AN ABSTRACT OF THE THESIS OF

Eric K. Cole for the degree of Master of Science in Wildlife Science presented on March 7, 1996. Title: Influence of Limited Access Roads on Roosevelt Elk in the Oregon Coast Range.

Abstract approved: Redacted for Privacy
Robert G. Anthony

No studies have evaluated the effects of limited vehicle access on movements, survival and habitat use of Roosevelt elk (Cervus elaphus roosevelti). We installed twenty gates, restricting motorized vehicle access by the public in seven discrete Road Management Areas (RMAs), comprising 35% of the study area. We radio-tracked 31 cow elk for 13 months in a 38,000 ha area of the Oregon Coast Range. Prior to the installation of the gates, 20 of these elk had been tracked for 14 months, allowing a paired comparison of elk movements and habitat use before and during the limited access period. The percentage of elk home ranges or core areas within the RMAs did not differ between periods, but there was a clear decrease in daily movement of elk during the limited access period. Survival rates increased during the limited access period and declined after the removal of the gates. During the limited access period, there was a significant increase in the use of open, foraging habitats and areas ≤ 150 m from roads. We conducted habitat selection analysis on vegetative cover types, distance from roads and distance from water. In general elk use of vegetative cover types was not significantly different from availability ($p < 0.05$). Elk avoided areas ≤ 150 m from roads and selected areas >150 m from roads. Elk selected areas ≤ 150 m from streams and avoided areas >600 m from streams. Roosevelt elk should benefit from the preferred alternative of the President's forest Plan, which maintains roadless areas near streams.

Influence of Limited Access Roads on Roosevelt Elk in the Oregon Coast Range

by

Eric K. Cole

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APPROVED:

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I understand that my thesis will become part of the permanent collection of Oregon State University Libraries. My signature below authorizes release of my thesis to any reader upon request.

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Eric K. Cole, Author

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This project would not have been possible without the monetary support of the Bureau of Land Management (BLM), Oregon Department of Fish and Wildlife (ODFW), and the Rocky Mountain Elk Foundation. Bret Christensen and Steve Langenstein of the BLM dedicated many hours implementing the limited road access program and ensuring that the gates were functional. John Toman of ODFW supervised the elk captures, retrieved radio-collars returned by hunters, and patiently answered many of my questions. Without the valuable assistance of Brigitte McBride, those rainy weeks in the Coast Range might not have been tolerable. Back in the office, my fellow graduate students Bob Steidl, Carolyn Marn, Eric Pelren, and John Loegering were always there to provide words of wisdom about analyses and offer comic relief. I especially thank Michael Pope, who did most of the thinking and ground breaking work for this cooperative venture; he suffered so I would not have to. Chris Kiilsgaard gave valuable help classifying the LANDSAT image and answering my GIS questions. Dan Edge and Bill McComb patiently offered advice throughout the course of the study. Bob Anthony, my advisor, deserves more thanks than I can give; he provided this great opportunity and pushed me just enough to encourage my independent thinking. Lastly, I need to thank my family. They did not want to see me go, but they offered nothing but love and support from beginning to end.

CONTRIBUTION OF AUTHORS

Michael D. Pope designed, conducted field work, and analyzed data for the pre-Road Management phase of the study. Dr. Robert G. Anthony acted as technical advisor and handled funding issues for both phases of the study. Eric K. Cole designed, conducted field work, analyzed data, and was the principal author for the Road Management study and manuscripts.

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This thesis is dedicated to Robert "Unk" Lauber: soldier, outdoorsman, and friend.

INFLUENCE OF LIMITED ACCESS ROADS ON ROOSEVELT ELK IN THE OREGON COAST RANGE

INTRODUCTION

Timber production is the dominant land use on forested land in western Oregon and Washington. Prior to recent timber injunctions on federal lands, approximately 200,000 ha were logged annually. (MacLean 1980). Forest management practices, which distribute logged patches evenly across the landscape also maximize the need for access and forest-road construction (Franklin and Forman 1987). Each square kilometer of intensively managed forest may contain as much as 4 km of road (Brown and Curtis 1985).

Avoidance of roads by Rocky Mountain elk (Cervus elaphus nelsoni) is well documented. Perry and Overly (1977) and Ward (1976) reported decreased habitat use in areas $\leq$ 0.4-0.8 km from roads and decreased use of cover in areas bisected by traveled roads. Lyon (1979) used pellet counts to demonstrate that elk in western Montana avoided habitat adjacent to forest roads and suggested that road avoidance by elk was a function of traffic volume, road quality, and density of cover near roads. However, there is less available evidence that Roosevelt elk (Cervus elaphus roosevelti) are negatively effected by roads. In the Oregon Coast Range, Witmer and deCalesta (1985) found that use of habitats by 8 elk was less than expected $\leq$ 500 m from paved forest roads, and there were fewer than expected observations $\leq$ 125 m from spur roads. Similarly, increased vehicle traffic on a forest highway within the Mt. St. Helens National Monument caused Roosevelt elk to avoid a 500-m corridor along the road (Czech 1991). There is evidence that avoidance of roads by Rocky Mountain elk is related to the amount of vehicle traffic. Rost and Bailey (1979) found greater road avoidance around well-travelled roads in their Colorado deer and elk study, and Edge (1982) suggested that elk were displaced by heavily travelled roads more than lightly travelled roads. Several researchers advocate limiting vehicle access to roads to mitigate elk avoidance of roads. Marcum (1976) indicated that areas closed to vehicle traffic received greater elk use than areas where roads remained open. Lyon et al. (1985) also recommended the use of road closures to enhance elk habitat. Road management has become a frequently used management tool, particularly for Rocky Mountain elk.

There is no information on the efficacy of road closures or limited-road access to benefit Roosevelt elk. Under the 1983 South Coast-Curry Timber Management plan, elk populations on Bureau of Land Management (BLM) lands within the study area were projected to decline 30-50% over 5 decades (Christensen and Langenstein et al.

1992). To ameliorate these effects, the current management plan calls for less timber harvest, decreased road construction, and limited vehicle access. Our objective was to evaluate the effectiveness of limited access roads for Roosevelt elk on BLM lands in the Oregon Coast range. Motorized vehicle access was limited on 7 discrete networks of secondary and spur roads (Road Management Areas) which comprised approximately 35% of the study area. To test hypotheses concerning the effectiveness of the road management strategy we quantified differences in traffic volume between roads under limited access and those that were not. We hypothesized that vehicle traffic on gated roads would be less than on non-gated roads.

Elk Movements

Geist (1978) and Craighead et al. (1972) demonstrated that Rocky Mountain elk have the ability to learn and adjust to favorable or unfavorable conditions. If elk attempt to minimize energy expenditures and maximize foraging efficiency, as suggested by Geist (1982), then elk should avoid areas associated with human harassment and favor areas that maximize security. Road closures should reduce human disturbance and increase elk security. Elk do not normally range widely within their home ranges in the course of daily activities. Schoen (1977) found that it was uncommon for Rocky Mountain elk to move > 1.7 km in 24 hours, and Irwin (1978) reported that elk move approximately 1,000 m per day. Typically, elk concentrate activity at preferred foraging areas until making a larger move to another location (Lieb 1981). Under pressure from human disturbance, however, elk will flee preferred areas, and movement may increase (Coop 1971, Edge 1982, Bryant et al. 1991).

One purpose of this study was to determine the influence of limited access on elk movements. We hypothesized elk activity would shift towards RMAs, which would be demonstrated by a higher percentage of home range and core areas within RMAs after roads were closed to the general public. We also hypothesized that the RMAs would provide security to the elk, and the distance between successive telemetry locations would decrease during this study compared to 1991-92 (Pope 1994). We further hypothesized that the decrease in movement would be correlated with the degree of elk association with RMAs.

Survival Rates

Other than harvest reports from hunters, there is little information on cause-specific mortality and survival rates for Roosevelt elk in the Oregon Coast Range, but survival estimates are important for population modelling. Pope

(1994) reported survival estimates for Roosevelt elk of 0.896 (SE =0.012) for 1 March 1991 to 28 February 1992. Potential causes of mortality in the study area for adult cow elk include legal harvest, poaching, cougar (Felis concolor) predation, disease, and malnutrition (Schwartz and Mitchell 1945, Toweill and Meslow 1977, Kistner 1982, Pope 1994). Another objective of this study was to estimate survival rates and causes of mortality and their relationship to the RMAs. We hypothesized that survival rates would be higher and poaching mortality would decline for elk associated with RMAs compared to elk in the pre-RMA study in 1991-92. We further hypothesized that survival rates would be higher during the RMA period than after the gates were removed.

Habitat Selection

Theory concerning the selection of resources by an organism suggests that a species will select habitats that best satisfy its life requirements (Rosenzweig 1981, Manly et al. 1993). Numerous studies have suggested that negative stimuli, such as roads, can cause elk to avoid habitats that might otherwise be selected (Perry and Overly 1977, Lyon 1979, Witmer and deCalesta 1985, Czech 1991). By removing most vehicle access, human harassment of elk should be reduced, elk security enhanced, and suitable habitat that otherwise would have been avoided should be used. Our objectives were to determine if limiting vehicle access with gates affected elk habitat selection in the Oregon Coast Range. We hypothesized that there would be increased selection for RMAs in 1993-94 compared with the 1991-92 pre-road management period (Pope 1994). We further hypothesized that elk use of non-timbered foraging habitat would increase. We expected that elk use of habitat close to roads would increase with increasing association with RMAs. We believed that these effects would be greatest during the high vehicle traffic season (August-December). Research on Rocky Mountain elk suggests that elk are seasonally associated with permanent water or riparian areas (Lyon 1973, Marcum 1975, Pedersen and Adams 1976, Pedersen et al. 1979). Grenier (1991) found that Roosevelt elk in northern California were typically $\leq$ 500 m from permanent water, and Pope (1994) found that elk within this study area selected areas $\leq$ 300 m from streams. Although, we did not expect RMAs to influence elk use of areas near streams, one objective of this study was to evaluate elk use of riparian areas.

Land management agencies currently use Habitat Effectiveness Index (HEI) models to make decisions regarding elk habitat. These models rank habitat quality on a scale of 0.0 to 1.0, with 0.0 representing the poorest quality habitat and 1.0 representing the best quality habitat. The model of choice for Roosevelt elk, "A Model to Evaluate Elk Habitat in Western Oregon" (Wisdom et al. 1986), calculates HEI values based on four variables. These variables are: The size and spacing of cover and forage areas, cover quality, forage quality, and the density of open roads. Unfortunately, there has been no rigorous research to assess the validity of these variables. Therefore, our second objective was to evaluate the validity of the Wisdom model variables by conducting a long-term habitat selection study on Roosevelt elk in the Oregon Coast Range.

Chapter 1

Effects of Limited Road Access on Vehicular Use

Eric K. Cole, Michael D. Pope, and Robert G. Anthony

INTRODUCTION

Timber production is the dominant land use on forested land in western Oregon and Washington. Prior to recent timber injunctions on federal lands, approximately 200,000 ha were logged annually (MacLean 1980). Forest management practices, which distribute logged patches evenly across the landscape also maximize the need for access and forest road construction (Franklin and Forman 1987). Each square kilometer of intensively managed forest may contain as much as 4 km of road (Brown and Curtis 1985).

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There is no information on the efficacy of road closures or limiting road access to benefit Roosevelt elk. Under the 1983 South Coast-Curry Timber Management plan, elk populations on BLM lands within the study area were projected to decline 30-50% over 5 decades (Christensen and Langenstein et al. 1992). To ameliorate these effects, the current management plan calls for less timber harvest, decreased road construction, and limited vehicle access. The objective of this study was to evaluate the effectiveness of limited access roads for Roosevelt elk on BLM lands in the Oregon Coast range. To test hypotheses concerning the effectiveness of the road management strategy, it is necessary to quantify differences in motorized vehicle traffic volume between roads under limited access and those that were not.

STUDY AREA

The study area spans approximately 380 km^2 in the Coos Bay District of the BLM including the northern Myrtlewood and southern Tioga Resource Areas. The area is approximately 30 km southeast of Coos Bay and 40 km west of Roseburg (Fig. 1). Typical of the southern Oregon Coast Range, the terrain is dominated by steep ridges and mountain slopes, divided by extensive stream systems (Franklin and Dryness 1973). Elevation ranges from 150 m in some drainages to 1,000 m on ridge tops. Climate is maritime, with moist winters and dry summers. Precipitation ranged from a 97-218 cm from 1969 to 1992 (Oregon Climatological Center 1993). Temperature during this time period ranged from a mean minimum of 1.67 C in January to a mean maximum of 25.93 C in August (Oregon Climatological Center 1993). Deep and persistent snowfall is possible at high elevations, potentially blocking road access for up to 2 months. There were no snowstorms that prevented vehicle access to any part of the study area for >1 week during this study.

Vegetation consists of the western hemlock (Tsuga heterophylla) series (Hemstrom and Logan 1986) and until 2 decades ago was predominately late-successional Douglas-fir (Pseudotsuga menziesii) and western hemlock forests. Today, the landscape is a mosaic of clearcuts, Douglas-fir plantations and old-growth, with some naturally regenerated mixed stands of western redcedar (Thuja plicata), red alder (Alnus rubra), bigleaf maple (Acer macrophylum), Douglas-fir and western hemlock. Riparian areas typically contain red alder, bigleaf maple and myrtle (Umbellularia californica). Understory vegetation is sparse in young Douglas-fir plantations, but can be quite dense in naturally regenerated stands and older seral stages. Sword fern (Polystichum munitum), huckleberry spp. (Vaccinium ovatum and V. parvifolium), vine maple (Acer circinatum), salal (Gaultheria shallon), rhododendron (Rhododendron macropyllus), and oceanspray (Holodiscus dicolor) are typical understory species (Franklin and Dryness 1973). Land ownership in most of the area is alternating sections of BLM and private land. The area has been under intensive forest management with the most recent logging on private lands. Although

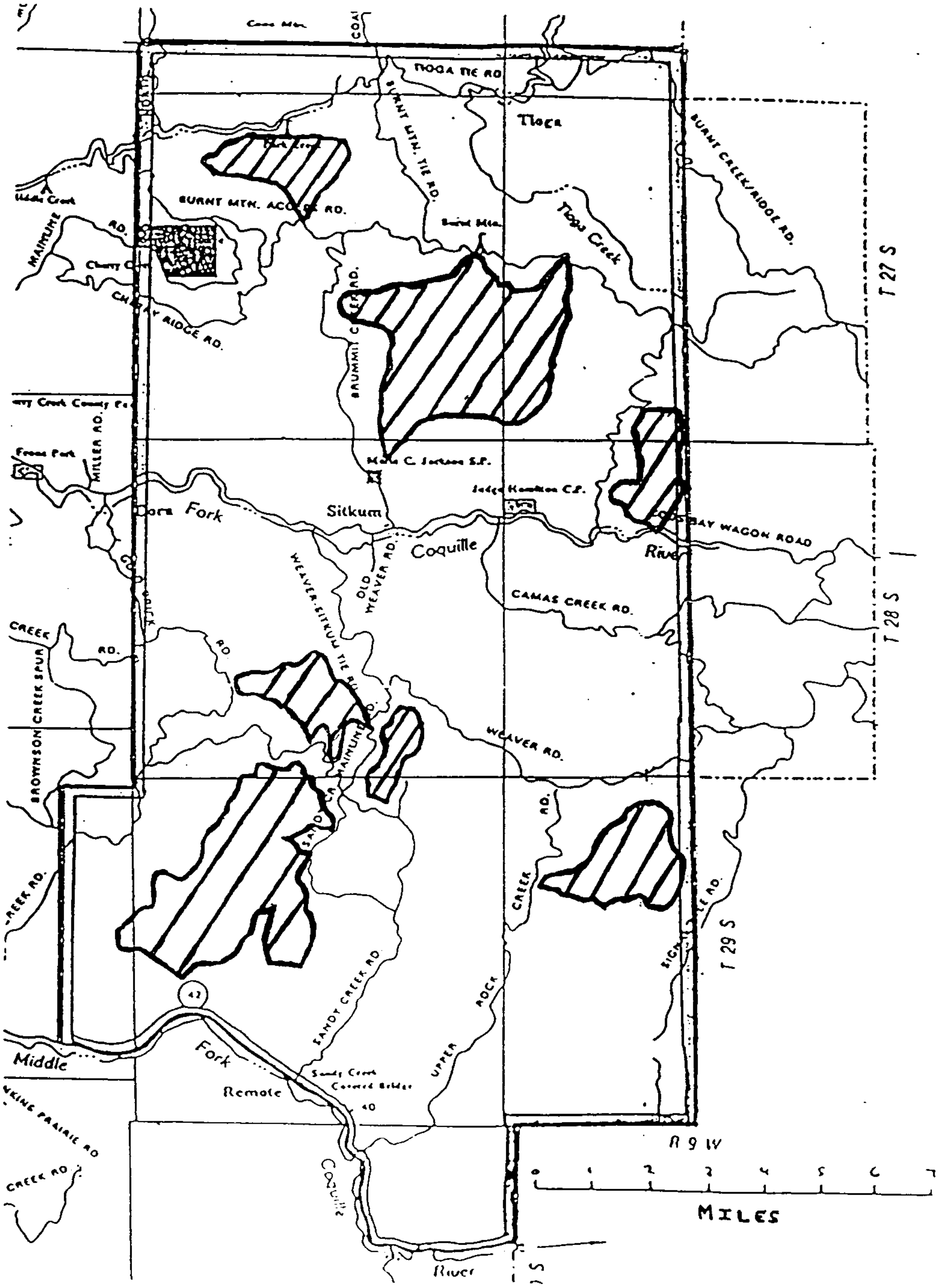

Figure 1. Roosevelt elk study area and Road Management Areas (denoted by diagonals) in the southern Oregon Coast Range.

commercial timber operations dominate the landscape, the area is also used for recreation including camping, hiking, fishing and hunting.

Access for forest management has produced an extensive road network within the study area. The BLM maintains paved roads that are also used by the private timber companies to access their lands. Rocked secondary roads branch from the paved roads with rocked and non-rocked spur roads branching off the secondary roads. Most roads are open to public access except during periods of high fire danger. One secondary road network on private land was gated for a month during summer 1994, but no other roads were closed due to fire danger during this study.

METHODS

Pre-Traffic Management Study

In order to evaluate elk response to limited access of vehicles, a previous study was conducted to determine movements, survival and habitat selection patterns prior to limited access management. From 15 June 1991 to August 1992, Pope (1994) collected location data on 29 radio-collared cow elk; 20 of these original elk were available for this study. Traffic volume was monitored on a random sample of secondary and spur roads during the pre-traffic management study using magnetic loop traffic counters.

Gate Placement and Road Management Areas

Motorized vehicle access was limited on 128 km of secondary and spur roads within the study area by installation and maintenance of 21 gates. Three percent of roads within the Coos Bay BLM District were affected. Gate placement was designed to include the home ranges of as many of the original radio-collared elk as possible. Access was limited on 7 discrete networks of secondary and spur roads (RMAs) (Fig. 1). The closures were initiated in October, 1992 at the end of Pope's (1994) study and remained in place until 20 August 1994. Road Management Areas comprised approximately 35% of the study area.

The gates did not provide true road closures. By definition, road closures prevent all vehicle access, and in some cases the road surface is destroyed, seeded and no longer maintained. Instead, the gates for this project limited vehicle access. The intent was to limit access to an average of ≤ 4 trips per week behind gates for administrative purposes such as forest management activities, wildlife research, fire suppression, and emergency access. Non-motorized access was not limited (Christensen and Langenstein 1992). True road closures would provide a more clearly defined experimental treatment. However, the interspersion of private and public lands made closures logistically impossible to implement, and road management had to be a cooperative venture. Therefore, limited access was used instead of road closures.

Traffic Monitoring

Loop traffic counters (Safetran model LDC355, Colorado Springs CO) were used to monitor vehicular traffic on a random sample of 20 roads. Randomization and balanced application of traffic counters was applied to 2 types of roads: (1) secondary roads in RMAs, and (2) secondary roads outside RMAs. Primary roads were not monitored because RMAs did not contain primary roads, and we assumed that vehicle traffic on primary roads was at least as high as non-gated secondary roads. Counters were monitored at 2-week intervals, and these data were used to generate average traffic counts for each road type. Secondary roads with counters were not thoroughfares, therefore 2 traffic counts were equivalent to 1 vehicle entering and leaving the secondary road. For each interval, 2-sample t-tests were used to test for differences in traffic volume between the roads inside and outside RMAs. Additionally, ≥ 1 traffic counter was present in each of the 7 RMAs, allowing variability in traffic volume among RMAs to be measured. Statistical tests were performed at the 0.05 level of significance.

Traffic analysis also was conducted during the pre-RMA study in 1991-92 (Pope 1994). Because these data were obtained using a slightly different methodology than the 1993-94 traffic data, statistical comparison was not possible. Instead, time-related trends were compared graphically between the 2 time periods.

RESULTS

Mean traffic counts for each 2-week interval were consistently higher for non-gated versus RMA roads, with the exception of the second week of May 1994 when the mean vehicle passes for both types of roads was 6 (=3 vehicles)(Fig. 2). Traffic counts for RMAs were consistently less than 10 vehicle passes (5 vehicles) per two week period throughout the study. Traffic counts were highest in RMAs in late October 1993, with a mean of 8 vehicle passes per 2-week period. Mean traffic counts peaked for non-gated roads in late November at 68 vehicle passes, and minimum means for non-gated roads of 6 vehicle passes occurred in late May and early July 1994. Mean

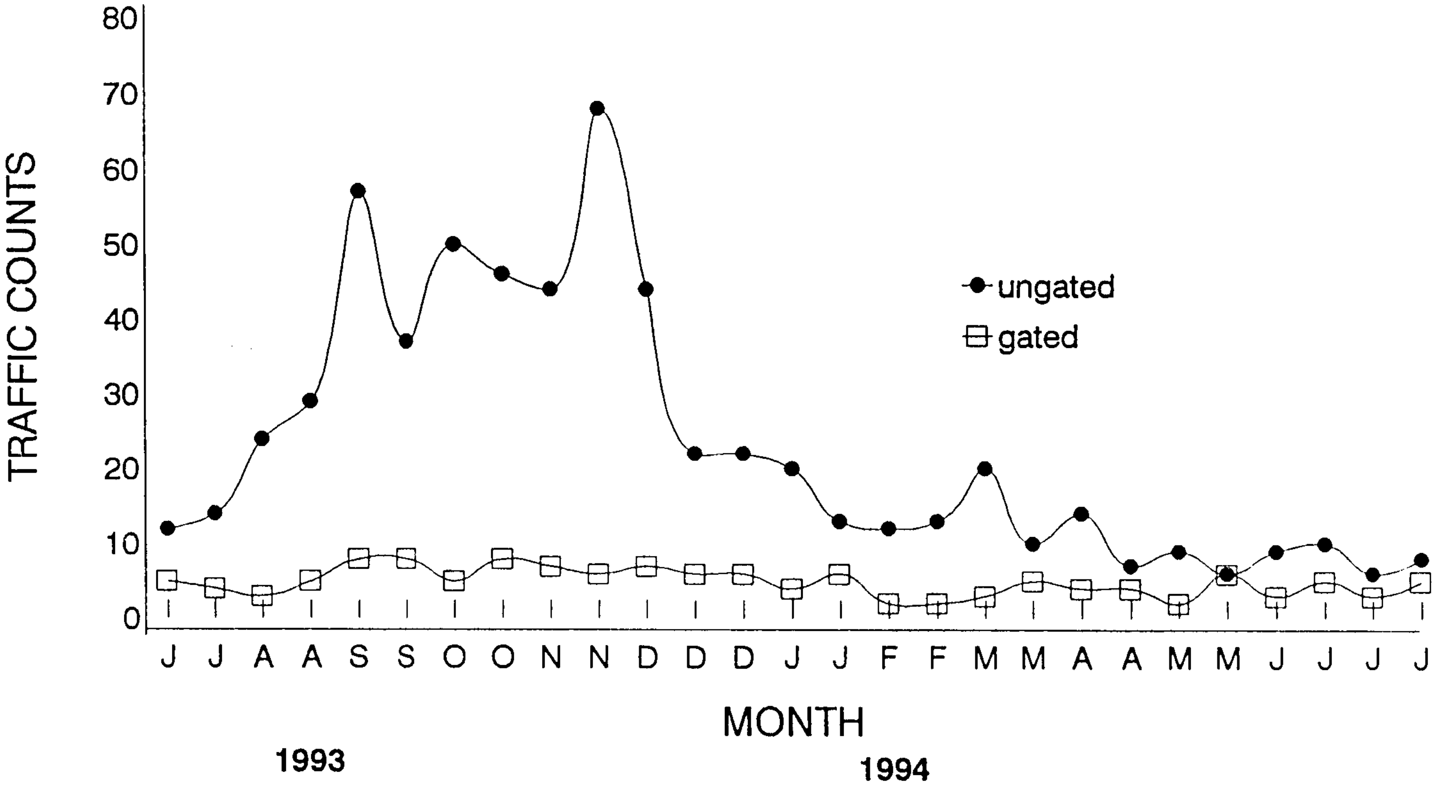

Figure 2. Average traffic counts for 2-week intervals on nongated and gated roads in the southern Oregon Coast Range, 1993-94.

traffic counts were significantly ($p \leq 0.05$) different between RMA and non-gated roads for each 2-week interval between August and December 1993. Differences were not significant ($p \leq 0.05$) from January to July 1994, but statistical power was not sufficient to detect differences of this magnitude during this time period. Power equalled 0.08 for most 2-week intervals. To improve statistical power, we pooled traffic counts from August through December and January through July. Traffic volume between gated and non-gated roads was significantly different ($p = .0001$) for both the August-December and January-July periods, but the magnitude of the difference was not nearly as great for the January-July period (Fig. 2).

