	Concentrated stable	Small	Peripheral	Rare temporary	High	Large
Managed forest	Concentrated transitory	Small ^{3,4}	—	Frequent ²	Lower ³	Smaller ³

¹ See Franklin et al., 1975; Franklin and Lieb, 1979.

² See Harper, 1964.

³ See Witmer, 1981.

⁴ See Graf, 1955.

calving and rutting marked by smaller group sizes (ca. 12) and greater frequencies of absence. Limited visibility in forested habitats prevented systematic counts of the three herd groups in this study, but sizes of all observed cow elk groups were recorded between August 1977 and August 1980. Elk groups were large in spring ($\bar{X} = 27$, $n = 7$), which suggested that absenteeism was low and stability of groups high. Group sizes decreased markedly in June ($\bar{X} = 15$, $n = 6$) as individuals became more solitary during calving, but increased in July ($\bar{X} = 26$, $n = 7$) presumably as more individuals rejoined the herd. Autumn data were not available, but groups were smaller in winter ($\bar{X} = 20$, $n = 14$). In contrast to large groups reported in this study and in open meadow habitats (Franklin and Lieb, 1979), small groups (ca. 3.3–6.9) were reported in western Oregon (Witmer, 1981).

Social parameters of cow elk groups in old-growth forests of this study were similar to those of elk in open meadow habitats in north-coastal California (Table 1). In contrast, patterns of group behavior of elk in silviculturally managed forests of western Oregon were dissimilar to those in both the stabilized habitats. These findings support the hypothesis of Franklin and Lieb (1979) that cohesiveness of elk groups is related to development and maintenance of strong social bonds in predictable and stabilized habitats.

Large group sizes in elk observed in the relatively dense habitats in Olympic National Park appeared to contradict sociobiological theory, which would predict larger groups in the more open habitats (Wilson, 1975:485). Positive relationships between openness of habitat and group size have been reported in several North American cervids: Columbia black-tailed deer, *Odocoileus hemionus columbianus* (Dasmann and Taber, 1958), white-tailed deer, *Odocoileus virginianus* (Hirth, 1977), and Roosevelt elk (Franklin et al., 1975). However, we suspect that large group sizes which were observed in both the closed forest and open meadow habitats were a function of the same processes of social maturation which could influence cohesiveness of elk social units (Franklin and Lieb, 1979). Populations with strong social bonding and traditionality would be expected to have larger group sizes than those lacking such attributes.

The uncharacteristically large home ranges of elk observed in this study might be related to the dispersed nature of the forage resource and the large group sizes of elk. Small groups or groups which inhabited more diverse environments with concentrated forage would have opportunity to obtain seasonal and daily requirements in a smaller area than large groups observed in the relatively homogeneous old-growth forest of Olympic National Park.

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MALE MOOSE SUCCESSFULLY BREED AS YEARLINGS

Some yearling female moose (*Alces alces*) ovulate in Finland (Rajakoski and Koivisto, 1966), Newfoundland (Pimlott, 1959), possibly in Montana (Peek, 1962), and likely elsewhere. Spermatogenesis was reported to occur in yearling male moose in Norway (Wildhagen, 1962, as cited by Markgren, 1969), in Montana (Huston, 1968), and in Sweden (Markgren, 1969). However, the literature contains no reference to a yearling male moose successfully inseminating a female. This paper describes such an occurrence.

At the Moose Research Center on the Kenai Peninsula, Alaska, five moose calves born in spring 1978 were hand-raised (Regelin et al., 1979), kept in a 7-ha enclosure, and fed a pelleted ration (Schwartz et al., 1980) ad lib.

During the usual breeding season in 1979 (late September to early October) three yearling males displayed expected behavioral attributes associated with breeding (Altmann, 1959; Lent, 1974). A dominance hierarchy was formed among individuals, and considerable agonistic behavior was observed. Actual breeding was not observed.

Between 28 May and 1 June 1980, one of the two yearling females enclosed with the yearling males produced a healthy male calf. This female must have been bred by at least one of the three yearling males as no adult bulls were present.

The birth of this calf confirms that yearling males fed at a high nutritional plane can breed females in the absence of dominant, older bulls.

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