There was variability in mean traffic volume among the 7 RMAs. Mean traffic counts for RMAs for July 1993 to August 1994 ranged from 0.09-7.69. For the same time period average traffic volume for non-gated roads was 23.24 vehicle passes, ranging from 6 to 68 counts.

DISCUSSION

BLM objectives were an average of ≤ 4 vehicle trips per week behind each gate. This is equivalent to ≤ 16 traffic counter counts per 2-week period. The RMA mean for each 2-week period was consistently less than 10 counts per two week period. Traffic volume for individual gates occasionally exceeded the 16-count maximum due to illegal public entry or management activities. On average however, the BLM road management objectives were met as outlined by Christensen and Langenstein (1992), and the RMA road treatment was considered successful for the purposes of this study.

Peak traffic volume from August 1993 to December 1993 coincided with the fall hunting seasons (Table 1). Big-game hunting accounted for the majority of traffic volume on non-gated roads. This is a typical pattern for the study area because hunting seasons occur at the same time each year, and traffic counts by Pope (1994) for 1991-92 showed a similar trend. Although hunting activity is a confounding variable when analyzing effect of roads on elk habitat use, the greatest difference in traffic volume between RMA and non-gated roads occurred in August-December 1993. Due to this difference, we conducted elk habitat analysis for both the entire study period and August through December alone (see Chapter III).

Traffic volume trends through time were similar for non-gated roads in 1991-92 (Fig. 3)(Pope 1994) compared with 1993-94. The number of vehicle passes over traffic counters peaked for both time periods in November, with

Table 1. Big game hunting seasons and associated traffic volume (mean vehicle passes per 2-week interval) in the southern Oregon Coast Range, 1993.

		Traffic Volume	
Season	Date	RMA roads	non-gated roads
Deer and Elk Bow	28 August-26 September	8	47
Bull Elk Rifle	13-17 November	6	56
Bear	28 September-30 November	6	50
Cow Elk Rifle	18-19 December	6	22

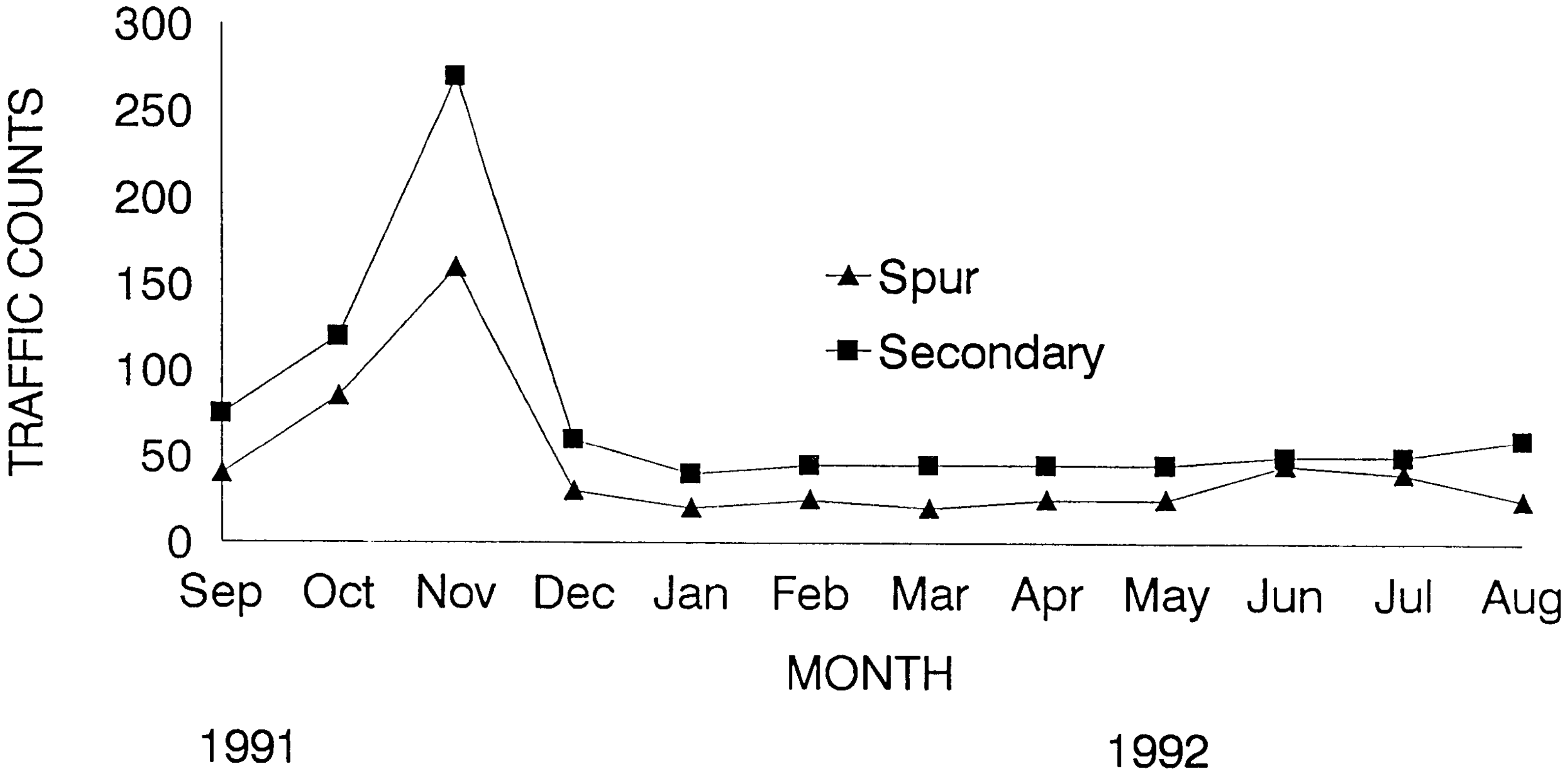

Figure 3. Mean monthly traffic volume on spur and secondary roads in the southern Oregon Coast Range, 1991-92 (from Pope 1994).

relatively stable and lower traffic volumes from January through July. There also were comparable seasonal traffic patterns and volume on a sample of 6 non-gated roads on nearby BLM land outside the study area (Badey 1992). There is very little information available concerning traffic volume on forest roads. Ou (1986) found traffic volume to range from 0.1 to 40 vehicle trips per hour on secondary roads in the Gifford Pinchot National Forest in Washington. This traffic volume is considerably higher than that found on non-gated roads within the study area probably because Ou examined recreational traffic associated with the Mt. St. Helens blast zone.

Chapter 2

Road Management Effects on Home Range, Movements and Survival of Roosevelt Elk in the Oregon Coast Range

Eric K. Cole, Michael D. Pope, and Robert G. Anthony

INTRODUCTION

White and Garrot (1990:145) defined home range as the map and numerical estimate of the area an animal normally uses in the course of its daily activities. Movements beyond the area normally used by the animal are not considered part of the home range (Burt 1943). A definition of these movements is needed, and the 95% utilization distribution is commonly used to demonstrate "normal" animal movements (Anderson 1982). Several home range estimators (Jennrich and Turner 1969, Dixon and Chapman 1980, Anderson 1982, Worton 1989) provide an estimate of home range size and a meaningful map of the area traversed. Core areas have been used to describe areas of intensive animal use (Kaufmann 1962, Leuthold 1977), because animals generally use space disproportionately within the boundaries of their home range. Thus, core areas are those portions of the animal's home range that exceed an equal use pattern (Samuel et al. 1985), typically a 50% utilization distribution. This definition of core area has been demonstrated in European red deer (Cervus elaphus) (Clutton-Brock et al. 1982).

Geist (1978) and Craighead et al. (1972) suggested that Rocky Mountain elk have the ability to learn and adjust to favorable or unfavorable conditions, and preferred habitats may be deserted if disturbance is excessive (Ward et al.1980). If elk attempt to minimize energy expenditures and maximize foraging efficiency as suggested by Geist (1982), then elk should avoid areas associated with human harassment and favor areas that maximize security. Thus, road closures should reduce human disturbance, and increase elk security. Elk do not normally range widely within their home range in the course of daily activities. Schoen (1977) found that it was uncommon for Rocky Mountain elk to move more than 1.7 km in 24 hours, and Irwin (1978) reported that elk move approximately 1,000 m per day. Typically, elk concentrate activity at preferred foraging areas until making a larger move to another location (Lieb 1981). Under pressure from human disturbance, however, elk will flee preferred areas, and the amount of movement may increase (Coop 1971, Edge 1982, Bryant et al. 1991).

Stussy et al. (1993) reported high poaching mortality of Roosevelt elk in an area with high road density in the Oregon Cascades. However, other than harvest reports from hunters, there is little information on cause-specific mortality and survival rates for Roosevelt elk in the Oregon Coast Range, but estimates of survival rate are important for population modeling. Pope (1994) reported survival estimates for Roosevelt elk of 0.896 (SE = 0.012) for 1 March 1991 to 28 February 1992. Potential causes of mortality in the study area for adult cow elk include legal harvest, poaching, cougar (Felis concolor) predation, disease, and malnutrition (Schwartz 1945, Toweill and Meslow 1977, Kistner 1982, Pope 1994).

The purpose of this study was to determine the influence of road closures on elk movements and survival. We hypothesized elk activity would shift towards road management areas (RMAs), and this would be demonstrated by a higher percentage of home range and core area within RMAs after roads were closed to the general public than during the pre-road management study. We also hypothesized that the RMAs would provide security to elk, and the distance moved between consecutive telemetry locations would decrease during this study compared to 1991-92 (Pope 1994). Further, we hypothesized that the decrease in movement would be correlated with the degree of elk association with RMAs. Our final objective was to estimate survival rates and causes of mortality and their relationship to the RMAs. We hypothesized that survival rates would be higher for elk associated with RMAs than for elk in the pre-RMA study in 1991-92, and poaching mortality would decline for the RMA-associated elk. We further hypothesized that survival rates would be higher in the RMA period than after the gates were removed.

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The study area spans approximately 380 square km of the Coos Bay District of the BLM, including the northern Myrtlewood and southern Tioga Resource Areas. The area is approximately 30 km southeast of Coos Bay and 40 km west of Roseburg (Fig. 1). Typical of the Southern Oregon Coast Range, the terrain is dominated by steep ridges and mountain slopes, divided by extensive stream systems (Franklin and Dryness 1973). Elevation ranges from 150 m in some drainages to 1,000 m on ridge tops. Climate is maritime, with moist winters and dry summers. Precipitation ranged from 97-218 cm per year from 1969 to 1992 (Oregon Climatological Center 1993). Temperature during this time period ranged from a mean minimum of 1.67 C in January to a mean maximum of 25.93 C in August (Oregon Climatological Center 1993). Deep and persistent snowfall is possible at high elevations, potentially blocking road access for up to 2 months. However, there were no snowstorms that prevented vehicle access to anywhere in the study area for > 1 week during this study.

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Access needs for forestry activities has produced an extensive road network within the study area. The BLM maintains paved main-line roads that are also used by the private companies to access and manage their forests. Rocked secondary roads branch from mainlines with rocked and non-rocked spur roads branching from secondary roads. Most roads are open to public access except during periods of high fire danger. One secondary road on private land was gated for a month during summer 1994, but no other roads were closed due to fire danger during this study.

METHODS

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In order to evaluate elk response to limited access of vehicles, a previous study was conducted to determine movement, survival, and habitat selection patterns prior to limited access management. From 15 June 1991 to August, 1992 Pope (1994) collected location data on 29 radio-collared cow elk; 20 of these original elk lived throughout this study. Traffic volume was monitored on a random sample of secondary and spur roads during the pre-traffic management study using magnetic loop traffic counters.

Gate Placement and Road Management Areas

Motorized vehicle access was limited on 128 km of secondary and spur roads within the study area by installation and maintenance of 21 gates. Three percent of roads within the Coos Bay BLM District were affected. Gate placement was designed to include the home ranges of as many of the original radio-collared elk as possible. Access was limited to 7 discrete networks of secondary and spur roads (RMAs) (Fig. 1). The closures were initiated in October, 1992 at the end of Pope's (1994) study, which allowed a nine month acclimation period, and remained in place until 20 August 1994. Road Management Areas comprised approximately 35% of the study area.

The gates did not provide complete road closures. By definition, road closures prevent all vehicle access, and in some cases the road surface is destroyed, seeded and no longer maintained. Instead, the gates for this project limited vehicle access. The intent was to limit access to an average of ≤ 4 trips per week behind gates for administrative purposes such as forest management activities, wildlife research, fire suppression, and emergency access. Non-motorized access was not limited (Christensen and Langenstein 1992). True road closures would provide a more clearly defined experimental treatment. However, the interspersion of private and public lands made closures logistically impossible to implement, and road management had to be a cooperative venture. Therefore, limited access was used for the study instead of road closures.

Elk Captures

Twenty-nine cow elk were immobilized in March 1991 by ODFW personnel using helicopter darting with carfentanil citrate as an immobilizing compound (Pope 1994). They attempted to capture elk from distinct bands throughout the study area and recorded location, estimates of age, weight, and physical condition for each capture. Radio transmitter collars (Telonics MOD-600 164 MHz, Mesa AZ) with a > 3 year operational life were attached to each captured elk. Each collar contained an activity sensor that increased the pulse rate from 50 pulses per minute (ppm) in the head-down position, to 100 ppm in the head-up position. To facilitate visual identification of collared elk, numbered and color-coded ear tags were attached to each ear (Nasco TUFF-FLEX cattle tags, Modesto CA). Twenty of these original 29 elk lived through Pope's (1994) and this study. Twelve additional elk were captured in April 1993 using a helicopter and Hughs 500-C net-gun without immobilizing agents. An effort was made to capture an equal number of elk within and outside RMAs and from distinct bands.

Radio-Telemetry

Telemetry procedures were identical to those described by Pope (1994). Two-element yagi antennas with Telonics TR-2 receivers were used to monitor radio signals. The "loudest signal method" as described by Springer (1979) was used to determine the direction of the radio signal, and 3-5 compass bearings were used to locate elk by triangulation. All locations were plotted using Universal Transverse Mercator grid (UTM) coordinates on USGS 1:24,000 quadrangle maps. To increase the accuracy of locations, we attempted to minimize the time elapsed between bearings and the distance between elk and the observer without influencing elk behavior. Elk locations were derived from azimuth and receiver information entered in the telemetry processing program XYLOG (Dodge and Steiner 1986), which provides a confidence ellipse (Lenth 1981, White and Garrott 1986) for each location. The confidence ellipse feature requires a measure of azimuth error. Potential triangulation error has been reviewed extensively in the literature (Springer 1979, Lee et al. 1985, Garrot et al. 1986, White and Garrot 1990: 47-75). Based on this review, we conducted a field trial to determine azimuth error and reduce telemetry error. Azimuths were estimated using TR-2 receivers and the loudest signal method on 50 unknown-transmitter locations at a variety of times, elevations, and distances from the transmitter. Average azimuth error was 5 degrees; we used this value to generate estimates of confidence ellipses with the XYLOG program.

Elk Monitoring

To assure independence of locations, the minimum interval between successive locations should be sufficient for the animal to move from one end of its home range to the other (White and Garrot 1990: 147). Therefore, we subjectively set the minimum time between successive locations at 24 hours, and individual elk were located $\geq$ 1 time per week between July 1993 and August 1994. All locations were diurnal, and we alternated locations between mid-day and crepuscular periods for each elk. Randomization of elk locations was logistically impossible because of the size of the study area and the need to obtain a $\geq$ 50 locations per elk to estimate home range size. We did not attempt to confirm radio locations visually to avoid disturbance of radio-collared elk. When radio-collared elk were visually located, we recorded UTM location, habitat type, band composition, date, time and elk activity.

Home Range and Core Areas

We used the adaptive kernel (ADK) estimator (Worton 1989) and the minimum convex polygon (MCP) method (Hayne 1949) to estimate home range in this study. The ADK (Worton 1989) is a non-parametric method which uses a smoothing parameter to reduce bias in the estimator. Home range estimates were calculated for the 31 elk with more than 50 locations. Utilization distributions of 95, 75 and 50% for the ADK and MCP methods were computed using program CALHOME (Baldwin and Kie 1992).

To facilitate comparison with Pope (1994), core areas were calculated using the harmonic mean method in program HOME RANGE (Ackerman et al. 1990). This method uses a chi-square test to determine at what point the existing distribution of locations exceeds a "uniform utilization distribution" as described by Samuel et al. (1985). Various researchers have used arbitrary home range utilization distribution levels such as 50% to define core area (Kaufman 1962, Michener 1979, Dixon and Chapman 1980). The biological significance of these arbitrary utilization distributions to define core area is questionable. Therefore, we used the harmonic mean method (Ackerman et al 1990) instead of a 50% ADK utilization distribution.

Road Management Area Boundary Determination

Topography (Edge and Marcum 1991) and cover (Basille and Lonner 1979, Lyon 1979) may ameliorate the affects of road disturbance on elk. Whether or not a road is visible or audible, may influence the degree the road disturbs elk. Ideally, the RMA boundary would have been defined taking visibility of roads into account. However, the mixture of slope, aspect, and vegetative cover conditions in the study area made this logistically impossible. Instead, the RMA boundary was defined as the mid-point between gated and the nearest non-gated road. Secondary road systems mapped by Coos and Douglas counties were imported into program ARC/INFO (ESRI 1991). Additional spur and new secondary roads were digitized from 7.5 minute USGS quads using the ARC/EDIT program within ARC/INFO (ESRI 1991). Roads that were permanently out of use due to vegetation or other natural obstacles were removed from the GIS using ARC/EDIT. With the complete and edited road layer, the boundaries of the RMAs were digitized. Using the distance function, a series of points were generated that were exactly half way between gated and the nearest non-gated roads. These points were connected using a digitizer to produce a map of RMA boundaries.

For each of the 20 elk common to this and Pope's (1994) study, boundaries of the 95% ADK home range and harmonic mean core areas were converted to ARC/INFO format. To test for changes in location of home range and core area after limited access, the intersection of each home range and core area file with RMAs was determined using program ARC/INFO. The percentage of home range and core area overlap with RMAs in this study was compared to the percentage of overlap in Pope's (1994) study using a paired t-test. Because Pope's (1994) study was conducted prior to limited access, an increase in home range and core area association with RMAs was hypothesized for this study. Pearson correlation tests on the change in home range and core area (dependent variable) with the percent RMA association (independent variable) were conducted in program SAS (SAS inst. 1994).

Movements Between Consecutive Locations

The distance moved between consecutive locations of individual elk was calculated in program Home Range (Ackerman et al. 1990) for this study and for the same elk in 1991-92 (Pope 1994). Because elk were not located at fixed time intervals, the distance moved between locations was expressed per 24 hour period by dividing the distance moved by the number of days between locations, and these values were averaged for each elk for the entire year (ADMSL). These values are not absolute measures of the distance moved in a 24 hour period, but they are indices of movement for comparison between this study and Pope (1994). A paired t-test was used to compare ADMSL for each elk in this study with the pre-RMA study in 1991-92 (Pope 1994). Two Pearson correlation tests were conducted; (1) on the difference in ADMSL between studies (dependent variable) with percent RMA association (independent variable), and (2) on ADMSL for each elk during this study (dependent variable) with percent RMA association (independent variable).

Survival Rates

Elk were located $\geq$ 1 time per week during Pope's (1994) study in 1991-92 and during this study (1993-94). Between the 2 studies (September 1992 to June 1993) elk were monitored at 2-month intervals to estimate survival rates. After this study and the removal of the gates, elk were monitored at 1-month intervals. If mortality was suspected due to similar successive locations or for constant transmitter pulse-rate, we visually located the elk and determined time and cause of death. Cause-specific mortality was not considered in calculation of survival rates because scavenging animals often disturbed the carcasses and prevented determination of cause of death.

The Pollock adaptation of the Kaplan-Meier product-limit estimator was used to estimate survival rates (Pollock et al 1989, Kaplan and Meier 1958). A SAS program in White and Garrott (1990: 236-239) was used to calculate survival rates, and a chi-square log rank test within the program was used to test for differences between survival curves at alpha = 0.05 (Cox and Oakes 1984). For comparison of survival curves relative to the RMA time period, the intervals were divided into equivalent time periods to compute the log rank test (Cox and Oakes 1984). For this reason, and to allow acclimation of the elk to road closures, the 1 November 1992 to 6 March 93 portion of the RMA interval were excluded from the comparison of the pre-RMA with the RMA interval. The pre-RMA interval was from 6 March 1991 to 31 August 1992, and the RMA interval was from 6 March 1993 to 31 August 1994. All elk (n = 29) were included in the pre-RMA interval, but only elk associated with the RMAs (n = 21) were included in the RMA interval. For comparison of the RMA period with the post-RMA interval, all elk were included in the post-RMA interval (n = 31), but only elk associated with RMAs (n = 21) were included in the RMA interval. The post-RMA interval was from 1 September 1994 to 31 March 1995. For comparison with the post-RMA interval, only the 1 September 1993 to 31 March 1994 portion of the RMA interval was considered.

Survival rates were calculated from 1 March 1991 to 28 February 1995 for each biologically important season within this time period. Biologically important seasons were defined by Witmer (1981) and Pope (1994) as: winter (January-February), spring (March-April), calving (May-June), summer (July-August), rut (September-October), and fall (November-December).

We conducted survival analyses two ways: (1)Censoring elk that disappeared, and (2) treating elk that disappeared as poaching mortalities. Seven elk disappeared (loss of radio signal and loss of visual location) between March 1991 and March 1995. Three of these elk disappeared after expected transmitter life and were censored from both types of analyses. The four elk that disappeared within expected transmitter life were probably killed by poachers. Pope (1994) reported suspicious activity (people driving the roads after dark) when the elk disappeared. Although the bands that the disappeared elk had been associated with were frequently seen, there were no collared-elk with them. Transmitter failure is unlikely, and poaching is the most likely type of mortality to produce these conditions.

RESULTS

Home Range and Core Areas

Thirty-two collared female elk were alive at the beginning of this study in July 1993. However, one elk with only 20 locations was harvested during the antlerless rifle season in December 1993 and was excluded from the analyses. The remaining 31 elk were each located 59 - 62 times between July 1993 and August 1994, resulting in a total of 1,883 locations, 17% of which were visual and 83% by triangulation. Mean confidence ellipse size for elk locations (Dodge and Steiner 1986) was 1.41 ha.

Mean 95% ADK home range size for all elk in this study was 742 ha (SD = 402). However, there was considerable variability among individual elk (range of ADK size = 230 to 1,672 ha. Ninety-five percent MCP estimates were smaller and ranged from 180 ha to 1,154 ha (mean = 494, SD = 270 ha) (Table 2).

Core area was estimated for 30 individual elk. The location distribution of one elk had no significant core area, so it could not be calculated. Mean core area size was 373 ha (SD = 191) and ranged from 92-869 ha. Mean percentage of harmonic mean home range for all elk core areas was 39.6% (SD = 5.49) (Table 3), with a range of 28 to 49%. Estimates of core area size were somewhat similar to the 75% utilization distribution by the ADK method (Table 2).

Home Range and Core Area Relative to Road Management Areas

Change in the percent of 95% ADK home range intersecting RMAs between the pre-RMA and the during RMA field season was variable. Of the 20 elk common to both studies, 11 animals increased in percent association with RMAs, 7 decreased association, and 2 did not change from 1991-92 to 1993-94 (Table 4). The increases ranged from 1 to 15% , and the decreases ranged from 1 to 22%. There was no significant difference in home range association with RMAs between the time periods, but the difference was suggestive (paired $t = 0.6188$, $p = 0.54$). There was no correlation between % change in home range overlap with RMAs between the time periods and percent RMA association ($p = 0.14$).

Table 2. Adaptive kernel (ADK) and minimum convex polygon (MCP) home range estimates (ha) for 95%, 75%, and 50% utilization distributions of Roosevelt elk in the southern Oregon Coast Range, 1993-94.

Elk Frequency	#locations	ADK 95	ADK 75	ADK 50	MCP 95	MCP 75	MCP 50
4.022	60	503	219	101	302	148	97
4.061	61	492	174	94	318	184	99
4.081	60	316	151	75	210	122	55
4.100	61	802	438	254	504	328	178
4.120	60	591	164	69	318	123	44
4.161	61	1372	614	382	854	587	286
4.181	61	820	384	211	550	282	173
4.232	59	230	157	82	180	117	71
4.251	59	294	125	36	211	130	59
4.271	59	280	176	81	242	164	106
4.291	60	1251	576	276	865	436	233
4.311	60	824	483	220	536	314	186
4.330	62	1410	542	246	1063	527	202
4.370	61	1476	798	337	989	658	434
4.390	60	650	307	154	472	290	98
4.421	61	540	196	98	308	141	86
4.532	60	385	214	93	271	193	61
4.551	60	888	397	238	592	385	175
4.631	59	567	267	122	431	220	95
4.651	60	402	238	104	308	201	105
[a]5.091	60	993	401	174	558	294	104
[a]4.591	60	1007	581	202	622	337	203
[a]5.071	60	271	182	63	227	166	94
[a]4.681	60	402	221	81	264	146	59
[a]5.081	60	674	235	95	358	207	67
[a]5.052	60	508	224	117	334	203	90
[a]5.031	60	784	389	226	613	256	123
[a]5.061	61	1672	816	266	1154	818	205
[a]4.611	60	1101	320	186	712	206	105
[a]5.100	60	928	356	180	587	255	155
[a]5.041	60	1078	415	203	642	369	217
$\bar{x}$	60.2	743	347	163	494	284	139
SD	0.69	402	188	87	270	169	83

[a] Following elk were captured in April 1993. All other elk were captured in March 1991.

Table 3. Core area size (ha), percent of total harmonic mean home range, and harmonic mean home range size (HM) of collared elk in the southern Oregon Coast Range, 1993 -94.

Elk Frequency	Core Area	% of Home Range	HM
4.022	237	39	602
4.061	296	28	936
4.081	92	33	275
4.100	582	46	1253
4.120	278	32	869
4.181	397	42	957
4.232	135	49	275
4.251	127	40	314
4.271	182	47	391
4.291	869	38	2316
4.311	444	44	1015
4.330	622	29	1590
4.370	759	32	2339
4.390	313	37	856
4.421	288	37	782
4.532	172	42	405
4.551	340	39	896
4.631	279	39	716
4.651	248	47	530
5.091	422	42	1016
4.591	447	43	1034
5.071	197	48	409
4.681	199	42	471
5.081	311	37	847
5.052	353	41	868
5.031	573	34	1708
5.061	506	29	1745
4.611	508	37	1367
5.100	475	39	1218
5.041	561	46	1230
$\overline{x}$	373	39.6	1008
SD	191	5.49	525

Table 4. Adaptive kernel 95% home range, area (ha) of home range within Road Management Area (RMA), percentage of hom range within RMA, and % change in RMA association between time periods for radio-collared elk in the southern Oregon Coast Range during this (1993-94) and Pope's (1994) study (1991-92).

Frequency[a]	Area 1991-92	RMA Area[b]	% RMA 1991-92	Area 1993-94	RMA Area[c]	% RMA 1993-94	% Change[d]
4.022	694	64	9	503	15	3	-6
4.061	497	152	31	494	184	37	+6
4.081	625	300	48	493	310	63	+15
4.100	690	20	3	802	29	4	+1
4.120	810	777	96	591	561	95	-1
4.161	1865	1011	54	1372	434	32	-22
4.181	1071	118	11	820	41	5	-6
4.232	364	276	76	230	203	88	+12
4.251	314	211	67	294	210	71	+4
4.271	296	234	79	280	225	80	+1
4.291	956	860	90	1251	1164	93	+3
4.311	910	0	0	824	0	0	0
4.330	1666	1246	75	1410	1015	72	-3
4.370	1156	197	17	1476	428	29	+12
4.390	476	435	91	650	614	95	+4
4.421	528	515	98	540	493	91	-7
4.532	790	659	83	385	376	98	+15
4.551	1025	602	59	888	530	60	+1
4.631	471	161	34	567	162	29	-5
4.651	437	150	34	402	138	34	0
$\bar{x}$	764	399	52.8	742	357	54.0	1.2
SD	407	353	33.3	402	314	35.2	8.67

[a] Elk radio transmitter frequency.

[b] Home range area within RMA in 1991 -92 based on the RMA boundary in 1993 - 94, [c] 1993 - 94.

[d] Change in the percentage of home range overlap with RMAs from 1991-92 to 1993-94.

Similar results were obtained when the percent of core area intersection with RMAs was tested between the 2 time periods. Of the 19 elk common to both studies for which appreciable core area was calculated, 10 increased in the percent intersection with RMAs, 6 decreased association, and 3 did not change (Table 5). The increases ranged from 1 to 25%, and the decreases ranged from 2 to 33%. There was no difference in core area association with RMAs between the time periods (paired $t = 0.110$, $p = 0.91$) and no correlation between change in core area overlap with RMAs between the time periods and percent RMA association ($p = 0.48$).

Distance Between Consecutive Locations

Because we were interested in the effect of RMAs on the distance moved between successive locations, only those elk associated with RMAs and common to both the 1991-92 study (Pope 1994) were considered in the analysis. Sixteen of the 20 elk common to both studies were substantially associated with RMAs (> 20% association). Fourteen of these 16 elk decreased average annual distance moved between successive locations (ADMSL) between 1991-92 and this study (Table 6), and there was a significant ($p \leq 0.05$) decrease in ADMSL between the two time periods (mean difference = 32.8 m, SD = 37.4, paired-t = 3.49, $p = 0.003$). When all 20 elk common to both studies were considered, the percent change in ADMSL between the time periods was negatively correlated ($r = -0.56$, $p = 0.013$) with the degree of elk association with RMAs (Fig. 4). For the 31 elk present in this study, ADMSL was negatively correlated ($r = -0.42$, $p = 0.02$) with the degree of elk association with RMAs (Fig. 5). When the two outlying data points were removed, the correlation was more significant ($r = -0.69$, $p = 0.0001$). Both of these outliers were elk that had large bimodal home ranges. Most foraging areas for these elk were located on the periphery of their home ranges and were separated by large areas of the closed pole habitat type. Pope (1994) found that elk avoided the closed pole habitat type, and large ADMSL values for these elk may have been the result of movements between the activity centers at opposite ends of the home ranges, and were not associated with effects of human disturbance. Therefore, we believe the removal of these outliers is justified.

Table 5. Core area, area in ha of core area within Road Management Area (RMA), percentage of core area within RMA, and % change in RMA association between time periods for radio collared elk in the southern Oregon Coast Range, 1991-92, and 1993-94.

Elk Frequency	Area 1991-92[a]	RMA Area[b]	%RMA Area[c]	Area 1993-94[d]	RMA Area[e]	%RMA Area[f]	% Change[g]
4.022	287	2	1	237	2	1	0
4.061	302	63	21	296	55	19	-2
4.081	238	162	68	92	75	82	+14
4.100	281	0	0	582	6	1	+1
4.120	327	316	97	278	270	97	0
4.161	891	581	65	[h]	[h]	[h]	[h]
4.181	545	55	10	397	4	1	-9
4.232	375	279	74	135	134	99	+22
4.251	228	154	68	127	82	65	+1
4.271	239	202	85	182	171	94	+9
4.291	778	710	91	869	817	94	+3
4.311	624	0	0	444	0	0	0
4.330	804	707	88	622	411	66	-22
4.370	689	105	16	759	199	26	+10
4.390	391	378	97	313	307	98	+1
4.421	308	308	100	288	275	95	-5
4.551	290	270	93	430	258	60	-33
4.532	494	479	97	172	172	100	+3
4.631	382	150	39	279	118	42	+3
4.651	406	145	36	248	116	47	+11
$\bar{x}$	433	253	57.3	373	183	57.2	0.32
SD	204	221	37.7	191	193	38.9	12.6

[a] Harmonic mean core area in ha 1991-92, [d] 1993-94.
[b] Core area within RMA in 1991-92 based on the RMA boundary in 1993-94, [e] 1993-94.
[c] Percentage of core area within RMA 1991-92, [f] 1993-94.
[g] Change in the percentage of core area overlap with RMAs, 1991-92 to 1993-94.
[h] No core area calculated in program HOME RANGE (Ackerman et al. 1990).

Table 6. Average distance moved between consecutive locations (m) for Pope (1994) and this study, with the difference between the time periods and % association with Road Management Areas for radio-collared elk in the Oregon Coast Range.

Elk Frequency	Distance 1991-92[a]	Distance 1993-94[a]	Difference	% Change	% RMA[b]
4.061	190	168	22	11.6	37
4.081	216	156	60	27.7	63
4.120	283	196	87	30.7	95
4.161	346	244	98	28.3	32
4.232	189	162	27	14.2	88
4.251	170	136	34	20.0	71
4.271	202	168	34	16.8	80
4.291	343	286	57	16.7	93
4.330	362	314	48	13.3	72
4.370	230	294	-64	-27.7	29
4.390	186	174	12	6.4	95
4.421	171	160	11	6.4	91
4.532	179	143	36	20.1	98
4.551	237	205	32	13.5	60
4.631	219	228	-9	-4.1	29
4.651	231	191	40	17.3	34
$\bar{x}$	235	202	32.8	12.1	66.7
SD	64.4	56.0	37.4	14.2	26.6

[a] Average annual distance between consecutive locations 1991-92, [a] 1993-94.

[b] Percentage of association with RMAs.

Figure 4. Average annual distance moved between successive locations expressed as 24-hour movement (ADMSL) for 1993-94 minus 1991-92 (Pope 1994) and percent Road Management Area (RMA) association for radio-collared elk in the southern Oregon Coast Range.

Figure 5. Average annual distance moved between successive locations expressed as 24-hour movement (ADMSL) and percent RMA association for radio-collared elk in the southern Oregon Coast Range, 1993-94 (outliers denoted by squares).

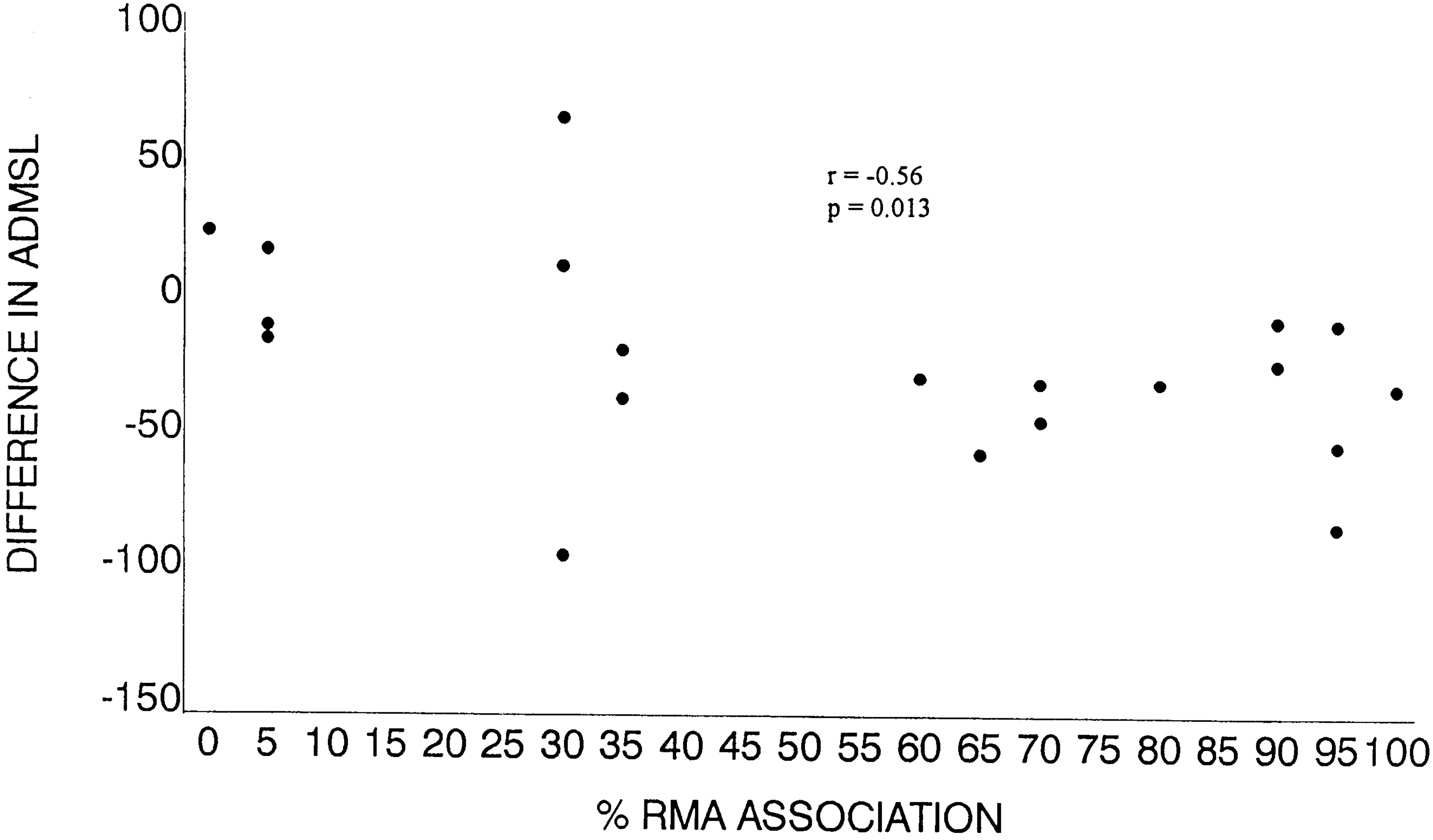
DIFFERENCE IN ADMSL
100
50
0
-50
-100
-150
r = -0.56
p = 0.013
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
% RMA ASSOCIATION

Figure 4.

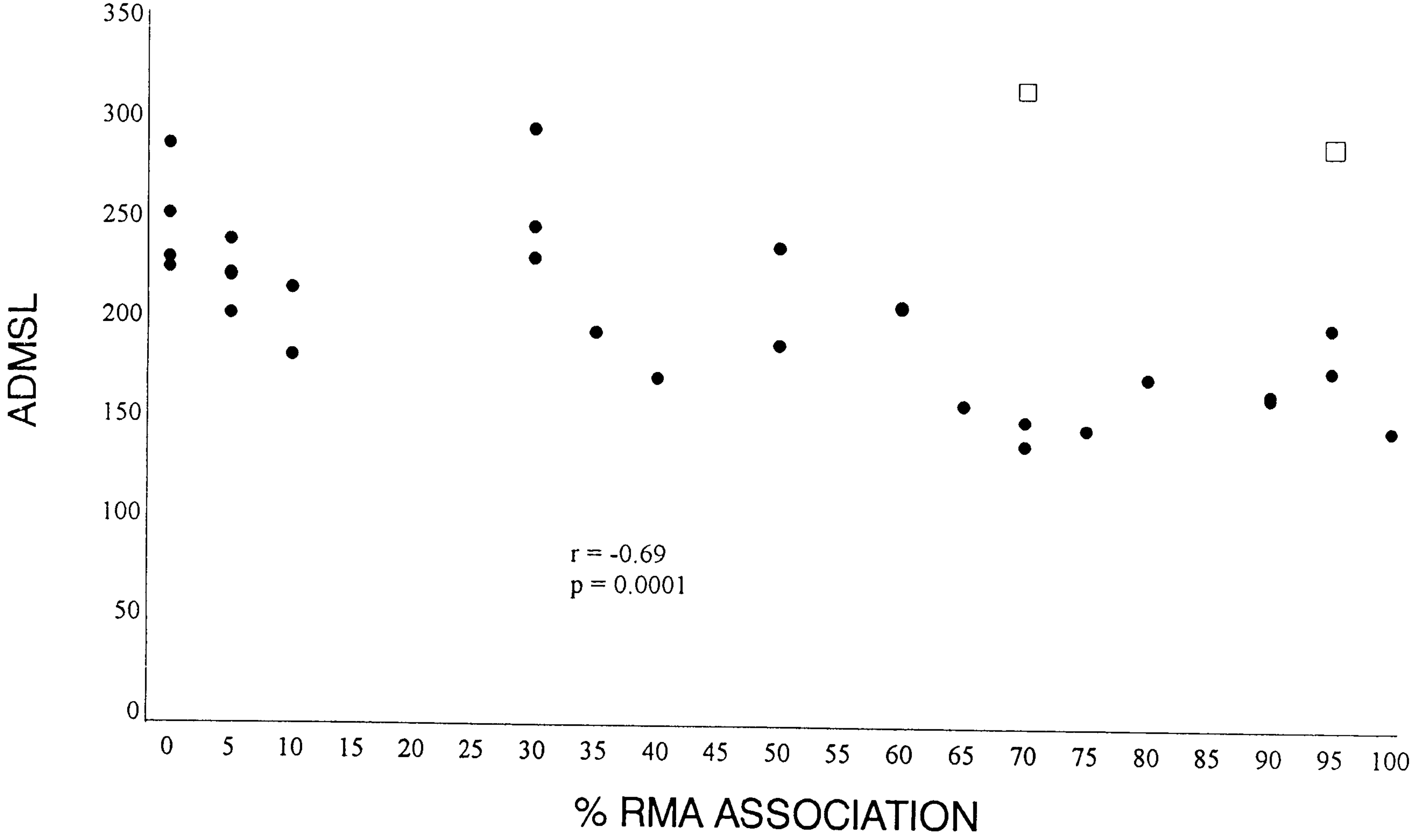
ADMSL
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
% RMA ASSOCIATION
r = -0.69
p = 0.0001

Figure 5.

Causes of Mortality

During Pope's (1994) study, there were 3 mortalities and 3 disappearances of radio-collared elk. The 3 confirmed mortalities were all by poaching (Table 7). There were 3 total mortalities and 1 disappearance during this study, and all of these animals were associated with RMAs (Table 7). Two elk were legally harvested in antlerless rifle seasons. No cause of death could be determined for the other recovered elk.

After the removal of the gates, there were 5 mortalities and 3 disappearances between 1 September 1994 and 31 March 1995 (7 months). Poaching accounted for 1 of the mortalities, and cause of death for the 4 other mortalities was unknown (Table 7). Expected transmitter life for these Telonics collars was 36 months, and all 3 of the elk that disappeared during the post-RMA interval were captured in March 1991. Because these disappearances occurred beyond the expected transmitter life, these observations were censored from the post-RMA interval.

Survival Rates Relative to RMAs

The survival estimate for the entire pre-RMA interval was 0.891 (95% CI = 0 .775-1.00), and the comparable estimate for the RMA time period was 0.957 (95% CI = 0 .873-1.00). These survival curves were not significantly different (chi-square = 1.41, p=0.24) (Fig. 6). However, if elk that disappeared were actually poached and not censored, the survival estimates were 0.793 (95% CI = 0.646-0.941) for the pre-RMA and 0.957 for the RMA time period. These survival curves were significantly different (chi-square = 4.52, p = 0.03) (Fig. 6). Survival for a 7-month interval following removal of the RMA gates was 0.834 (95% CI = 0.700-0.967), and the survival estimate for a seasonally comparable segment of the RMA time period was 0.957 (95% CI = 0.873-1.00). These survival curves were significantly different (chi-square = 3.76, p = 0.05) (Fig. 7).

Seasonal Survival Rates

When elk that disappeared were censored, there were mortalities in only 8 of 24 2-month intervals between spring 1991 and winter 1995. There were 11 total confirmed mortalities, 5 of which occurred in winter. There were no confirmed mortalities during the calving season (Table 8). When survival rates were averaged across the

Table 7. Frequency, fate, and month and year of mortality for radio-collared elk in the southern Oregon Coast Range, March 1991-March 1995.

Carcass found, unknown cause		Disappeared, loss of radio signal		Poaching		Legal hunting	
4.351	4/93	4.441	12/91	4.211	7/91	4.461	12/92
5.052	9/94	4.571	1/92	4.611	2/92	5.021	12/93
4.232	12/94	4.041	5/92	4.591	2/92		
4.532	1/95	4.491	12/92	[a]4.611	1/95		
5.081	2/95	[b]4.081	1/95				
		[b]4.370	1/95				
		[b]4.390	3/95				

[a] Re-used collar on new animal.

[b] Disappeared after expected transmitter life.

Figure 6. Survival rates for the pre-Road Management Area (RMA) (6 March 1991-31 August 1992) and RMA (6 March 1993-31 August 1994) intervals, treating disappeared elk as censored (rma), and disappeared elk as poaching mortalities (poaching).

Figure 7. Survival rates for the post-Road Management Area (RMA) (1 September 1994-31 March 1995), and the RMA (1 September 1993-31 March 1994) intervals.

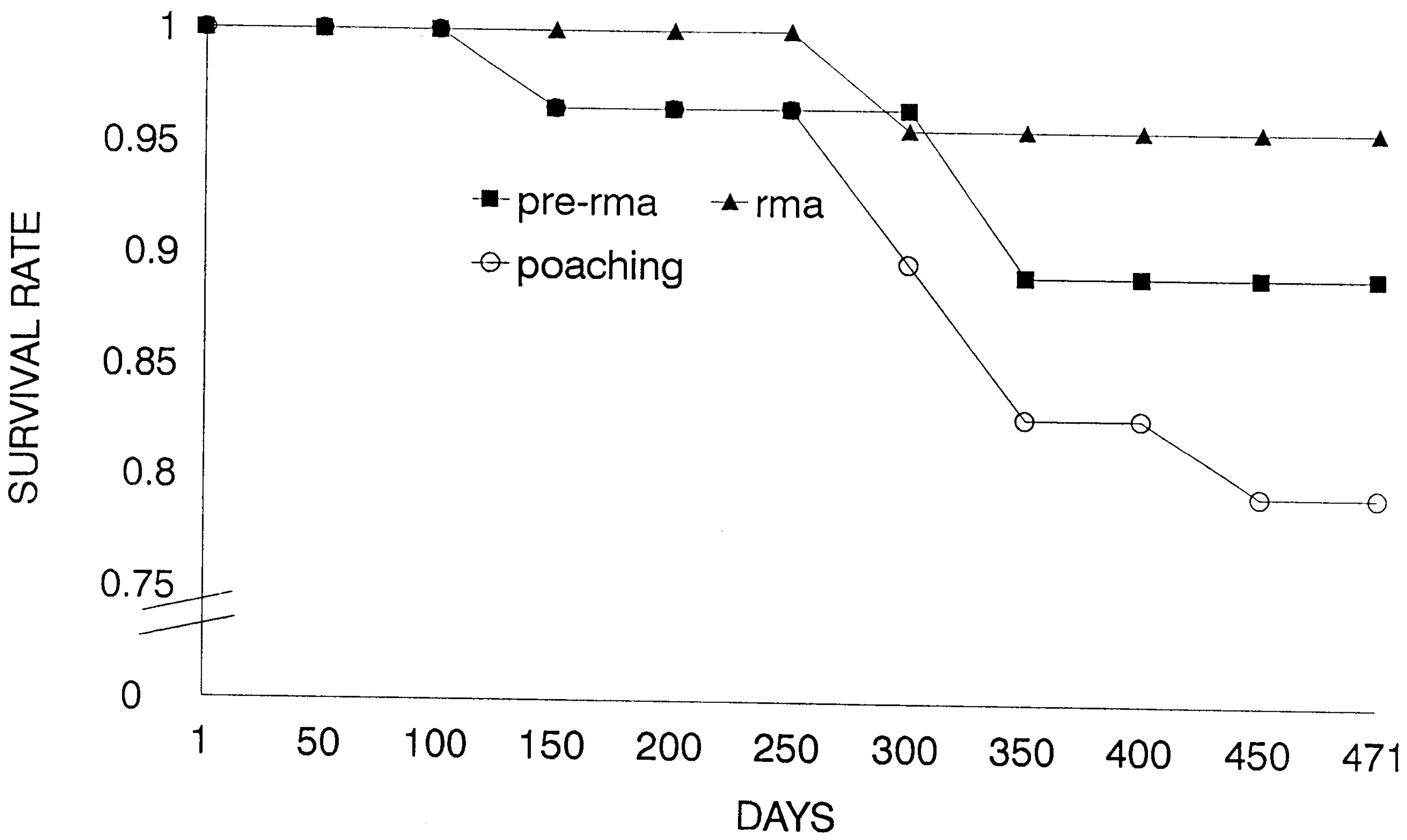
SURVIVAL RATE
1
0.95
0.9
0.85
0.8
0.75
0
DAYS
1
50
100
150
200
250
300
350
400
450
471
pre-rma
rma
poaching

Figure 6.

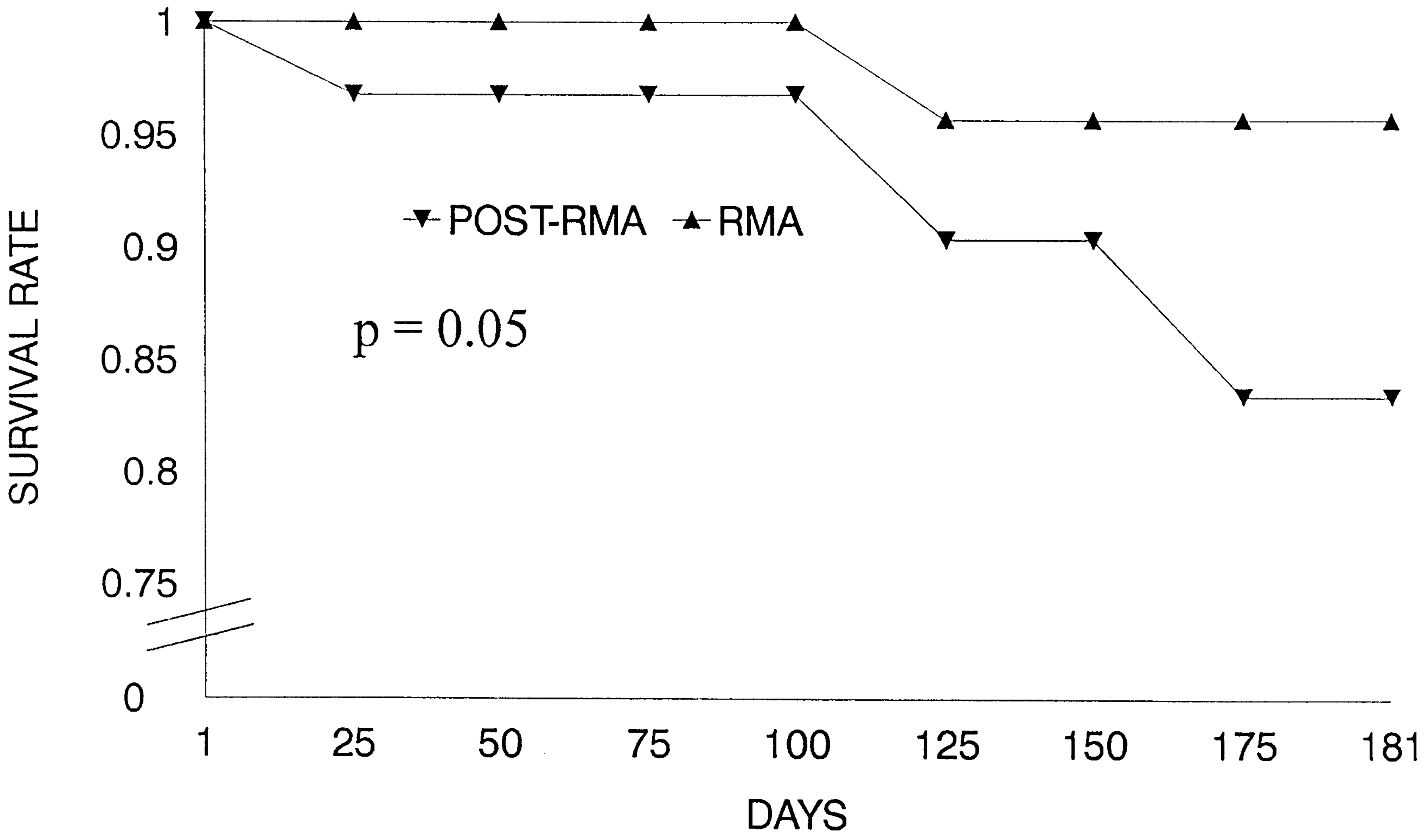
1
0.95
0.9
0.85
0.8
0.75
0
SURVIVAL RATE
POST-RMA
RMA
p = 0.05
1
25
50
75
100
125
150
175
181
DAYS

Figure 7.

Table 8. Mean survival rate, standard deviation, and total number of mortalities for each season for radio-collared elk in the southern Oregon Coast Range, April 1991-February 1995.

	Disapperarences Censored			Disappearances Mortalities		
Season	Mean	SD	#Mortalities	Mean	SD	#Mortalities
Winter	0.953	0.056	5	0.953	0.056	5
Spring	0.988	0.024	1	0.988	0.024	1
Calving	1.0	00.0	0	0.990	0.021	1
Summer	0.991	0.017	1	0.991	0.017	1
Rut	0.992	0.016	1	0.992	0.016	1
Fall	0.972	0.019	3	0.944	0.023	6

4 years by season, survival was lowest during winter at 0.953 (SD = 0.056) and highest during the calving season at 1.0. The lowest survival rate for an individual season was 0.889 (95% CI = 0.770-1.00) in winter 1995.

When elk that disappeared within expected transmitter life were considered poaching mortalities, there were mortalities in 10 seasonal periods. There were 15 total mortalities, 6 of which occurred in the fall seasons and 5 in winter seasons. The spring, calving, summer and rut seasons each had only 1 mortality between 1991 and 1995 (Table 7). When survival rates were averaged across years by season, survival rates ranged from a low of 0.944 (SD = 0.023) in fall, to a high of 0.992 (SD = 0.016) during the rut.

DISCUSSION

Home Range and Core Area

Annual home range size estimates during this study were similar to Pope (1994), who studied the same elk using the same telemetry methods from 1991-92; mean 95% ADK home range size was 742 ha (SD = 402) during this study, and 764 ha (SD = 407) in 1991-92 (Pope 1994). Both the ADK and MCP mean estimates were > 50% larger than the home range estimates of Witmer (1981) who reported mean MCP estimates of 135 ha for 6 Roosevelt elk in the same area. Witmer had mean MCP estimates of 135 ha, and a confidence ellipse estimate of 240 ha. Franklin and Leib (1979), Witmer (1981), and Starkey et al. (1982) suggested that more stable habitats such as late-successional forests may result in smaller elk bands and smaller home range sizes. Without question, there was less late-successional forest habitat available during this and Pope's (1994) than during Witmer's study (1981). A more fragmented landscape during our studies could have resulted in the large difference in home range size. Alternatively, difference in methodology or Witmer's limited sample size could account for the difference. Witmer radio-marked only six elk from two distinct bands. Whereas Pope (1994) and I monitored 25 and 29 distinct bands of elk, respectively. Our larger sample was probably more representative of the area's elk population, and variability in home range size could have been masked by limited sample size in the Witmer (1981) study.

Pope (1994) reported a mean core area of 433 ha, while mean core area was 373 ha in this study. In other studies, core area has been reported as 50% contour levels of various home range estimators (Kaufman 1962, Michener 1979, Dixon and Chapman 1980). Difference in methodology could account for the large difference in core area size in this study compared to other Roosevelt elk studies. Franklin et al. (1975) reported a core area of 68 ha for Roosevelt elk in the Prairie Creek Redwoods State Park in northern California, and Witmer and de Calesta (1985) determined "central core activity areas" of 85 ha in the southern Oregon Coast Range. Even using methods comparable to Franklin et al. (1975) and Witmer and de Calesta (1985) such as 50% home range contours, our estimates of core area remain considerably higher. (mean 50% ADK = 163 ha, mean 50% MCP = 139 ha). The disparity in core area size between the Franklin study and our results is not surprising considering the differences in habitat and human disturbance. The Prairie Creek herd is associated with stable late-successional forests, permanent meadow foraging areas, and most importantly is not hunted. The Roosevelt elk population of this study is heavily hunted and is associated with highly fragmented and frequently changing habitat. Witmer and de Calesta (1985) studied 6 elk in the same area as this study, but our mean core area estimate was double the size using 50% home range estimates, and four times larger based on the Ackermann et al. (1990) method.. As with difference in home range size, the increase in core area size from 1981 to present could be the result of increased habitat fragmentation, differences in methods, or Witmer and de Calesta's (1985) limited sample size (as discussed above).

Home Range and Core Area Relative to Road Management Areas

Craighead et al. (1972), Geist (1978) and Ward et al. (1980) suggested that elk have the ability to learn from negative or positive experience and adjust their behavior accordingly. Ward et al. (1980) demonstrated that even productive habitats can be deserted if human disturbance is excessive. We hypothesized that RMAs should have reduced human disturbance of elk and resulted in a shift in home range and core area towards RMAs in 1993-94 compared to 1991-92. However, there was considerable variation in size of home ranges (Table 4), and core areas (Table 5) associated with RMAs between the time periods, and a similar number of animals decreased or maintained the same association with RMAs as those that increased use of these areas. There was no correlation between change in home range or core area association with RMAs and % RMA association. Thus, the data failed to support our hypotheses.

Because we used a paired t-test to compare differences in individuals between both time periods, variability among individual elk was not a factor and differences should be treatment related. Potential factors influencing elk movement between the time periods include the presence of RMAs, weather, habitat changes due to logging, and elk age. These non-RMA related variables may have played a more important role in the changes in home range and core area than any security benefits produced by the RMAs. Irwin and Peek (1983) found that selection of home range by Rocky Mountain elk was related to forage and cover availability. Edge et al. (1985) found no significant change in home range fidelity between Rocky mountain elk subjected to logging disturbance and those that were not. Thus, elk may react to disturbance by shifting activity within their home range rather than changing the location and size of their home range.

Distance Moved Between Consecutive Locations

Because elk in this study area are hunted during and outside the legal hunting seasons, they are probably sensitive to human disturbance. This disturbance may be more accurately detected by measuring elk movement within home ranges rather than by changes in the locations and size of home ranges. We hypothesized that average annual distance moved between successive locations (ADMSL) would decrease for RMA-related animals between 1991-92 (Pope 1994) and this study, and any difference in ADMSL would be correlated with the degree of elk association with RMAs. Although ADMSL does not provide an absolute measure of the actual distance moved in a 24 hour period, it is a relative measure that is comparable between elk and study periods.

The significant difference in ADMSL between the 1991-92 time period (Pope 1994) and this study suggest that the RMAs reduced elk movement within their home ranges. The correlation between the magnitude of the decrease in ADMSL and the degree of elk association with RMAs suggests that the decrease is related to the RMAs. Also, within this study period ADMSL was negatively correlated with the degree of elk association with RMAs. Given the high variability typical among elk, these results suggest a strong relationship between RMAs and reduction in elk movement.

Other researchers have found that human disturbance can increase elk movements. Edge (1982) reported that elk move greater distances away from logging activity than towards it in western Montana. Bryant et al. (1991) continuously monitored both hunter and elk movements in Oregon's Blue Mountains and found that elk did not move substantial distances until they encountered hunters or vehicles. When elk were disturbed they would move a substantial distance and then remain in that area until they encountered a hunter or a vehicle again. The type and degree of disturbance, cover availability, and season may effect the distance elk move after a disturbance (Coop 1971, Marcum 1975, Ward and Cupal 1979). As in this study, Fiedler et al. (1992) found that Roosevelt elk moved less frequently within road closure areas than in areas with open roads.

Mortality Causes and Survival Rates

From April 1991 to 31 March 1995 there were 11 confirmed elk mortalities and 7 disappearances. Four of the confirmed mortalities were due to poaching, 2 were legal hunting, and 5 were unknown but probably were age, disease or parasite related. No carcasses had evidence of cougar predation. Four of the disappearances occurred within the expected transmitter life and were probably poaching mortalities, as poaching is the most likely source of mortality that would result in a missing or non-functional transmitter. Transmitter failure was unlikely within expected transmitter life, and there were no sightings of marked elk following the disappearance of the radio-signals, even though the elk bands from which animals disappeared were frequently observed (Pope 1994, this study).

High poaching rates are not surprising in a heavily roaded landscape in rural areas. Stussy et al. (1994) also reported that poaching was the dominant source of mortality on cow Roosevelt elk in the Oregon Cascades. Potential bias in hunter or poacher selection of collared elk was a possibility. The highly visible collars and eartags on the marked elk may have caused either an avoidance or increased likelihood of the elk being shot. Personal communication with hunters in the study area suggested that some hunters would avoid shooting collared elk because they feared it was illegal, and some would not preferentially kill the collared elk, but would shoot them if they presented the best opportunity. In Idaho most hunters did not know that the elk that they shot was collared until the animal was recovered (Unsworth et al. 1993). It was not possible to assess these potential biases in this study.

Patterns in seasonal survival were predictable and high (Fig. 8). From April 1991 through February 1995, the lowest survival was 0.889 for winter 1995. Treating disappeared elk within expected transmitter life as mortalities, there were mortalities in only 10 of 24 2-month seasonal intervals. As expected, survival rates were highest from spring through rut and lowest during fall and winter (Table 8). This pattern of seasonal survival is typical in northern ungulates (Peek et al. 1992). Stussy et al (1994) also found mortality to be greatest from October to

Figure 8. Seasonal survival rates for biologically important seasons (sp = spring, ca = calving, su = summer, ru = rut, fa = fall, wi = winter), with 95% confidence intervals for radio-collared elk in the southern Oregon Coast Range, March 1991-March 1995.

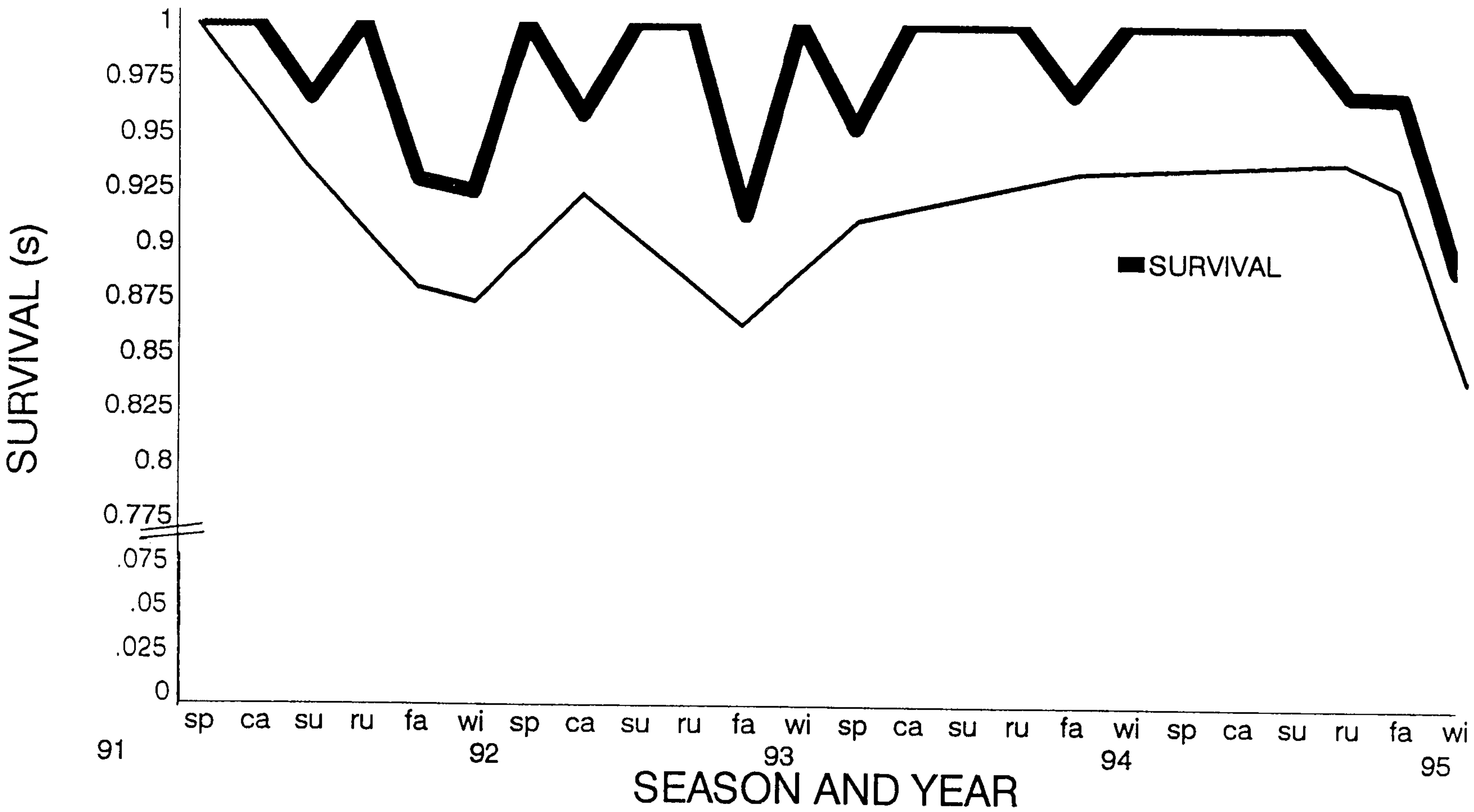
SURVIVAL (s)
1
0.975
0.95
0.925
0.9
0.875
0.85
0.825
0.8
0.775
.075
.05
.025
0
SURVIVAL
sp ca su ru fa wi sp ca su ru fa wi sp ca su ru fa wi sp ca su ru fa wi
91
92
93
94
95
SEASON AND YEAR

Figure 8.

January. Poaching and legal harvest accounted for most fall deaths in this study. The large number of mortalities due to unknown causes prevented conclusions concerning causes of natural mortality.

Survival Related to Road Management Areas

We hypothesized that the presence of RMAs would decrease poaching mortality. Accordingly, there were no poaching mortalities during the RMA period; poaching occurred before installation or after removal of gates. Two legal hunting mortalities occurred behind gates during the RMA period. The gates were not intended to discourage legal hunting opportunities, and as with a similar limited vehicle access program in northeastern Oregon (Coggins and Magera 1973), opportunities were probably enhanced for energetic hunters.

This road management strategy appears to have increased cow survival rates. If elk that disappeared within expected transmitter life are considered poaching mortalities, there was a significant increase in survival in the RMA period compared to the pre-RMA period and a significant decrease in survival following the removal of the gates. Decrease in number of elk killed by poaching from 8 to 0, accounts for the increase in survival rate between the pre-RMA and the RMA period. Gates probably discouraged poachers from shooting at elk from vehicles and would make recovery of animals difficult. In the post-RMA interval, cause of most mortalities was unknown, but there was a decrease in survival rate following the removal of the gates. Although several researchers have determined that road closures have little impact on legal elk harvest rates, (Burbridge and Neff 1976, Basile and Lonner 1979, Coggins 1976), there is no published information available concerning the relationship of poaching and road closures.

Studies of radio-collared elk have estimated similar survival rates. Pope (1994) found mean annual survival rates of 0.90 for the same elk population as in this study. Stussy et al. (1994) found Roosevelt elk annual survival in the Oregon Cascades to be 0.89. Annual survival rates for hunted Rocky Mountain elk cows are also similar; Unsworth et al. (1993), and Leptich and Zager (1991) estimated annual survival of 0.886 and 0.880 in Idaho, respectively.

Chapter 3

Road Management Effects on Habitat Associations

Eric K. Cole, Michael D. Pope, and Robert G. Anthony

INTRODUCTION

Prior to European settlement, Roosevelt elk (Cervus elaphus roosevelti) were most likely associated with late-successional Douglas-fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla) forests in the Pacific Northwest (Starkey et al. 1982). Because of blow-downs, fire, disease, insects and landslides, there were many openings interspersed in the older forest (Franklin and Spies 1991), and as presently, Roosevelt elk were associated with the ecotone between older forest and regenerating vegetation (Witmer 1982). Most late-successional forest has been converted to managed timber stands in western Oregon since the 1940's (Flora and Kellet 1995). Therefore, pressure for elk to adapt to habitat alterations and increased human disturbance associated with timber harvest and recreation is a recent condition.

Resource selection theory suggests that a species will select habitats that best satisfy their life requirements (Rosenzweig 1981, Manly et al. 1993). Numerous studies have suggested that negative stimuli such as human disturbance associated with roads can cause Rocky Mountain elk (Cervus elaphus nelsoni) to avoid habitats that might otherwise be selected. Perry and Overly (1977) and Ward (1976) reported decreased habitat use in areas 0.4 - 0.8 km adjacent to roads and decreased use of cover in areas bisected by traveled roads. Lyon (1979) reported that elk in western Montana avoided habitat adjacent to forest roads and suggested that road avoidance was a function of traffic volume, road quality, and density of cover near roads. There is also evidence that Roosevelt elk avoid roads. Witmer and deCalesta (1985) found that elk use was less than expected $\leq$ 500 m of paved forest roads, and there were fewer than expected observations $\leq$ 125 m of spur roads. Similarly, increased vehicle traffic on a forest highway within the Mt. St. Helens National Monument caused elk to avoid a 500-m corridor around the road (Czech 1991). Avoidance of roads by elk may be related to the amount of vehicular traffic; Rost and Bailey (1979) found greater road avoidance around well-traveled roads in their Colorado deer and elk study, and Edge (1982) suggested that elk were displaced by heavily traveled roads more than lightly traveled roads. Road closures are commonly used to manage for Rocky Mountain elk (Basile and Lonner 1979, Lyon et al. 1985), but the benefits of limiting vehicular access have not been demonstrated for Roosevelt elk. By removing vehicle access, human harassment of elk should be reduced, elk security enhanced, and suitable habitat that otherwise would have been avoided should be used.

The purpose of this study was to determine the response of Roosevelt elk to Road Management Areas (RMAs) that limited vehicular access. Our specific objective was to determine if limiting vehicular access with gates affected elk habitat selection in the southern Oregon Coast Range. We hypothesized that there would be increased selection for RMAs in 1993-94 compared with the 1991-92 pre-road management period, which was conducted by Pope (1994). We further hypothesized that elk use of foraging habitat (early- successional stages) and use of habitat close to roads would increase under road management.

STUDY AREA

The study area spans approximately 380 square km in the Coos Bay District of the BLM, including the northern Myrtlewood and southern Tioga Resource Areas. The area is approximately 30 km southeast of Coos Bay and 40 km west of Roseburg (Fig. 1). Typical of the Southern Oregon Coast Range, the terrain is dominated by steep ridges and mountain slopes, divided by extensive stream systems (Franklin and Dryness 1973). Elevation ranges from 150 m in some drainages to 1,000 m on ridge tops. Climate is maritime, with moist winters and dry summers. Precipitation ranged from 97-218 cm from 1969 to 1992 (Oregon Climatological Center 1993). Temperature during this time period ranged from a mean minimum of 1.67 C in January to a mean maximum of 25.93 C in August (Oregon Climatological Center 1993). Deep and persistent snowfall is possible at high elevations, potentially blocking road access for up to 2 months. However, there were no snowstorms that prevented vehicle access to any part of the study area for ≥ 1 week during this study.

Vegetation is primarily the western hemlock series (Hemstrom and Logan 1986) and until two decades ago was predominately late-successional Douglas-fir and western hemlock forests. Today, the landscape is a mosaic of clearcuts, Douglas-fir plantations and old-growth, with some naturally regenerated mixed stands of western redcedar (Thuja plicata), red alder (Alnus rubra), bigleaf maple (Acer macrophylum), Douglas-fir and western hemlock. Riparian areas typically contain red alder, bigleaf maple and myrtle (Umbellularia californica) as well as Douglas fir. Understory vegetation is sparse in young Douglas-fir plantations, but can be quite dense in naturally regenerated stands and older seral stages. Sword fern (Polystichum munitum), huckleberry (Vaccinium ovatum and V. parvifolium), vine maple (Acer circinatum), salal (Gaultheria shallon), rhododendron (Rhododendron macropyllus), and oceanspray (Holodiscus dicolor) are typical understory species (Franklin and Dryness 1973).

Land ownership in most of the area is alternating sections of BLM and private land, and the area has been managed intensively for timber harvest with most recent logging on the private ownerships. Although commercial timber operations dominate the landscape, the area is also used for recreation including camping, hunting, trapping and berry picking.

Access for forest management has produced an extensive road network within the study area. The BLM maintains paved roads that are also used by the private timber companies to access their lands. Rocked secondary roads branch from mainlines with rocked and non-rocked spur roads branching from secondary roads. Most roads are open to public access except during periods of high fire danger. One secondary road network on private land was gated for a month during summer 1994, but no other roads were closed due to fire danger during this study.

METHODS

Pre-Traffic Management Study

In order to evaluate elk response to vehicles and associated human disturbance an earlier study was conducted to investigate movements, survival, and habitat selection of elk prior to limited access management (Pope 1994). From 15 June 1991 to August 1992, Pope (1994) collected location data on 29 adult cow elk using radio telemetry techniques. Twenty of these original elk lived to the end of this study. Traffic volume was monitored on a random sample of secondary and spur roads during the pre-traffic management study using magnetic loop traffic counters.

Gate Placement and Road Management Areas

Motorized vehicle access was limited on 128 km of secondary and spur roads within the study area by installation and maintenance of 21 gates. RMAs comprised approximately 35% of the study area. Gate placement was designed to include the home ranges of as many of the original radio-collared elk as possible. Access was limited to 7 discrete networks of secondary and spur roads (RMAs) (Fig. 1). A detailed description of how the RMA boundaries were delineated is given in Chapter II. Road closures were initiated in October 1992 at the end of Pope's (1994) study, which allowed a 9-month acclimation period, and remained in place until 20 August 1994.

The gates did not provide complete road closures. By definition, road closures totally prevent vehicle access, and in some cases the road surface is destroyed, seeded and no longer maintained. Instead, the gates for this project limited vehicle access. The intent was to limit access to an average of ≤ 4 vehicle trips per week for administrative purposes such as forest management activities, wildlife research, fire suppression, and emergency access. Non-motorized access was not limited. (Christensen and Langenstein 1992). Although true road closures would provide a more clearly defined experimental treatment, the interspersion of private and public lands made closures logistically impossible to implement, and road management had to be a cooperative venture. Therefore, limited vehicular access was used instead of road closures.

Elk Captures

Twenty-nine adult cow elk were immobilized in March 1991 by ODFW personnel using a helicopter and dart-gun with carfentanil citrate as an immobilizing compound (Pope 1994). They attempted to capture elk from distinct bands throughout the study area and recorded location and estimates of age, weight, and physical condition for each capture. Radio collars (Telonics MOD-600, 164 MHZ) with a > 3 year operational life were attached to each captured elk. Each collar contained an activity sensor that increased the pulse rate from 50 pulses per minute (ppm) in the head-down position to 100 ppm in the head-up position. To facilitate visual identification of collared elk, numbered and color-coded ear tags were attached to each ear (Nasco TUFF-FLEX cattle tags, Modesto CA). Twenty of these original 29 elk lived throughout Pope's (1994) and this study. Twelve additional elk were captured in April 1993 using a helicopter and Hughs 500-C net-gun without immobilizing agents to augment this study. An effort was made to capture an equal number of elk within and outside RMAs and from distinct bands.

Radio-Telemetry

Telemetry procedures were identical to those described by Pope (1994). Two-element yagi antennas with Telonics TR-2 receivers were used to monitor radio signals. The "loudest signal method" as described by Springer (1979) was used to determine the direction of the radio signal, and 3-5 compass bearings were used to locate elk by triangulation. All receiver locations were plotted using Universal Transverse Mercator grid (UTM) coordinates on USGS 1:24,000 quadrangle maps. To increase the accuracy of locations, we attempted to minimize the time elapsed between bearings and the distance between elk and the observer without influencing elk behavior. Elk locations were derived from azimuth and receiver information entered in the telemetry processing program XYLOG (Dodge and Steiner 1986). XYLOG also provided a confidence ellipse (Lenth 1981, White and Garrott

1986) for each location. The confidence ellipse feature requires a measure of azimuth error. Potential triangulation error has been reviewed extensively in the literature (Springer 1979, Lee et al. 1985, White and Garrott 1990: 47-75, Garrott et al. 1986). Based on this review we conducted a field trial to determine azimuth error and reduce telemetry error. Azimuths were estimated using TR-2 receivers and the loudest signal method on 50 unknown-transmitter locations at a variety of times, elevations, and distances from the transmitter. Average azimuth error was 5 degrees; we used this value to generate estimates of confidence ellipses with the XYLOG program.

Elk Monitoring

To assure independence of locations, the minimum interval between successive locations should be sufficient for the animal to move from one end of its home range to the other (White and Garrott 1990: 147). Therefore, we subjectively set the minimum time between successive locations of an individual elk at 24 hours. All locations were diurnal, and we alternated locations between mid-day and crepuscular periods for each elk. Randomization of elk locations was logistically impossible because of the size of the study area and the need to obtain a sufficient number of locations per elk to estimate home range size (see chapter II). We did not attempt to confirm radio locations visually to avoid disturbance of radio-collared elk. When radio-collared elk were visually located, we recorded UTM location, habitat type, band composition, date, time and elk activity.

Habitat Variables

Habitat availability was delineated by the 100% adaptive kernel home range utilization distribution for all locations of the 16 elk common to this and the 1991-92 study (Pope 1994) and associated with RMAs. The 95% adaptive kernel distribution was used to define habitat availability within home ranges of individual elk. Habitat variables considered within these areas were vegetative cover types, distance to roads, distance to water, and presence of RMAs. Slope, aspect, and elevation were not considered because there was little selection for these attributes during the pre-road management phase of the study (Pope 1994).

Vegetative cover types were determined from a Landsat Thematic Mapper (TM) image acquired on 15 July 1993. The TM scene was resampled to 25 m resolution, and a 6-band image composite was constructed for the study area using TM bands 1 through 5 and 7; band 6 has sufficiently different spectral characteristics that it is rarely included in vegetation classification analyses. All digital image analysis was conducted with the Earth Resources Data Analysis System (ERDAS) software. Preliminary classification identified 37 spectrally unique classes and assigned pixels to those classes. The resulting pixel cluster image was smoothed to remove extraneous or individual pixels. Next, the 37 spectral classes were related to the 7 vegetative cover types chosen for the study. The 7 classes correspond to those used by Pope (1994) and include: grass/forb, shrub, open sapling, pole/small sawtimber, large sawtimber/mature, old growth and hardwoods. To resolve conflicts between the 37 spectral classes and the 7 cover types, a pixel based map was plotted and taken to the study area for ground truthing. Ground truthing resolved most of the spectral class/land cover class questions. The final vegetative cover map was refined by consulting Pope's (1994) cover map, Bureau of Land Management forest resource inventory data, and interpreting 1:12,000 true color aerial photographs.

Road and stream layers were obtained from the Oregon State Service Center for Douglas and Coos counties, and were imported into program ARC/INFO (ESRI 1991). Additional spur and new secondary roads were digitized from 7.5-minute USGS quadrangle maps using program ARC/EDIT (ESRI 1991). Roads that were permanently out of use due to vegetation or other natural obstacles were removed from the GIS using ARC/EDIT.

Availability and Observed Habitat Use of Individual Elk

A 95% adaptive kernel home range generated in program CALHOME (Baldwin and Kie 1992) was used to define habitat availability and home range of the 31 elk. The home range boundaries were imported into ERDAS and ARC/INFO (ESRI 1991) to define availability for each habitat within each home range. The 95% utilization distribution was used because it eliminated outlying observations and long-distance movements by elk Habitat categories were identical to the previous study by Pope (1994). The vegetative cover types were divided into 6 categories: grass/forb/shrub, open sapling, pole/small sawtimber, large sawtimber/mature, old growth and hardwoods. Distance of elk locations from roads and streams were categorized as: <50 m, 51-150 m, 151-300 m, 301-450 m, and >450 m. After examining the results from these analyses, distance categories were combined to improve statistical power. For roads, categories were changed to areas $\leq$ 150 m from roads and areas > 150 m from roads. The minimum distance to stream class was increased to $\leq$ 150 m; the other categories were unchanged.

Elk locations for each of the 31 elk were compared to available habitat within individual home ranges using a Chi-square statistic (Neu et al. 1974, Zar 1984) to determine if there was a significant difference between expected and observed use of habitats. If significant selection was detected, a Bonferoni Z-statistic (Neu et al. 1974, Byers et al 1984) was used to test whether the observed use of specific habitat categories was greater or less than expected ($p < 0.05$). Data for elk during the pre-gate time-period (Pope 1994) were reanalyzed using more accurate road and stream data.

Availability and Observed Habitat Use of Pooled Elk

All telemetry locations were pooled for the 16 elk that were both associated with RMAs and present during the study by Pope (1994). Telemetry locations also were pooled for the 4 elk that had no significant association with RMAs and were present in 1991-92.

As with the habitat selection analysis within the home ranges of individual elk, habitat variables were cover type, distance to nearest road and distance to nearest water. However, pooling elk locations increased the statistical power of the selection analyses and allowed us to expand the number of categories within each habitat variable. For example, the forb/grass/shrub type was divided into separate forb/grass and shrub categories. Distance categories for streams were further divided into <50, 51-100, 151-300, 301-450, 451-600 and > 900 m).

A Chi-square goodness of fit test was used to determine if observed use differed significantly from expected ($p < 0.05$), and a Bonferoni Z-statistic was used to test if observed use of habitat categories differed from availability. The habitat selection results were compared to the results for the same pooled elk during the previous study by Pope (1994). Because some elk died between the study periods and Pope did not take RMAs into account in his study, we reanalyzed Pope's (1994) location data using comparable groups of animals.

Seasonal Habitat Use

All elk locations were divided into 6 biologically important seasons as defined by Witmer (1981) and Pope (1994): winter (January to February), spring (March-April), calving (May-June), summer (July-August), rut (September-October), and fall (November-December). Elk locations for this study and Pope (1994) were divided into a high vehicle traffic season (August-December) and a low vehicle traffic season (January-July) (see chapter

D). For each season, a Chi-square goodness-of-fit test was used to determine if observed use of habitat variables was different from expected ($p < 0.05$), and a Bonferoni Z-statistic was used to determine if use of each habitat category was more, less or equal to expected. The seasonal habitat selection results in this study were compared to the results for the same elk in Pope's (1994) study.

RMA Effects on Individual Elk Habitat Selection

To test the hypothesis that increased use of foraging habitats was associated with increased association with RMAs, we conducted a paired t-test on the change in the percent use of grass/forb/shrub habitats between this study and that of Pope (1994). The test was conducted using the 16 elk common to both studies that were associated with RMAs. A Pearson correlation analysis was conducted using program SAS (SAS inst. 1994) on the percent change in use between the time periods (dependent variable) and percentage of an elk's home range associated with an RMA (independent variable). The same methods were used to test the hypothesis that use of areas ≤ 150 m of roads increased with increasing RMA association. Although there were no specific hypotheses concerning RMA effects on elk use of the remaining vegetation classes and distance from streams, the same methods were used to evaluate changes between the time periods and potential RMA effects on use of these classes.

RESULTS

We conducted selection analysis on 31 individual elk (1883 total location points)and pooled analyses on 16 RMA-associated elk (953 location points). Pooled results from this study were compared to the 16 RMA-associated elk (1,011 location points) from Pope's (1994) study.

Use of Road Management Areas

Most individual elk used RMAs in proportion to their availability. Only 1 of the 28 elk for which RMA habitat was available used RMAs more than expected (Table 9), and one elk used RMAs less than expected. Of the 20 elk also present during Pope's (1994) study, only 1 elk used RMA habitat more than expected. Contrary to our hypothesis, only one elk increased its degree of selection for RMAs in 1993-94 compared to 1991-92 (from less than expected to equal to expected) (Table 9). Eleven elk selected RMAs to the same extent as in 1991-92, and 7 elk decreased their selection of RMAs (Table 9). A paired t-test suggested a decline in percent use of RMA

Table 9. Availability and use of Road Management Areas by radio-collared elk in the southern Oregon Coast Range, 1991-92 (Pope 1994) and 1993-94 (this study).

Elk No.	% Use 1991-92	% Avail. 1991-92	1991-92 RMA[a] selection[b]	% Use 1993-94	% Avail. 1993-94	1993-94 RMA selection	Change in % use
4.022	4.8	9.0	0	0.0	3.0	0	-4.8
4.061	26.7	31.0	0	15.8	37.0	-	-10.9
4.081	61.3	48.0	0	64.9	63.0	0	3.6
4.100	1.6	3.0	0	1.7	4.0	0	0.1
4.120	96.4	96.0	0	100	95.0	0	3.6
4.161	62.5	54.0	0	29.3	32.0	0	-33.2
4.181	1.7	11.0	-	0.00	5.0	0	-1.8
4.232	90.3	76.0	+	92.9	88.0	0	2.6
4.251	56.9	67.0	0	58.9	71.0	0	2.0
4.271	93.8	79.0	+	82.1	80.0	0	-11.7
4.291	94.3	90.0	0	94.7	93.0	0	0.4
4.330	87.5	75.0	+	71.2	72.0	0	-16.3
4.370	15.3	17.0	0	29.3	29.0	0	14.0
4.390	93.3	91.0	0	98.3	95.0	0	5.0
4.421	100	100		94.8	91.0	0	-5.2
4.532	94.8	83.0	+	94.7	98.0	0	-0.1
4.551	89.1	59.0	+	50.9	60.0	0	-38.2
4.631	56.1	34.0	+	44.6	29.0	+	-11.5
4.651	51.7	34.0	+	40.4	34.0	0	-11.3
$\bar{x}$	62.0	55.6		50.8	56.8		-6.0
SD	35.8	31.9		36.4	33.8		12.9

[a] Based on 1993-94 RMA boundaries.

[b] (- = use less than availability ($p < 0.05$); + = use greater than availability ($p < 0.05$); 0 = use proportional to availability).

habitat from the pre-RMA period (Pope 1994) to this study (mean change = -5.979, SD = 12.85, t = -2.03, p = 0.058) (Table 9).

Selection of Vegetation Types

Most elk during this study used vegetation types in proportion to their availability (Table 10) (Appendix A, Tables 1-6). Only one of the 31 elk, (elk # 4.611), used pole/small sawtimber more than expected and hardwoods less than expected. During this study, none of the 21 elk that were associated with RMAs used vegetation types differently than expected therefore, they displayed no selectivity for these types (Table 11). There was a significant increase in percent use of the forb/shrub habitat type between 1991-92 (Pope 1994) and this study (Table 12). The mean increase was 6.14 percent (SD = 8.57, paired-t = -2.86, p = 0.01). However, there was no significant correlation between the increase in percent use between the time periods and percent association with RMAs (r = 0.13, p = 0.59). Of the other vegetation types only large sawtimber/mature was used differently during the 2 studies with a mean decline of -3.90 percent (SD = 5.66, paired-t = -2.75, p = 0.02) (Table 12).

Pooled elk associated with RMAs during this study used all vegetative types in proportion to availability (Table 13). In comparison, during the pre-RMA study Pope (1994) found that the same elk used old growth more than expected and hardwoods less than expected (Table 13). All other vegetative types were used in proportion to availability during Pope's (1994) study. Seasonally there was very little selection for vegetative types (Table 14)(Appendix A, Tables 7-12). In winter large sawtimber was used less than expected (Appendix A, Table 7). There was no selection for any vegetation types by pooled elk associated with RMAs during the high traffic season (August-December) (Appendix A, Table 13), and there was little selection for vegetative types during the low traffic season (January-July) (Appendix A, Table 14). The mature/large saw timber type was used less than expected during the low traffic season, and all other vegetative types were used equal to expected. Similarly, all vegetation types were used equal to expected by the four pooled elk that were not associated with RMAs. (Appendix A, Table 15).

Influence of Roads on Elk Habitat Selection

Individual elk use relative to distance from roads was mostly in proportion to availability (Table 15). When all 31 elk were considered, four cows used areas 0-150 m from roads less than expected and areas > 150 m from

Table 10. Number of elk (of 31 radio-collared) whose use of vegetation classes was less than, proportional to, or greater than availablity in the southern Oregon Coast Range, 1993-94.

Vegetation class	Use compared with expected[a]		
	Less than	Equal to	More than
grass/forb/shrub	0	31	0
open sapling	0	31	0
pole/small sawtimber	0	30	1
large sawtimber/mature	0	31	0
old-growth	0	31	0
hardwoods	1	30	0

[a] Expected values were calculated using proportions of vegetative cover types within a 95% adaptive kernel home range for each elk.

Table 11. Number of elk (of 21 radio-collared) associated with Road Management Areas whose use of vegetation classes was less than, proportional to, or greater than availablity in the southern Oregon Coast Range, 1993-94.

Vegetation class	Use compared with expected[a] Less than	 Equal to	 More than
grass/forb/shrub	0	31	0
open sapling	0	31	0
pole/small sawtimber	0	30	1
large sawtimber/mature	0	31	0
old-growth	0	31	0
hardwoods	1	30	0

[a] Expected values were calculated using proportions of vegetative cover types within a 95% adaptive kernel home range for each elk.

Table 12. Mean change and S.D. in percent use of vegetative cover types from 1991-92 (Pope 1994) to 1993-94 (this study), for elk associated with Road Management Areas (n = 16).

Cover type	Mean change	S.D.	Paired-t	P-value
grass/forb/shrub	+6.14	8.57	2.86	0.01
open sapling	+2.21	5.43	1.63	0.13
pole/small sawtimber	-0.98	6.44	-0.61	0.55
large sawtimber/mature	-3.90	5.66	-2.75	0.02
old growth	+0.01	9.47	0.01	0.99
hardwoods	-1.28	7.48	-0.69	0.50

Table 13. Use, availability, and selection[a] of vegetative types by 16 elk associated with Road Management Areas in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 1,011) and 1993-94 (this study) (n = 953).

Vegetation type	% Use	% Avail.	95% C.I.	Selection[b]
		1991-92		
grass/forb	9.05	10.7	6.6-11.5	0
shrub	14.8	16.6	11.7-17.8	0
open sapling	5.70	5.32	3.73-7.67	0
pole/small saw	30.8	30.1	26.6-34.7	0
large saw/mature	18.5	17.5	15.2-21.8	0
old growth	16.4	13.0	13.3-19.6	+
hardwoods	4.82	6.98	3.00-6.64	-
		1993-94		
grass/forb	15.2	14.9	12.0-18.3	0
shrub	18.5	15.6	15.1-21.9	0
open sapling	6.44	5.16	4.29-8.59	0
pole/small saw	28.7	30.9	24.7-32.7	0
large saw/mature	14.2	17.0	11.2-17.3	0
old growth	13.8	13.6	10.8-16.9	0
hardwoods	3.12	2.90	1.60-4.64	0

[a] (- less than expected, 0 proportional to expected, + more than expected).

[b] Selection based on Pearson chi-sqaure and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

Table 14. Selection[a] of vegetative cover types by elk (n=16) associated with Road Management Areas in the southern Oregon Coast Range, 1993-94.

Season	Vegetation Type						
	grass/forb	shrub	open sapling	pole/ small saw	mature/ large saw	old growth	hard-woods
High Traffic	Equal	Equal	Equal	Equal	Equal	Equal	Equal
Low Traffic	Equal	Equal	Equal	Equal	Less	Equal	Equal
Winter	Equal	Equal	Equal	Equal	Less	Equal	Equal
Spring	Equal	Equal	Equal	Equal	Equal	Equal	Equal
Calving	Equal	Equal	Equal	Equal	Equal	Equal	Equal
Summer	Equal	Equal	Equal	Equal	Equal	Equal	Equal
Rut	Equal	Equal	Equal	Equal	Equal	Equal	Equal
Fall	Equal	Equal	Equal	Equal	Equal	Equal	Equal

[a] Observed use compared with expected based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

Table 15. Number of elk (of 31 radio-collared) whose use relative to distance from roads was less than, proportional to, or greater than availability in the southern Oregon Coast Range 1993-94.

Road class (m)	Use compared with expected[a]		
	Less than	Proportional to	More than
<150	4	26	1
>150	1	26	4

[a] Expected values were calculated using proportions of road distance classes within a 95 % adaptive kernel home range for each elk.

roads more than expected. One elk used areas 0-150 m from roads more than expected and areas > 150 m from roads less than expected. As hypothesized, there was a significant increase in percent use of areas within 150 m of roads between 1991-92 (Pope 1994) and this study; the mean increase was 7.33 percent (SD = 9.80 t = 2.99 p = 0.009) (Table 16). This change was not correlated with the percent association of individual elk's home range with RMAs (r = 0.27, p = 0.25).

Locations of all elk that were associated with RMAs were pooled to increase statistical power. When pooled, elk used areas within 150 m of roads less than expected and areas > 150 m from roads more than expected during the pre-RMA (Pope 1994) and this study (Table 17). There was no selection of road distance classes by elk that were not associated with RMAs during either phase of the study (Table 17). Similarly, elk used areas < 150 m from roads less than expected and areas > 150 m from roads more than expected during the high traffic seasons of both phases of the study (Table 18). Elk avoided areas near roads and selected areas more distant from roads during the low traffic season of Pope's (1994) study, but there was no selection for these categories during the low traffic season of this study (Table 18). During this study, fall was the only biologically important season with significant selection of road distance categories (Table 19); areas ≤ 150 m from roads were used less than expected, and areas > 150 m from roads were used more than expected (Appendix B, Table 16). In contrast, there was considerable selection for distances from roads during the pre-RMA phase of the study Pope (1994). In every season except winter, elk during the pre-RMA study (Pope 1994) avoided areas ≤ 150 m from roads and selected areas ≥ 150 m from roads (Appendix B, Tables 16-21). During winter there was no selection for road distance classes (Appendix B, Table 21). The effects of the RMAs (increase in use of areas ≤ 150 m of roads) probably accounts for the lack of selection for distances from roads during this study.

Influence of Streams on Elk Habitat Selection

In general, the individual elk that selected for stream distance used areas near streams more than expected and areas more distant from streams less than expected. Of 31 elk , 6 used areas < 151 m from streams more than expected, and one used habitat between 301 and 450 m greater than expected. One elk used areas between 151 and 300 m from streams less than expected and 3 elk avoided areas > 450 m from streams (Table 20) (Appendix

Table 16. Change in use of areas within 150 m of roads by elk (n=16) associated with Road Management Areas in the southern Oregon Coast Range, 1991-92 (Pope 1994) and 1993-94 (this study).

Elk No.	% Use		Change	% Change
	1991-92	1993-94		
4.061	31.3	39.3	8.0	25.6
4.081	56.3	66.1	9.8	17.4
4.120	53.5	91.5	38.0	71.0
4.161	42.7	49.2	6.5	15.2
4.232	22.7	28.1	5.4	23.8
4.251	25.0	17.0	-8.0	-32.0
4.271	22.4	34.5	12.1	54.0
4.291	50.0	56.7	6.7	13.4
4.330	51.7	57.6	5.9	11.4
4.370	54.1	52.5	-1.6	-3.0
4.390	10.9	15.0	4.1	37.6
4.421	9.2	24.6	15.4	166
4.532	77.1	79.7	2.6	3.4
4.551	19.7	25.0	5.3	26.9
4.631	31.2	37.3	6.1	19.6
4.651	41.9	42.9	1.0	2.4
$\bar{x}$	37.5	44.8	7.3	28.3
SD	18.9	21.9	9.8	43.5

Table 17. Elk use, availability and selection[a] of distances from roads by 16 elk associated with Road Management Areas in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 1,011) and 1993-94 (this study) (n = 953).

Road Class (m)	Percent Use	Percent Avail.	95% C.I.	Selection[b]
		1991-92		
0-150	36.1	49.7	32.7-39.5	-
>150	63.9	50.3	60.5-67.3	+
		1993-94		
0-150	42.8	48.6	39.2-46.4	-
>150	57.2	51.3	53.6-60.8	+
	Four Elk not associated with Road Management Areas .			
		1991-92 (n = 257)		
0-150	42.4	49.6	35.4-49.4	0
>150	57.6	50.9	50.6-64.6	0
		1993-94 (n=239)		
0-150	52.3	52.4	45.0-59.6	0
>150	47.7	47.6	40.4-55.0	0

[a] (- less than expected, 0 equal to expected, + more than expected)

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

Table 18. Elk use, availability and selectiion[a] of distances from roads by 16 elk associated with Road Management Areas during the high traffic season (August-December) and low traffic season (January-July)in the southern Oregon Coast Range in 1991-92 (Pope 1994) and 1993-94 (this study).

Road Class (m)	Percent Use	Percent Avail.	95% C.I.	Selection[b]
		High traffic season 1991-92 (n = 331)		
0-150	36.3	49.7	30.3-42.2	-
>150	63.8	50.3	57.8-69.7	+
		1993-94 (n = 342)		
0-150	40.1	48.7	34.1-46.1	-
>150	60.0	51.3	53.9-65.9	+
		Low traffic season		
		1991-92 (n = 684)		
0-150	35.7	49.7	31.5-39.8	-
>150	64.3	50.3	60.2-68.5	+
		1993-94 (n = 600)		
0-150	44.3	48.7	39.7-48.9	0
>150	55.7	51.3	51.1-60.3	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

Table 19. Seasonal selection[a] of distances from roads by 16 elk associated with Road Management Areas in the southern Oregon Coast Range, 1991-92 (Pope 1994) and 1993-94 (this study).

Season	Road distance class (m)	
	0 - 150	>150
	1991 - 92	
Winter	Equal	Equal
Spring	Less	More
Calving	Less	More
Summer	Less	More
Rut	Less	More
Fall	Less	More
	1993 - 94	
Winter	Equal	Equal
Spring	Equal	Equal
Calving	Equal	Equal
Summer	Equal	Equal
Rut	Equal	Equal
Fall	Less	More

[a] Observed use compared with expected based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

Table 20. Number of elk (of 31 radio-collared) whose use of distances relative to streams was less than, proportional to, or greater than availability in the southern Oregon Coast Range, 1993-94.

Stream class (m)	Use compared with expected[a]		
	Less than	Equal to	More than
<151	0	25	6
151 to 300	1	30	0
301 to 450	0	30	1
>450	3	28	0

[a] Expected values were calculated using proportions of stream distance classes within a 95% adaptive kernel home range for each elk.

C, Tables 22-26). As predicted, there were no changes in percent use of stream distance classes between 1991-92 (Pope 1994) and this study (Table 21).

When all locations from elk that were substantially associated with RMAs were pooled, elk used areas ≤ 150 m from streams more than expected, and avoided areas > 600 m from streams (Table 22). We did not expect the gates to influence selection of distance from streams, and as we predicted selection of stream distance was similar during both phases of the study (Table 22). The elk during the pre-RMA study (Pope 1994) used areas ≤ 150 m from streams more than expected and used areas 301-600 m less than expected. Areas 151-300 and areas > 600 m from streams were used equal to expected.

Seasonally, there was no selection by pooled elk during the high-traffic season, but during the low traffic season elk used areas ≤ 150 m from streams more than expected and avoided areas > 600 m from streams (Table 23). During most of the biologically important seasons, there was no selection for distances from streams (Table 24). For combined locations elk avoided areas > 600 m from streams in winter and spring, and they used areas ≤ 150 m of streams more than expected in spring (Appendix C, Tables 27-31).

DISCUSSION

Proximity to roads, vehicular traffic and streams probably had a greater influence on movements and use patterns of elk than the RMAs. We hypothesized that use of RMAs for individual elk would increase during this study compared to the pre-RMA study in 1991-92. However, we did not observe an increase; use of RMAs was generally greater during 1991-92 when the gates were not present. Only 1 elk used RMAs more than expected in 1993-94, but this elk also selected an RMA during the pre-RMA period. The presence of gated roads did not influence selection of RMAs by the elk; therefore we were unable to accept our hypothesis. In contrast, Irwin and Peek (1979) found that Rocky Mountain elk in Idaho preferred road closure areas. The abundance of vegetative cover in the Oregon Coast Range might explain the lack of selection for RMAs. Basile and Lonner (1979) compared the effects of road closures in areas with different amounts of forest cover in Montana. They found that road closures influenced Rocky Mountain elk movements during the hunting season in the low cover areas, but not in high cover areas. In the dense vegetation and steep terrain typical of the Oregon Coast Range, Roosevelt elk may find security only a few meters from a road ; RMAs may not be important in areas with adequate cover and

Table 21. Mean change in percent use of distances from streams from 1991-92 (Pope 1994) to 1993-94 (this study) with standard deviation, paired t-test, and p-value for elk (n=16) associated with Road Management Areas.

Distance Class (m)	Mean Change	S.D.	Paired-t	p-value
< 150	-3.53	10.0	-1.41	0.17
151-300	-0.23	8.20	-0.11	0.91
301-450	4.53	10.1	1.81	0.09
> 450	-1.20	9.30	-0.52	0.61

Table 22 . Use, availability, and selection[a] of distances from streams by 16 elk associated with Road Management Areas in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 1,011) and 1993-94 (this study) (n = 953).

Stream class (m)	% Use	% Availability	95% C.I..	Selection[b]
		<u>1991-92</u>		
0-150	32.7	23.5	28.9-36.6	+
151-300	22.7	22.1	19.3-26.1	0
301-450	14.8	19.4	11.9-17.7	-
451-600	12.0	15.7	9.36-14.6	-
>600	17.8	19.3	14.7-20.9	0
		<u>1993-94</u>		
0-150	29.1	23.4	25.3-32.9	+
151-300	22.1	22.2	18.6-25.5	0
301-450	19.8	19.8	16.5-23.1	0
451-600	15.3	15.9	12.3-18.3	0
>600	13.8	18.7	10.9-16.7	-

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

Table 23. Use, availability, and selection[a] of distances from streams by 16 elk associated with Road Management Areas during the low traffic (January-July) and high traffic (August-December) seasons in the southern Oregon Coast Range in 1993-94.

Stream Class (m)	Percent Use	Percent Avail.	95% C.I..	Selection[b]
		Low Traffic (n = 600)		
0-150	31.7	23.4	26.8-36.6	+
151-300	21.9	22.2	17.5-26.2	0
301-450	19.7	19.8	15.5-23.9	0
451-600	14.7	15.9	11.0-18.4	0
>600	12.0	18.7	8.60-15.4	-
		High Traffic (n = 342)		
0-150	24.6	23.4	18.7-30.6	0
151-300	22.9	22.2	17.1-28.7	0
301-450	19.4	19.8	13.9-24.9	0
451-600	15.9	15.9	10.9-21.0	0
>600	17.1	18.7	11.9-22.3	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

Table 24. Seasonal selection[a] of distances from streams by 16 elk associated with Road Management Areas in the southern Oregon Coast Range, 1993-94.

Season	Stream distance class (m)				
	0-150	151-300	301-450	451-600	>600
Winter	Equal	Equal	Equal	Equal	Less
Spring	More	Equal	Equal	Equal	Less
Calving	Equal	Equal	Equal	Equal	Equal
Summer	Equal	Equal	Equal	Equal	Equal
Rut	Equal	Equal	Equal	Equal	Equal
Fall	Equal	Equal	Equal	Equal	Equal

[a] Observed use compared with expected based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984)

high topographic relief. Additionally, the elk had only 9 months between the pre-RMA study (Pope 1994) and this study to acclimate to the gates; given more time the elk may have shown increased use for RMAs. Lastly, roads in the RMA program were not truly closed. Administrative vehicle traffic was allowed behind the gates. Poaching was a major source of mortality for this elk population (Chapter II) (Pope 1994), and elk probably do not differentiate between administrative vehicles traveling behind the gates and poachers.

Selection of Vegetative Types

Individual Elk-Other studies have shown tremendous variability in the selection of vegetation types by Roosevelt elk. In the southern Oregon Coast Range, Witmer (1981) found that adult cows used old-growth and hardwood forests more than expected, and mixed forest and sapling/pole stands were used less than expected. On the Olympic Peninsula, Schroer et al. (1993) found that elk avoided even-aged regenerating stands and recent clearcuts. Pope (1994) found little selection for vegetation types by individual elk, but when all elk locations were pooled, elk showed a preference for grass/forb habitats and avoided pole stands. During this study, most vegetation types were used in proportion to their availability. At the individual elk level, one cow used hardwoods less than expected and pole/small sawtimber more than expected, and this elk was not significantly associated with RMAs. In contrast, Pope (1994) found significant selection of vegetation types by 11 of the 16 elk that were also present during this study and associated with RMAs. For individual elk, we hypothesized that elk use of open, foraging habitats (grass/forb and shrub) would increase compared to the pre-RMA period, and that use of these habitats would be positively correlated with the degree of association with RMAs. There was a significant increase in percent use of the forb/shrub type and a significant decrease in use of large sawtimber/mature from 1991-92 through this study. Thus, our results supported our first hypothesis, but not the second. Rocky Mountain elk select forest cover during periods of increased disturbance (McLean 1972, Bohne 1974, Marcum 1975, Lonner 1976). The reduction in vehicular traffic and associated human disturbance during the RMA period may be responsible for increased elk use of open, foraging habitat.

Locations Pooled-When locations of the 16 elk that were associated with RMAs were pooled, there was also no vegetation type selection. The same elk during Pope's (1994) study used hardwoods less than expected and old-growth more than expected. Seasonally, other researchers have reported selection for hardwoods and old- growth by Roosevelt elk. Witmer (1981) found elk used old-growth Douglas fir more than expected in all seasons, and they selected hardwood forests more than expected in summer and fall. In the Mt St. Helens blast zone, Merrill et al. (1987) found that elk selected mature forest during spring. Jenkins (1984) reported that alder flats in the Hoh River floodplain and old-growth forest were used more than expected during the winter. On the Olympic Peninsula, elk used hardwoods more than expected during spring, summer and winter and old growth was selected during fall and winter (Schroer et al. 1993).

In this study there was no selection of old-growth or hardwoods during any season. When locations were pooled for elk associated with RMAs, large sawtimber/mature was used less than expected during the winter, but all vegetation types were used proportional to availability during the other biologically important seasons. In the pre-RMA study, Pope (1994) found old-growth was used more than expected and hardwoods less than expected during summer, shrub habitats were used less than expected during rut, and grass/forb habitats used less than expected during the fall. There was no selection for any vegetation types by elk associated with RMAs in either the high-traffic season (August-December) or the low-traffic season (January-July). During the pre-RMA period in 1991-92 (Pope 1994) the same elk used forb/grass and shrub habitats less than expected in the high-traffic season. This suggests an increased use of open, foraging habitats during the high-traffic season, and supports our hypothesis that the effects of RMAs would be greatest during the high-traffic season. Use of grass/forb habitats increased from 6.02 to 10.9 %, and use of shrub habitat increased from 11.1 to 17.0 % from 1991-92 to 1993-94. During the high traffic season in 1991-92 (Pope 1994), elk were exposed to frequent human disturbance. The presence of the gates reduced vehicle traffic (Fig. 3), and the access restriction probably reduced hunting pressure as well as vehicle traffic. With decreased disturbance elk are more likely to be associated with open foraging habitats. As previously noted, research on Rocky Mountain elk indicates increased use of timber cover during the fall and hunting seasons (McLean 1972, Bohne 1974, Marcum 1975, Lonner 1976).

There was a general lack of selection for any vegetative type during this study. Broad vegetation categories examined in this and other studies might be meaningless to elk. Microhabitat conditions not measured in these studies might be more important to elk than general vegetation types.

Influence of Roads on Elk Habitat Selection

Individual elk-Avoidance of roads by Rocky Mountain elk is well documented (Ward 1976, Perry and Overly 1977, Lyon 1979, Hershey and Leege 1982); However, there is less evidence that Roosevelt elk are displaced by roads. Rost and Bailey (1979) and Edge and Marcum (1991) suggested that elk were displaced by heavily traveled roads more than lightly traveled roads. Road closures have been used to mitigate road avoidance by Rocky Mountain elk (Marcum 1976, Basile and Lonner 1979), but there is no information on the efficacy of limited road access for Roosevelt elk. Witmer and deCalesta (1985) found Roosevelt elk cows used areas ≤ 500 m from paved forest roads less than expected, and there were fewer than expected observations ≤ 125 m from spur roads. We hypothesized that areas close to roads would be used more during the limited access phase of the study than during the pre-RMA phase of the study (Pope 1994), and increased use would be correlated with the degree of elk association with RMAs. We also hypothesized that the effects of RMAs would be greater during the high traffic season from August through January.

During this study there was little selection of road distance classes within the home ranges of individual elk Four elk used areas ≤ 150 m from roads less than expected and areas > 150 m from roads more than expected. One elk used areas ≤ 150 m of roads more than expected and areas > 150 m from roads less than expected. All elk that selected distances from roads were significantly associated with RMAs. The general trend was for elk to use areas near roads less than they were available, even when no significant selection was detected. Patterns of selection were similar prior to the installation of the gates (Pope 1994). Seven of the 16 elk that were also present during this study and associated with RMAs avoided areas ≤ 150 m of roads and selected areas >150 m from roads. Lack of avoidance of roads for individual elk may be the result of low numbers of locations and limited statistical power. We hypothesized that elk use of areas ≤ 150 m from roads would increase during this study compared to Pope's (1994) study, and as hypothesized there was a significant increase in use of these areas. However, this increase was not correlated with the percent association with RMAs. The increase in use of these areas may not be correlated with RMAs because of the way that RMA boundaries were delineated. RMAs boundaries were determined by plotting the mid-point between gated roads and the nearest non-gated roads (see Chapter II). This analysis revealed that elk only avoided areas ≤ 150 m of roads. Therefore, a RMA boundary delineated as the area ≤ 150 m of gated roads might have produced different results.

Locations Pooled-When all locations for elk associated with RMAs were combined, elk avoided areas ≤ 150 m from roads and used areas >150 m from roads more than expected during this study and during the pre-RMA study. Although the pattern of selection was the same, elk use of areas ≤ 150 m from roads increased from 36.1 to 42.8 % between the two studies. As with the results within individual elk home ranges, this suggests the RMAs mitigated the disturbance by vehicular traffic.

During the high-traffic seasons (August-December) of both studies, elk avoided areas near roads and selected areas more distant from roads. Although there was little vehicular traffic behind the gates during the high-traffic season, there was an increase in non-motorized activity such as hunting. Disturbance by hunters walking and biking behind the gates could account for elk avoidance of areas near roads during this time period. During the low-traffic season of this study, there was no selection of road distance classes, but during the pre-RMA study elk avoided areas near roads and selected areas more distant from roads. Elk use of areas ≤ 150 m from roads increased from 35.7 to 44.3 % between the two studies during the low-traffic season. Reduction in vehicle traffic between the two time periods could account for increased use of areas near roads. The change in selection within this study from the high-traffic season to the low-traffic season suggests that elk may respond rapidly to reductions in vehicle traffic and human activity. Other research suggests that avoidance of roads by elk is related to the amount of vehicle traffic. Czech (1991) found increased traffic on a forest highway in the Mt. St. Helens National Monument caused Roosevelt elk to avoid a 500-m corridor around the road. Rost and Bailey (1979) found greater road avoidance by Rocky Mountain elk around well traveled roads in their Colorado study, and Edge and Marcum (1991) suggested similar findings in Montana.

Most road distance classes were used equal to expected by elk associated with RMAs during each biological seasons. The fall season was an exception when elk avoided areas ≤ 150 m from roads and selected areas > 150 m from roads. In contrast, the same elk during the pre-gate period (Pope 1994) avoided areas near roads and selected areas more distant from roads during each biological season except winter. Because this pattern was confined to the fall season during this study, it suggests the RMAs reduced elk avoidance of roads during most of the year. As previously mentioned, most hunting occurred during the fall season, and there was a considerable amount of non-motorized human activity behind the gates . The increase in human disturbance might explain the avoidance of areas near roads, and the selection for areas further away from roads during the fall hunting season.

Influence of Streams on Elk Habitat Selection

Rocky Mountain elk are seasonally associated with permanent water or riparian areas (Lyon 1973, Marcum 1975, Pedersen and Adams 1976, Pedersen et al. 1979). Grenier (1991) found that Roosevelt elk in northern California were typically < 500 m from permanent water, and Pope (1994) found that elk within this study area used areas ≤ 300 m from streams more than expected. Individual elk tended to select areas ≤ 150 m from streams and avoid areas more distant from streams regardless of their association with RMAs during this study.

When locations of all elk were combined, elk selected areas ≤ 150 m from streams and avoided areas > 600 m from streams. The same pooled elk used areas < 150 m more than expected and avoided areas 300-600 m from streams during the pre-RMA study (Pope 1994). We did not expect the gates to influence selection of distance from streams, and as predicted, selection of stream distance was similar during both phases of the study. During the biologically important seasons, elk used most stream distance classes in proportion to availability. Elk avoided areas > 600 m from streams during winter and spring and selected areas ≤ 150 m from streams during spring. In contrast, the same elk during 1991-92 selected areas within 150 m of streams during every season except fall, where elk selected areas 151-300 m from streams and avoided areas 451-600 m from streams. Witmer (1981) found that elk selected areas near permanent water during calving season. Elk may seasonally favor areas near streams and avoid areas more distant from streams due to more favorable microclimate, forage and cover characteristics. Also, the differences in selection of stream distances between the studies could be the result of weather variation.

SUMMARY

Limited-vehicle access affected elk behavior in the southern Oregon Coast Range. Although elk did not shift movements toward Road Management Areas (RMAs) or select RMA habitat, the reduction in vehicle traffic and human disturbance associated with RMAs influenced elk behavior. Daily elk movements were reduced during the limited-access period, and the reduction in movement was correlated with the degree of association of individual elk with RMAs. Elk during this study increased use of open, foraging habitats, and decreased use of mature stands compared to the pre-RMA study (Pope 1994). Elk still avoided areas ≤ 150 m of roads, but there was a 7% increase in use of these areas during this study as compared to the pre-RMA period (Pope 1994). To maximize benefits, limited-access areas should be at least 743 ha, to encompass as much of an elk's home range as possible.

There was a clear reduction in vehicle traffic behind the gates compared to non-gated roads. Not surprisingly, denying vehicle access to the public reduced poaching mortality. If elk that disappeared were considered poaching mortalities, survival rates increased during the limited access period and declined after the removal of the gates. The limited access program had no effect on legal elk harvest.

This study confirmed Pope's (1994) findings that elk select areas near streams and avoid areas more distant from streams. These effects were not associated with the limited access program, but should be considered in future elk management decisions. Riparian areas provide natural travel corridors, serve to moderate temperature extremes, and contain diverse vegetation types.

MANAGEMENT RECOMMENDATIONS

Managers should consider the conditions and timing of the Road Management Areas (RMAs) in this study before implementing road closure or management programs. The gates did not provide true road closures, but limited vehicle access to ≤ 4 trips per week for forest management activities, wildlife research, fire suppression and emergency access. By definition, road closures prevent all vehicle access, and in some cases the road surface is destroyed, seeded and no longer maintained. Although this assumption requires testing, true closures probably would have a greater impact on elk behavior than limited access. Additionally, the elk had only nine months to acclimate to the limited access program. With more time to respond to RMAs and/or complete closures, the effects of road management on elk behavior may have been stronger.

Elk did not shift activities into RMAs after the gates were installed. There was no increase in the percentage of elk home ranges or core areas associated with the gated areas during this study compared to the pre-RMA study, but elk did benefit from the RMAs in other ways. Limited-vehicle access reduced daily movement of elk. If the reduction in elk movement is a reaction to decreased vehicular traffic and human harassment of elk, elk may benefit from limited-access management. Reduced movement suggests that elk expend less energy when associated with RMAs than when they are not. The potential benefits of reduced energy expenditure include increased fat reserves, increased survival rate, and increased productivity. In general, limited-access management may promote more productive elk populations, and increase hunter opportunity. To maximize benefits, future road management programs should limit vehicle access on as much of an elk's range as possible.

Although elk populations in western Oregon are increasing, illegal harvest of elk is a major issue. Stussey et al. (1993), Pope (1994) and I found poaching to be an important cause of mortality for female Roosevelt elk. Not surprisingly, road management reduced poaching in this study if elk that disappeared were treated as poaching mortalities. Survival rates increased during the road management period compared to the pre-road management period (Pope 1994), and declined after removal of the gates. Reduced poaching may result in an increase in elk numbers, which may or may not be desirable, depending on the management objectives for a given area.

Limited vehicle access produced modest changes in habitat use by elk. Reductions in vehicular traffic and human disturbance of elk may allow elk to use habitats that they otherwise might avoid. Although elk still avoided areas near roads, there was a 7% increase in the use of areas ≤ 150 m from roads and a 6 % increase in use of open, foraging habitats during this study as compared to the pre-gate study (Pope 1994). Increased use of these habitats may increase access to favorable forage or cover conditions; however, an increase in elk use of open habitats and areas near roads may make elk more vulnerable to legal harvest. These tradeoffs should be considered before initiating road management areas.

Although not related to the limited-access program, this study confirmed Pope's (1994) findings that elk use areas near streams more than expected and avoid areas more distant from streams. Many biologists and managers have questioned the importance of riparian areas to Roosevelt elk. Water is not a limiting resource in the Oregon Coast Range, but elk may be using riparian areas as travel corridors, foraging areas, or for preferred microclimates. These findings coupled with elk avoidance of areas near roads, suggest that Roosevelt elk will benefit from the preferred alternative of the President's Forest plan (Thomas et al. 1993). Much of the study area is included in late-successional forest reserves under the preferred alternative, and the preferred alternative mandates the establishment of riparian reserves. These reserves eliminate logging and road building in a protective buffer around streams. The maintenance of intact watersheds without roads will likely benefit elk.

The Wisdom model (Wisdom et al.1986) is currently used to model habitat effectiveness for Roosevelt elk, and two important parameters in the model include the amount of roads and old-growth forest. Roads that receive any vehicular traffic are considered open, but based on the results of this study this assumption may be too stringent. Under limited-vehicle access, which allowed as many as 4 vehicle trips per week on gated roads, elk increased their use of areas ≤ 150 m of roads. Thus, administrative vehicle traffic might be allowed and the road would still be considered closed. The Wisdom model considers old-growth forests to be optimum cover (Habitat Effectiveness = 1.0) for Roosevelt elk. Other studies (Jenkins 1984, Witmer 1981, Schroer 1993) have suggested that Roosevelt elk select old-growth. However, (Pope 1994, this study) found no strong selection of old-growth. The value of old-growth as habitat for Roosevelt elk may be over-emphasized in the Wisdom model. Lastly, the Wisdom model does not consider the importance of streams in roadless areas. During this and Pope's (1994) study, elk selected areas near streams and avoided areas more distant from streams. Managers should consider areas > 150 m from roads and ≤ 150 m from streams in future elk management decisions and models of habitat suitability.

Hunting was the dominant recreational activity within the study area, which accounted for much of the vehicular traffic during fall. Although not a scientific survey, hunter reaction to the limited-access program was mixed. Many elk and deer hunters encountered during this study said that the gates enhanced their hunting experience. In general, hunters with less dependence on vehicles (such as bow hunters) favored the gates, while other hunters and houndsmen were more critical of the limited-access program. Many hunters complained about the difficulty of retrieving game while hunting behind the gates. Vandalism and illegal entry of vehicles behind the gates was a common problem, particularly during the hunting seasons; therefore maintenance of gates was expensive in time and money. True road closures using permanent barriers would be less costly and more effective. Managers should consider permanent road closures where feasible.

LITERATURE CITED

Ackermann, B., F. Leban, M. Samual, and E. Garton. 1990. User's manual for HOMERANGE. Forest. Wildl. and Range Exp. Sta., Univ. Idaho, Moscow 63pp.

Anderson, D.J. 1982. The home range: a new nonparametric estimation technique. Ecology 63:103-112.

Badey, J.L. 1992. Unpublished memorandum: Road closure plan monitoring progress report. Bureau of Land Management, Coos Bay District, North Bend, Oreg. 9pp.

Baldwin, J., and J. Kie. 1992. Program CALHOME. Unpublish. USDA For. Serv. For. Sci. Lab., Fresno Cal. 12pp.

Basile, J.V., and T.N. Lonner, 1979. Vehicle restrictions influence elk and hunter distribution in Montana. J. For 77:155-159.

Bohne, J.R. 1974. Food habits, seasonal distribution, and habitat utilization of elk in the South Fork of Fish Creek, Lolo National Forest, Montana. M.S. Thesis. Univ. Montana, Missoula. 197pp.

Bryant L.D., B.K. Johnson, J.W. Thomas, and J.H. Noyes. 1991. Hunter and Rocky Mountain elk interactions in the Starkey Experimental Forest and Range. Pages 168-174 in A.G. Christensen, L.J. Lyons, and T.N. Lonner (eds.). Proc. of a symposium on elk vulnerability. Montana State Univ., Bozeman.

Burbridge, W.R., and D.J. Neff. 1976. Conconino National Forest-Arizona Game and Fish Department cooperative roads-wildlife study. Pages 44-57 in S.R. Hieb (ed) Proc. Elk-logging-roads Symp., Univ. Idaho, Moscow.

Burt, W.H. 1943. Teritoriality and home range concepts as applied to mammals. J. Mammal. 66:1-12.

Brown, R.E., and A.B. Curtis. 1985. Introduction. Pages 1-15 in E.R. Brown (ed), Management of wildlife and fish habitats in forest of western Oregon and Washington. USDA For. Ser., PNW Region No. R6-F&WL-192. U.S. Gov. Print. Washington, D.C. 332pp.

Byers, C.R., R.K. Steinhorst, and P.R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48:1050-1053.

Christensen, B. and S. Langenstein. 1992. A proposal to temporarily limit vehicle access on selected federal and private administered roads in the Tioga and Myrtlewood resource areas of the Coos Bay District. EA No. OR129-92-13. Bur. Land Manage., North Bend, Oreg. 8pp.

Clutton-Brock T.H., F.E. Guinness, and S.D Albon. 1982. Red deer: behavior and ecology of two sexes. University of Chicago Press. Chicago Il. 378pp.

Coggins, V.L., and G.G. Magera. 1973. Vehicle restrictions, elk harvest, and hunter behavior in the Chesnimmus Unit. Spec. Unpubl. Rep. Oregon Dep. Fish and Wildl., Salem, Oreg. 25pp.

Coggins, V.L.. 1976. Controlled vehicle access during elk season in the Chesnimnus Area, Oregon. Pages 58-61 in S.R. Hieb (ed) Proc. Elk-logging-roads Symp. Univ Idaho, Moscow.

Coop, K.J. 1971. Habitat use, distribution, movement and associated behavior of elk, Little Belt, Montana. Compl. Rep. Proj. No. W-120-R-1 & 2. Montana Fish and Game Dep., Helena. 61pp.

Cox, D.R., and D. Oakes. 1984. Analysis of survival data. Chapman and Hall, New York, N.Y. 201pp.

Craighead, J.J., G. Atwell, and B.W. O'Gara. 1972. Elk migrations in and near Yellowstone National Park. Wildl Monogr. 29:1-48.

Craighead, J.J., F.C. Craighead, Jr., R.L. Ruff, and B.W. O'Gara. 1973. Home ranges and activity patterns of non-migratory elk of the Madison drainage herd as determined by biotelemetry. Wildl. Monogr. 33:1-50.

Czech, B. 1991. Elk behavior in response to human disturbance at Mt St. Helens National Volcanic Monument. Appl. Anim. Behav. Sci. 29:269-277.

Dixon, K.R., and J.A. Chapman. 1980. Harmonic mean measure of animal activity areas. Ecology 61:1040-1044.

Dodge W., and A.J. Steiner. 1986. XYLOG: a computer program for field processing locations of radio-tagged wildlife. USDI Fish and Wildlife Technical Report 4. Washington D.C. 22pp.

Edge, W.D. 1982. Habitat use and elk movements in relation to roads and human disturbance in western Montana. M.S. Thesis, Univ. Montana, Missoula. 98pp.

__________, C.L. Marcum, and S.L. Olson. 1985. Effects of logging activities on home-range fidelity of elk. J. Wildl. Manage. 49:741-744.

Edge, W.D., and C.L. Marcum. 1991. Topography emeliorates the effects of roads and human disturbance on elk. pages 132-137 in A.G. Christensen, L.J. Lyons, and T.N. Lonner (eds.) Proc. of a symposium on elk vulnerability. Montana State Univ., Bozeman.

Environmental Systems Research Institute Inc. 1991. Program ARC/INFO. Redlands, Cal.

Fiedler, P.F., M. Eden, T. O'Connor, and D. Zalunardo. 1992. Clackamas Drainage elk telemetry study com. report. Unpubl. Rep., USDA Forest Service, Mt. Hood National Forest. 35pp.

Flora, J., and M. Kellett. 1995. Watershed analysis Sandy Creek subbasin. Unpubl. Rep., Bureau of Land Management, North Bend, Oreg. 79pp.

Franklin, J.F., and C.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA For. Ser. Gen. Tech. Rep. PNW-8, PNW For. and Range Exp. Sta., Portland, Oreg. 417pp.

Franklin, J.F., and R.T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles: Landscape Ecol. 1:5-18.

Franklin, J.F., and T.A. Spies. 1991. Composition, function, and structure of old-growth Douglas fir forests. Pages 71-83 in K.B. Aubry and M.H. Brookes (eds) Wildlife and vegetation of unmanaged Douglas fir forests. USDA Forest Service Gen. Tech. Report PNW-GTR-285, PNW For. and Range Exp. Sta., Portland, Oreg.

Franklin, W.L., L.S. Mossman, and M. Dole. 1975. Social organization and home range of Roosevelt elk. J. Mammal. 56:102-118.

Franklin, W.L., and J.W. Lieb. 1979. The social organization of a sedentary population of North American elk: a model for understanding other populations. Pages 185-195 in M.S. Boyce and L.D. Hayden-Wing (eds) North American elk: ecology behavior and management. Univ. of Wyoming, Laramie, Wyoming.

Garrott, R.A., G.C. White, R. Bartmann, and D.L. Weybright. 1986. Reflected signal bias in biotelemetry triangulation systems. J. Wildl. Manage. 50:747-752.

Geist V. 1978. Behavior. Pages 283-296 in J.L. Schmidt and D.L Gilbert (eds) Big game of North America: ecology and management. Stackpole Books. Harrisburg, Penn.

_______. 1982. Adaptive behavioral strategies. Pages 219- 278 in Thomas and D.E. Toweill (eds) Elk of North America: ecology and management. Stackpole Books. Harrisburg, PA.

Grenier, J.J. 1991. Habitat use by Roosevelt elk in the Bald Hills of Redwood National Park. M.S. Thesis, Humboldt State Univ., Arcata Cal. 75pp.

Hayne, D.W. 1949. Calculation of size of home range. J. Mammal. 30:1-18.

Hemstrom, M.A., and S.E. Logan. 1986. Plant association and management guide: Siuslaw National Forest. USDA For. Ser. Rep. R6-Ecol 220-1986b. 91pp.

Hershey, T.J., and T.A. Leege. 1976. Influences of logging on elk on summer range in north-central Idaho. Pages 73-80 in S.R. Hieb (ed) Proc. elk/logging roads symp. Univ. Idaho, Moscow.

Irwin, L.L. 1978. Relationships between intensive timber culture, big game habitats, and elk habitat use in northern Idaho. Ph.D. Univ. of Idaho, Moscow. 282pp.

_______, and J.M. Peek. 1979. Relationship between road closures and elk behavior in northern Idaho. Pages 199-204 in M.S. Boyce and L.D. Hayden-Wing (eds) North American elk: ecology behavior and management. Univ. of Wyoming, Laramie, Wyoming.

_______, __________. 1983. Elk habitat use relative to forest succession in Idaho. J. Wildl. Manage. 47:664-672.

Jenkins, K.J. 1984. Habitat use by Roosevelt elk in unmanaged forests of the Hoh River, Washington. J. Wildl. Manage. 48:642-646.

Jennrich, R.I., and F.B. Turner. 1969. Measurement of non-circular home range. J. Theor. Biol. 22:227-237.

Kaplan, E.L., and P. Meier. 1958 Nonparametric estimation from incomplete observations. J. Am. Stat. Assoc. 53:457-481.

Kaufman, J.H. 1962. Ecology and social behavior of the coati, (Nausia narica) on Barro Colorado Island, Panama. Univ. California, Publ. Zoology 60:95-222.

Kistner, T.P. 1982. Diseases and parasites. Pages 181-2219 in J.W. Thomas and D.E. Toweill (eds) Elk of North America: ecology and management. Stackpole Books. Harrisburg, Penn.

Lee, J.E., G.C. White, R.A. Garrott, R.M. Bartmann, and A.W. Alldredge. 1985 Assessing accuracy of a radiotelemetry system for estimating animal locations. J. Wildl. Manage. 49:658-663.

Lenth, R.V. 1981 On finding the source of a signal. Technometrics 23:149-154.

Leuthold, W. 1977. African ungulates: A comparative review of their ethology and behavioral ecology. Springer-Verlag, New York. 307pp.

Leptich, D.J., and P. Zager. 1991. Road access management effects on elk mortality and population dynamics. Pages 126-132 in A.G. Christensen, L.J. Lyons, and T.N. Lonner (eds.) Proc. of a symposium on elk vulnerability. Montana State Univ., Bozeman.

Lieb, J.W. 1981. Activity, heartrate, and associated energy expenditure of elk in western Montana. Ph.D. Thesis, Univ. Montana, Missoula. 200pp.

Lonner, T.M. 1976. Elk use-habitat type relationships on summer and fall range in Long Tom Creek, southwestern Montana. Pages 101-109 in S.R. Hieb (ed) Proc. elk/logging roads symp. Univ. Idaho, Moscow.

Lyon, L.J. 1973. Elk use of Burdette Creek. PP 101-106. Western states elk workshop proc., Bozeman, Mont.

________. 1979. Habitat effectiveness for elk as influenced by roads and cover. J. For. 77:658-660.

________, T.N. Lonner, J.P. Weigland, C.L. Marcum, W.D Edge, J.D. Jones, D.W. McCleery, and L.L. Hicks. 1985. Coordinating elk and timber management. Final report of the Montana cooperative elk-logging study 1970-1985. Mont. Dep. of Fish, Wildl. and Parks, Bozeman. 53pp.

Maclean, C.D. 1980. Opportunities for silvicultural treatment in western Oregon. USDA For. Ser. Res. Bull. PNW-90. 5pp.

Manly, B.F., L.L. McDonald, and D.L. Thomas. 1993. Resource selection by animals. Chapman and Hall, London. 205pp.

Marcum, C.L. 1975. Summer-fall habitat selection and use by a western Montana elk herd. Ph.D. Thesis. Univ. of Montana, Missoula. 188pp.

__________. 1976. Habitat selection and use during summer and fall months by a western Montana elk herd. Pages 91-96 in S.R. Hieb (ed) Proc. elk/logging roads symp. Univ. Idaho, Moscow.

McLean, L.S. 1972. Movements and migrations of the Lochsa elk herd. M.S. Thesis. Univ. Idaho, Moscow. 65pp.

Merrill, E., K. Raedeke, and R. Taber. 1987. Population dynamics and habitat ecology of elk in the Mount St. Helens blast zone. Wildl. Sci. Group, Univ. Washington, Seattle, Wash. 186pp.

Michener, G.R. 1979. Spatial relationships and social organization of adult Richardson's ground squirrels. Can. J. Zoology. 57:125-139.

Neu, C.W., C.R. Byers, and J.M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Oregon Climatological Center. 1993. Unpublished data. Oregon State Univ., Corvallis, Oreg.

Pedersen, R.J., and A.W. Adams. 1976. Rocky Mountain elk research project progress report. Prog. Rep. Proj. No. W-70-R-6. Oregon Dep. Fish and Wildl., Portland. 19pp.

___________, ______________, and J. Skovlin. 1979. Elk management in Blue Mountain habitats. Res. and Dev. Rep. W-70-R-6. Oregon Dep. Fish and Wildl., Portland. 27pp.

__________, __________, __________,1980. Elk habitat use in an unlogged and logged forest environment. Oreg. Dep. Fish Wildl., Wildl. Res. Rep. 9. 121pp.

Peek, J.M., R,J. Mackie, and G.I. Dusek. 1992 Over-winter survival strategies of North American cervidae. Pages 156-161 in W.B. Ballard and V. Crichton (eds) 3rd international moose symposium. Komi Science Center of the Ural Division of the U.S.S.R. Acad. of Sci., Syktyvkar, U.S.S.R.. 242pp.

Perry, C., and R. Overly. 1977. Impacts of roads on big game distribution in portions of the Blue Mountains of Washington, 1972-1973. Appl. Res. Sect. Bull. No. 11. Washington Game Dept., Olympia, WA. 39pp.

Pollock, K.H., S.R. Winterstein, and M.J. Conroy. 1989. Estimation and analysis of survival distributions for radio-tagged animals. Biometrics 45:99-109.

Pope, M.D. 1994. Roosevelt elk habitat use in he Oregon Coast Range. M.S. Thesis. Oregon State Univ., Corvallis 78pp.

Rosenzweig, M.L. 1981. A theory of habitat selection. Ecology 62:327-335.

Rost, G.R,. and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. J. Wildl. Manage. 43:634-641.

Samuel, M.D., D.J. Pierce, and E.O. Garton. 1985. Identifying areas of concentrated use within the home range. J. Animal Ecol. 54:711-719.

SAS Institute Inc. 1994. SAS: Statistical application software. Cary, N.C.

Schoen, J.W. 1977. The ecological distribution and biology of wapiti in the Ceder River watershed. Ph.D. Thesis. Univ. Washington, Seattle, Wash. 408 pp.

Schroer, G.L., K.J. Jenkins, and B.B. Moorhead. 1993. Roosevelt elk selection of temperate rain forest seral stages in western Washington. Northwest Sci. 67:23-29.

Schwartz, J.E., and G.E. Mitchell 1945. The Roosevelt elk on the Olympic Peninsula, Washington. J. Wildl. Manage. 9:295-319.

Springer, J.T. 1979. Some sources of bias and sampling error in radio triangulation. J. Wildl. Manage. 43:926-935.

Starkey, E.E., D.S. deCalesta, and G.W. Witmer. 1982. Management of Roosevelt elk habitat and harvest. Trans. N. Am. Wildl. Nat. Resor. Conf. 47:353-362.

Stussy, R.J., W.D. Edge, and T.A. O'Neil. 1994. Survival of resident and translocated elk in the Cascade Mountains of Oregon. Wildl. Soc. Bull. 22:242-247.

Thomas, J.W., M.G. Raphael, and E.C. Meslow. 1993. Forest ecosystem management: an ecological, economic and social assessment. Report of the Forest Ecosystem Assessment Team. USDA For. Ser, USDI Fish and Wildl. Ser., USDC Nat. Ocean. Admin Nat. Marine Fish. Ser., USDI Nat. Park Ser., USDI Bur. Land Manage., Env. Pro. Ag. 785 pp.

Toweill, D.E., and E.C. Meslow. 1977. Food habits of cougars in Oregon. J. Wildl. Manage 41:232-234.

Unsworth, J.W., L. Kuck, M.D. Scott, and E.O. Garton. 1993. Elk mortality in the Clearwater drainage of northcentral Idaho. J. Wildl. Manage. 57:495-502.

Ward, A.L. 1976. Elk behavior in relation to timber harvest operations and traffic on the Medicine Bow Range in south-central Wyoming. Pages 32-43 in S.R. Hieb (ed) Proc. elk/logging roads symp. Univ. Idaho, Moscow.

________, and J.J. Cupal. 1979. Telemetered heart rate of three elk affected by activity and human disturbance. Pages 47-56 in Dispersed recreation and natural resource management. Symposium Proceedings., Utah State Univ., Logan.

________, N.E. Fornwalt, S.E. Henry, and R.A. Hodorff. 1980. Effects of highway operation practices on elk, mule deer, and pronghorn antelope. Rep. No. FHWA-RD-79-143. National Technical Information Service, Springfield , Virg. 48pp.

White, G.C., and R.A. Garrott. 1986. Effects of biotelemetry triangulation error on detecting habitat selection. J. Wildl. Manage. 50:509-513.

________, ____________. 1990. Analysis of wildlife radio-tracking data. Press Inc, San Diego, Cal. 383 pp.

Wisdom, M.J., L.R. Bright, C. Carey, W.W. Hines, R.J. Pedersen, D.A. Smithey, J.W. Thomas, and G.W. Witmer. 1986. A model to evaluate elk habitat in western Oregon. USDA For. Ser. Pub. No. R6-F&WL-216-1986. 36pp.

Witmer, G.W. 1981. Roosevelt elk habitat use in the Oregon Coast Range. Ph.D. Thesis, Oregon State Univ., Corvallis. 104pp.

_________, and D.S. deCalesta. 1985. Effect of roads on habitat use by Roosevelt elk. Northwest Sci. 59:122-125.

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home range studies. Ecology 70:164-168.

Zar, J.H. 1984. Biostatistical analysis. Prentice-Hall Inc. Englewood Cliffs, N.J. 718pp

APPENDICES

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Table 1. Use, availability and selection[a] of grass/forb/shrub vegetative cover type within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	13.3	19.1	1.62-25.0	0
4.061	37.7	27.2	-1.90-15.0	0
4.081	21.7	20.4	7.48-35.9	0
4.100	18.0	18.5	4.90-31.2	0
4.120	41.7	32.8	24.7-58.7	0
4.161	45.9	36.4	28.9-62.9	0
4.181	26.2	33.1	11.2-41.3	0
4.232	33.9	25.7	17.5-50.3	0
4.251	23.7	30.2	8.95-38.5	0
4.271	40.7	25.3	23.6-57.7	0
4.291	26.7	31.7	11.4-41.9	0
4.311	18.3	15.1	5.00-31.7	0
4.330	22.6	30.5	8.41-36.8	0
4.370	27.9	35.3	12.6-43.2	0
4.390	26.7	21.7	11.4-41.9	0
4.421	29.5	27.6	13.9-45.1	0
4.532	58.3	46.4	41.4-75.3	0
4.551	30.0	25.4	14.2-45.8	0
4.631	33.9	29.2	17.5-50.3	0
4.651	38.3	28.3	21.6-55.1	0
5.091	20.0	18.9	6.22-33.8	0
4.591	25.0	16.3	10.1-39.9	0
5.071	31.7	32.2	15.7-47.7	0
4.681	37.7	36.1	21.1-54.3	0
5.052	10.0	9.54	-0.33-20.3	0
5.031	8.33	18.3	-1.19-17.8	0
5.061	13.1	18.2	1.58-24.6	0
4.611	21.7	30.7	7.48-35.9	0
5.100	31.7	26.4	15.7-47.7	0
5.041	20.0	14.6	6.22-33.8	0
$\bar{x}$	27.8	26.0	12.2-41.3	
SD	11.1	8.09	7.83 13.7	

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 2. Use, availability and selection[a] of open sapling vegetative cover type within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	5.00	4.11	-2.51-12.5	0
4.061	6.56	5.64	-1.90-15.0	0
4.081	10.0	11.3	-0.33-20.3	0
4.100	1.64	10.2	-2.70-5.98	0
4.120	3.33	4.10	-2.85-9.51	0
4.161	9.84	9.34	-0.33-20.0	0
4.181	4.08	8.20	-1.17-17.6	0
4.232	6.78	6.86	-1.95-15.5	0
4.251	1.69	2.90	-2.79-6.17	0
4.271	8.47	6.13	-1.20-18.1	0
4.291	10.0	6.86	-0.33-20.3	0
4.311	8.33	7.53	-1.19-17.9	0
4.330	9.68	4.03	-0.34-19.7	0
4.370	0.00	2.56	0.00-0.00	0
4.390	3.33	2.75	-2.85-9.51	0
4.421	4.92	3.34	-2.47-12.31	0
4.532	18.3	20.3	5.00-31.7	0
4.551	5.00	5.80	-2.51-12.5	0
4.631	1.69	3.86	-2.79-6.17	0
4.651	3.33	4.20	-2.85-9.51	0
5.091	1.67	3.77	-2.74-6.08	0
4.591	5.00	3.38	-2.51-12.5	0
5.071	0.00	2.38	0.00-0.00	0
4.681	1.64	3.05	-2.70-5.98	0
5.052	16.7	16.9	3.83-29.5	0
5.031	6.67	3.92	-1.92-15.3	0
5.061	8.20	5.47	-1.17-17.6	0
4.611	5.00	6.12	-2.51-12.5	0
5.100	1.67	6.00	-2.74-6.08	0
5.041	8.33	3.58	-1.19-17.9	0
$\bar{x}$	6.00	6.15	-1.39-13.5	
SD	4.41	4.11	1.86 7.46	

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 3. Use, availability and selection[a] of pole/small saw vegetative cover type within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	4.02	37.0	31.1-65.5	0
4.061	34.4	38.9	18.2-50.7	0
4.081	45.0	40.5	27.9-62.1	0
4.100	44.3	34.4	27.3-61.2	0
4.120	38.3	45.5	21.6-55.1	0
4.161	23.0	21.0	8.59-37.3	0
4.181	49.2	38.9	32.1-66.3	0
4.232	20.3	21.5	6.36-34.0	0
4.251	32.2	23.3	16.0-48.4	0
4.271	15.3	20.5	2.76-27.7	0
4.291	43.3	30.1	26.3-60.4	0
4.311	35.0	36.0	18.6-51.4	0
4.330	29.0	30.2	13.7-44.4	0
4.370	45.9	43.4	28.9-62.9	0
4.390	30.0	30.9	14.2-45.8	0
4.421	24.6	25.1	9.88-39.3	0
4.532	8.33	6.91	-1.19-17.9	0
4.551	25.0	25.8	10.1-39.9	0
4.631	22.0	26.5	7.63-36.4	0
4.651	21.7	25.1	7.48-35.9	0
5.091	31.7	31.5	15.7-47.7	0
4.591	33.3	34.3	17.1-49.6	0
5.071	23.3	20.7	8.76-37.9	0
4.681	23.0	20.4	8.59-37.3	0
5.052	36.7	37.1	20.1-53.3	0
5.031	25.0	24.8	10.1-39.9	0
5.061	29.5	37.0	13.9-45.1	0
4.611	53.3	27.2	36.2-70.5	+
5.100	28.3	28.4	12.8-43.9	0
5.041	38.3	45.5	21.6-55.1	0
$\bar{x}$	31.9	30.2	16.4-47.4	
SD	10.8	8.84	7.89 12.3	

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[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 4. Use, availablity and selection[a] of large saw/mature vegetative cover type within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	10.0	15.7	-0.33-20.3	0
4.061	4.92	9.65	-2.47-12.3	0
4.081	8.33	9.76	-1.19-17.9	0
4.100	16.4	20.9	3.74-29.0	0
4.120	10.0	9.19	-0.33-20.3	0
4.161	9.84	13.2	-0.33-20.0	0
4.181	6.56	6.12	-1.90-15.0	0
4.232	13.6	13.0	1.67-25.5	0
4.251	8.47	12.3	-1.20-18.4	0
4.271	11.9	11.3	-0.63-23.1	0
4.291	13.3	16.6	1.62-25.0	0
4.311	11.7	18.2	0.61-22.7	0
4.330	24.2	24.6	9.68-38.7	0
4.370	18.0	11.0	4.90-31.2	0
4.390	20.0	24.6	6.22-33.8	0
4.421	24.6	26.4	9.88-39.3	0
4.532	5.00	7.40	-2.51-12.5	0
4.551	13.3	24.0	1.62-25.0	0
4.631	25.4	22.9	10.3-40.5	0
4.651	16.7	23.4	3.83-29.5	0
5.091	13.3	17.9	1.62-25.0	0
4.591	13.3	17.0	1.62-25.0	0
5.071	10.0	12.0	17.1-49.6	0
4.681	9.84	12.8	-0.33-20.0	0
5.052	16.7	19.5	3.83-29.5	0
5.031	21.7	24.7	7.48-35.9	0
5.061	23.0	17.9	8.59-37.3	0
4.611	10.0	19.5	-0.33-20.3	0
5.100	21.7	16.1	7.48-35.9	0
5.041	20.0	21.1	6.22-33.8	0
$\bar{x}$	14.4	16.6	3.22 27.3	
SD	6.00	5.80	4.71 9.1	

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 5. Use, availability and selection[a] of old-growth vegetative cover type within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	20.0	15.2	6.22-33.8	0
4.061	11.5	11.3	0.59-22.4	0
4.081	11.7	10.7	0.61-22.7	0
4.100	11.5	11.3	0.59-22.4	0
4.120	5.00	6.71	-2.51-12.5	0
4.161	11.5	17.5	-1.90-15.0	0
4.181	6.56	6.12	-1.90-15.0	0
4.232	23.7	29.6	8.95-38.5	0
4.251	27.1	29.6	11.7-42.6	0
4.271	20.3	33.8	6.36-34.3	0
4.291	0.33	11.9	-2.85-9.51	0
4.311	21.7	17.0	7.48-35.9	0
4.330	12.9	8.76	1.54-24.3	0
4.370	6.56	5.94	-1.90-15.0	0
4.390	15.0	16.5	2.70-27.3	0
4.421	6.56	13.5	-1.90-15.0	0
4.532	10.0	16.0	-0.33-20.3	0
4.551	23.3	17.8	8.76-37.9	0
4.631	13.6	12.7	1.67-25.5	0
4.651	20.0	12.7	6.22-33.8	0
5.091	30.0	18.5	14.2-45.5	0
4.591	18.3	19.3	5.00-31.7	0
5.071	33.3	28.9	17.1-49.6	0
4.681	21.3	24.8	7.32-35.3	0
5.052	6.67	10.2	-1.92-15.3	0
5.031	33.3	20.9	17.1-49.6	0
5.061	16.4	15.0	3.74-29.0	0
4.611	10.0	15.2	-0.33-20.3	0
5.100	21.7	16.1	7.48-35.9	0
5.041	10.0	14.1	-0.33-20.3	0
$\bar{x}$	16.0	16.3	4.03-27.9	
SD	8.52	7.12	5.75 11.3	

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[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 6. Use, availability and selection[a] of hardwoods vegetative cover type within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	3.33	8.91	-2.85-9.51	0
4.061	4.92	7.32	-2.47-12.3	0
4.081	3.33	7.39	-2.85-9.51	0
4.100	8.20	4.72	-1.17-17.6	0
4.120	1.67	1.66	-2.74-6.08	0
4.161	0.00	2.55	0.00-0.00	0
4.181	3.28	4.55	-2.80-9.36	0
4.232	1.69	3.33	-2.79-6.17	0
4.251	6.78	2.70	-1.95-15.5	0
4.271	3.39	2.99	-2.90-9.68	0
4.291	3.33	2.83	-2.85-9.51	0
4.311	5.00	6.13	-2.51-12.5	0
4.330	1.61	1.98	-2.65-5.87	0
4.370	1.64	1.80	-2.70-5.98	0
4.390	5.00	3.63	-2.51-12.5	0
4.421	9.84	4.04	-0.33-20.0	0
4.532	0.00	3.03	0.00-0.00	0
4.551	3.33	1.20	-2.85-9.51	0
4.631	3.39	4.79	-2.90-9.68	0
4.651	0.00	6.29	0.00-0.00	0
5.091	3.33	9.46	-2.85-9.51	0
4.591	5.00	9.71	-2.51-12.5	0
5.071	1.67	3.85	-2.74-6.08	0
4.681	6.56	2.95	-1.90-15.0	0
5.052	13.3	6.76	1.62-25.0	0
5.031	5.00	7.45	-2.51-12.5	0
5.061	9.84	6.36	-0.33-20.0	0
4.611	0.00	1.33	0.00-0.00	-
5.100	0.00	1.45	0.00-0.00	0
5.041	3.33	1.08	-2.85-9.51	0
$\bar{x}$	3.93	4.41	-1.86-9.71	
SD	3.23	2.58	1.30 6.29	

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[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 7. Use, availability, and selection[a] of vegetative types by 16 elk associated with Road Management Areas during the winter season (January-February) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 128) and 1993-94 (this study) (n = 163).

Vegetation Type	% Use	% Avaiable	95% C.I.	Selection [b]
		1991-92		
grass/forb	0.00	10.6	0.00-0.00	0
shrub	17.9	16.6	-1.79-37.5	0
open sapling	3.57	5.32	-5.95-13.1	0
pole/small saw	42.9	30.1	17.5-68.3	0
large saw/mature	10.7	17.5	-5.16-26.6	0
old growth	17.9	13.0	-1.79-37.5	0
hardwoods	7.14	6.98	-6.07-20.4	0
		1993-94		
grass/forb	21.3	14.9	12.7-30.0	0
shrub	19.5	15.6	11.1-27.9	0
open sapling	9.76	5.16	3.47-16.1	0
pole/small saw	27.4	30.9	18.0-36.9	0
large saw/mature	6.71	17.0	1.41-12.0	-
old growth	11.0	13.6	4.35-17.6	0
hardwoods	4.27	2.90	-0.02-8.56	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 8. Use, availability and selection[a] of vegetative types by all 16 elk associated with Road Management Areas during the spring season (March-April) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 182) and 1993-94 (this study) (189).

Vegetation Type	% Use	% Available	95% C.I.	Selection [b]
		1991-92		
grass/forb	8.11	10.6	2.66-13.6	0
shrub	14.6	16.6	7.54-21.6	0
open sapling	9.73	5.32	3.81-15.6	0
pole/small saw	30.3	30.1	21.1-39.4	0
large saw/mature	20.0	17.5	12.0-28.0	0
old growth	12.4	13.0	5.84-19.0	0
hardwoods	4.86	6.98	0.57-9.15	0
		1993-94		
grass/forb	13.1	14.9	6.46-19.7	0
shrub	20.9	15.6	13.0-28.9	0
open sapling	6.81	5.16	1.86-11.8	0
pole/small saw	27.8	30.9	19.0-36.6	0
large saw/mature	19.9	17.0	12.1-27.7	0
old growth	9.42	13.6	3.68-15.2	0
hardwoods	2.09	2.90	-0.72-4.90	0

[a] (-less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 9. Use, availability and selection[a] of vegetative types by 16 elk associated with Road Management Areas during the calving season (May-June) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 186) and 1993-94 (this study) (n = 153).

Vegetation Type	% Use	% Available	95% C.I.	Selection [b]
		1991-92		
grass/forb	11.2	10.6	4.93-17.4	0
shrub	19.2	16.6	11.4-26.9	0
open sapling	2.66	5.32	-0.53-5.85	0
pole/small saw	33.5	30.1	24.1-42.9	0
large saw/mature	14.4	17.5	7.42-21.3	0
old growth	16.0	13.0	8.71-23.2	0
hardwoods	3.19	6.98	-0.29-6.67	0
		1993-94		
grass/forb	18.8	14.9	10.3-27.4	0
shrub	18.8	15.6	10.3-27.4	0
open sapling	4.55	5.16	-0.01-9.11	0
pole/small saw	31.2	30.9	21.0-41.3	0
large saw/mature	9.74	17.0	3.25-16.2	0
old growth	13.6	13.6	6.13-21.2	0
hardwoods	3.25	2.90	-0.63-7.13	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 10. Use, availability and selection[a] of vegetative types by 16 elk associated with Road Management Areas during the summer season (July-August) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 260) and 1993-94 (this study) (n = 215).

Vegetation Type	% Use	% Available	95% C.I.	Selection [b]
		1991-92		
grass/forb	9.23	10.6	4.36-14.1	0
shrub	17.3	16.6	10.9-23.7	0
open sapling	4.23	5.32	0.84-7.62	0
pole/small saw	26.9	30.1	19.5-34.4	0
large saw/mature	17.3	17.5	11.0-23.7	0
old growth	21.5	13.0	14.6-28.5	+
hardwoods	3.46	6.98	0.38-6.54	-
		1993-94		
grass/forb	18.1	14.9	11.0-25.2	0
shrub	16.7	15.6	9.78-23.6	0
open sapling	6.94	5.16	19.1-35.5	0
pole/small saw	27.3	30.9	19.1-35.5	0
large saw/mature	11.6	17.0	5.66-17.5	0
old growth	17.6	13.6	10.6-24.6	0
hardwoods	1.85	2.90	-0.64-4.34	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 11. Use, availability and selection[a] of vegetative types by all 16 elk associated with Road Management Areas during the rut season (September-October) in the southern Oregon Coast Range in 1991-92 (Pope 1994) ($n = 117$) and 1993-94 (this study) ($n = 107$).

Vegetation Type	% Use	% Avail.	95% C.I.	Selection [b]
		1991-92		
grass/forb	9.32	10.6	2.05-16.6	0
shrub	5.93	16.6	0.03-11.8	-
open sapling	4.24	5.32	-0.80-9.28	0
pole/small saw	35.6	30.1	23.6-47.6	0
large saw/mature	21.2	17.5	11.0-31.4	0
old growth	19.5	13.0	9.59-29.4	0
hardwoods	4.24	6.98	-0.80-9.28	0
		1993-94		
grass/forb	7.34	14.9	0.56-14.1	0
shrub	19.3	15.6	9.01-29.5	0
open sapling	1.83	5.16	-1.66-5.32	0
pole/small saw	33.9	30.9	21.6-46.3	0
large saw/mature	17.4	17.0	7.56-27.3	0
old growth	13.8	13.6	4.80-22.7	0
hardwoods	6.42	2.90	0.05-12.8	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 12. Use, availability and selection[a] of vegetative types by 16 elk associated with Road Management Areas during the fall season (November-December) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 138) and 1993-94 (this study) (n = 126).

Vegetation Type	% Use	% Available	95% C.I.	Selection [b]
		1991-92		
grass/forb	3.12	10.7	-1.63-7.63	-
shrub	12.6	16.6	3.18-20.8	0
open sapling	8.33	5.33	0.63-15.4	0
pole/small saw	33.0	29.9	20.2-45.8	0
large saw/mature	29.1	17.5	16.7-41.3	0
old growth	11.1	13.0	2.51-19.5	0
hardwoods	4.42	6.99	-0.132-9.32	0
		1993-94		
grass/forb	7.81	14.9	1.37-14.3	0
shrub	15.6	15.6	6.91-24.3	0
open sapling	7.03	5.16	0.90-13.2	0
pole/small saw	26.6	30.9	16.0-37.2	0
large saw/mature	22.7	17.0	12.6-32.7	0
old growth	18.0	13.6	8.76-27.2	0
hardwoods	2.34	2.90	-1.29-5.97	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

APPENDIX A

Table 13. Use, availability, and selection[a] of vegetative types by 16 elk associated with Road Management Areas during the high traffic season (August-December) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 331) and 1993-94 (this study) (n = 342).

Vegetation Type	% Use	% Available	95% C.I.	Selection [b]
		1991-92		
grass/forb	6.02	10.7	2.48-9.56	-
shrub	11.1	16.6	6.45-15.8	-
open sapling	6.02	5.33	2.48-9.56	0
pole/small saw	34.3	29.9	27.3-41.4	0
large saw/mature	20.8	17.5	14.7-26.8	0
old growth	17.5	13.0	11.8-23.1	0
hardwoods	4.22	6.99	1.22-7.22	0
		1993-94		
grass/forb	10.9	14.9	6.38-15.46	0
shrub	17.0	15.6	11.5-22.4	0
open sapling	4.60	5.16	1.55-7.65	0
pole/small saw	29.9	30.9	23.2-36.6	0
large saw/mature	18.1	17.0	12.5-23.7	0
old growth	16.1	13.6	10.7-21.4	0
hardwoods	3.45	2.90	0.79-6.11	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

APPENDIX A

Table 14. Use, availability, and selection[a] of vegetative types by 16 elk associated with Road Management Areas during the low traffic season (January-July) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 684) and 1993-94 (this study) (n = 600).

Vegetation Type	% Use	% Available	95% C.I.	Selection[b]
		1991-92		
grass/forb	10.6	10.7	7.42-13.8	0
shrub	16.7	16.6	12.9-20.6	0
open sapling	5.52	5.33	3.16-7.88	0
pole/small saw	29.1	29.9	24.4-33.8	0
large saw/mature	17.4	17.5	13.5-21.4	0
old growth	15.8	13.0	12.1-19.6	0
hardwoods	4.80	6.99	2.59-7.01	0
		1993-94		
grass/forb	17.6	14.9	13.4-21.8	0
shrub	19.4	15.6	15.1-23.8	0
open sapling	7.48	5.16	4.57-10.4	0
pole/small saw	28.1	30.9	23.1-33.0	0
large saw/mature	12.1	17.0	8.52-15.7	-
old growth	12.5	13.6	8.81-16.1	0
hardwoods	2.82	2.90	0.99-4.65	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 15. Use, availability and selection[a] of vegetative types by 4 elk not associated with Road Management Areas in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 257) and 1993-94 (this study) (n = 239).

Vegetation Type	% Use	% Available	95% C.I.	Selection[b]
		1991-92		
grass/forb	3.50	8.51	0.39-6.61	0
shrub	14.0	11.0	8.13-19.9	0
open sapling	3.89	4.34	0.62-7.16	0
pole/small saw	41.6	37.7	33.3-50.0	0
large saw/mature	16.3	17.1	10.1-22.6	0
old growth	14.8	15.3	8.78-20.8	0
hardwoods	5.84	6.04	1.87-9.81	0
		1993-94		
grass/forb	7.02	8.71	2.56-11.5	0
shrub	12.0	11.6	6.31-17.7	0
open sapling	5.79	4.22	1.71-9.87	0
pole/small saw	44.2	37.9	35.5-52.9	0
large saw/mature	11.2	17.2	5.66-16.7	0
old growth	14.9	13.5	8.67-21.1	0
hardwoods	4.96	6.94	1.17-8.75	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-sqaure and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

APPENDIX B

Table 16. Use, availability, and selection[a] of road distances by 16 elk associated with Road Management Areas during the fall season (November-December) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 138) and 1993-94 (this study)(n = 126).

Road Class (m)	% Use	% Available	95% C.I.	Selection[b]
		<u>1991-92</u>		
0-150	37.7	49.7	28.3-47.0	-
>150	62.3	50.3	53.0-71.7	+
		<u>1993-94</u>		
0-150	38.1	48.7	28.3-47.9	-
>150	61.9	51.3	52.1-71.7	+

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 17. Use, availability, and selection[a] of road distances by 16 elk associated with Road Management Areas during the spring season (March-April) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 182) and 1993-94 (this study)(n = 189).

Road Class (m)	% Use	% Available	95% C.I.	Selection[b]
		1991-92		
0-150	35.7	49.7	27.7-43.8	-
>150	64.3	50.3	56.3-72.3	+
		1993-94		
0-150	42.3	48.7	43.2-50.5	0
>150	57.7	51.3	49.5-65.8	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 18. Use, availability, and selection[a] of road distances by 16 elk associated with Road Management Areas during the calving season (May-June) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 186) and 1993-94 (this study) (n = 153).

Road Class (m)	Percent Use	Percent Avail.	95% C.I.	Selection[b]
		1991-92		
0-150	36.6	49.7	28.6-44.6	-
>150	63.4	50.3	55.4-71.4	+
		1993-94		
0-150	45.8	48.7	36.6-54.9	0
>150	54.3	51.3	45.1-63.4	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 19. Use, availability, and selection[a] of road distances by 16 elk associated with Road Management Areas during the summer season (July-August) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 260) and 1993-94 (this study) (n = 215).

Road Class (m)	% Use	% Available	95% C.I.	Selection[b]
		1991-92		
0-150	33.9	49.7	27.2-40.5	-
>150	66.2	50.3	59.5-72.8	+
		1993-94		
0-150	44.7	48.7	37.0-52.3	0
>150	55.4	51.3	47.7-63.0	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 20. Use, availability, and selection[a] of road distances by 16 elk associated with Road Management Areas during the rut season (September-October) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 117) and 1993-94 (this study) (n = 107).

Road Class (m)	% Use	% Available	95% C.I.	Selection[b]
		1991-92		
0-150	32.5	49.8	22.7-49.3	-
>150	67.5	50.3	57.7-77.3	+
		1993-94		
0-150	43.0	48.7	32.2-53.8	0
>150	57.0	51.3	46.2-67.9	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 21. Use, availability, and selection[a] of road distances by 16 elk associated with Road Management Areas during the winter season (January-February) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 128) and 1993-94 (this study) (n = 163).

Road Class (m)	% Use	% Available	95% C.I.	Selection[b]
		1991-92		
0-150	42.2	49.7	32.3-52.1	0
>150	57.8	50.3	47.9-67.7	0
		1993-94		
0-150	41.7	48.7	33.0-50.5	0
>150	58.3	51.3	49.5-67.0	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 22. Use, availability and selection[a] of areas 0-150 m from streams within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	65.0	45.3	49.5-80.6	+
4.061	34.4	31.1	23.5-55.1	0
4.081	13.3	25.6	2.25-24.4	0
4.100	29.5	30.2	14.8-44.3	0
4.120	48.3	26.1	31.7-64.9	+
4.161	21.3	25.4	8.07-34.6	0
4.181	28.3	28.9	13.6-43.0	0
4.232	13.6	19.6	2.30-24.8	0
4.251	32.2	21.8	16.8-47.6	0
4.271	11.9	19.6	1.23-22.5	0
4.291	26.7	18.3	12.3-41.1	0
4.311	16.7	17.5	4.52-28.8	0
4.330	29.0	20.6	14.5-43.6	0
4.370	23.3	22.1	9.54-37.1	0
4.390	13.3	22.8	2.25-24.4	0
4.421	19.7	20.4	6.81-32.5	0
4.532	31.7	24.9	16.5-46.8	0
4.551	45.8	28.0	29.4-62.1	+
4.631	31.0	24.9	15.7-46.4	0
4.651	40.7	28.6	24.5-56.8	0
5.091	35.0	19.6	19.5-50.6	0
4.591	33.3	19.7	18.0-48.7	0
5.071	26.7	29.2	12.3-41.1	0
4.681	25.0	26.5	10.9-39.1	0
5.081	48.3	22.1	32.0-64.6	+
5.052	31.7	24.6	16.5-46.8	0
5.031	51.7	35.7	35.4-68.0	0
5.061	24.6	24.8	10..7-38.5	0
4.611	17.0	21.6	4.61-29.3	0
5.100	36.7	20.4	21.0-52.4	+
5.041	43.3	23.1	27.2-59.5	+
$\bar{x}$	30.6	24.7	16.4-45.2	
SD	12.7	5.87	11.3 14.3	

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 23. Use, availability and selection[a] of areas 151-300 m from streams within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	23.3	37.0	9.54-37.1	0
4.061	39.3	25.6	23.5-55.1	0
4.081	13.3	25.6	2.25-24.4	0
4.100	34.4	30.3	19.1-49.8	0
4.120	19.0	21.2	5.97-32.0	0
4.161	24.6	22.9	10.7-38.5	0
4.181	21.7	25.4	8.23-35.1	0
4.232	28.8	20.0	13.9-43.7	0
4.251	27.1	22.1	12.5-41.7	0
4.271	28.8	20.7	13.9-43.7	0
4.291	13.3	18.2	2.25-24.4	0
4.311	13.3	19.8	2.25-24.4	0
4.330	19.4	21.3	6.68-32.0	0
4.370	21.7	23.2	8.23-35.1	0
4.390	16.7	19.1	4.52-28.8	0
4.421	8.20	18.2	-0.67-17.1	-
4.532	21.7	23.4	8.23-35.1	0
4.551	28.8	28.4	13.9-43.7	0
4.631	25.9	24.2	11.3-40.4	0
4.651	17.0	25.1	4.61-29.3	0
5.091	25.0	18.8	10.9-39.1	0
4.591	16.7	18.1	4.52-28.8	0
5.071	16.7	24.7	4.52-28.8	0
4.681	28.3	25.3	13.6-43.0	0
5.081	16.7	24.3	4.52-28.8	0
5.052	13.3	19.5	2.25-24.4	0
5.031	21.7	31.6	8.23-35.1	0
5.061	32.8	29.8	17.6-48.0	0
4.611	23.7	20.1	9.74-37.7	0
5.100	25.0	23.3	10.9-39.1	0
5.041	18.3	22.3	5.71-31.0	0
$\bar{x}$	21.8	23.5	8.82-35.4	
SD	7.08	4.40	5.51 8.64	

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[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 24. Use, availability and selection[a] of areas 301-450 m from streams within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	6.67	13.9	-1.47-14.8	0
4.061	11.5	17.1	1.17-21.8	0
4.081	25.0	22.2	10.9-39.1	0
4.100	18.0	23.3	5.50-30.5	0
4.120	17.2	18.8	4.71-29.8	0
4.161	21.3	19.2	8.07-34.6	0
4.181	21.7	21.1	8.23-35.1	0
4.232	11.9	17.0	1.23-22.5	0
4.251	18.6	21.4	5.83-31.5	0
4.271	20.3	20.7	7.10-33.6	0
4.291	18.3	19.3	5.71-31.0	0
4.311	25.0	20.9	10.9-39.1	0
4.330	22.6	20.1	9.17-36.0	0
4.370	23.3	21.1	9.54-37.1	0
4.390	26.7	15.9	12.3-41.1	0
4.421	34.4	14.4	19.1-49.8	+
4.532	11.7	18.7	1.20-22.1	0
4.551	13.6	23.4	2.30-24.8	0
4.631	19.0	23.5	5.97-32.0	0
4.651	20.3	21.4	7.10-33.6	0
5.091	18.3	17.6	5.71-31.0	0
4.591	13.3	17.5	2.25-24.4	0
5.071	20.0	18.5	6.96-33.0	0
4.681	20.0	24.1	6.96-33.0	0
5.081	11.7	22.0	1.20-22.1	0
5.052	18.3	15.2	5.71-31.0	0
5.031	11.7	18.0	1.20-22.1	0
5.061	9.84	10.8	0.21-19.5	0
4.611	18.7	18.6	5.83-31.5	0
5.100	20.0	23.6	6.96-33.0	0
5.041	15.0	21.4	3.36-26.6	0
$\bar{x}$	18.2	19.4	5.84 -30.6	
SD	5.73	3.19	4.22 9.32	

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[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 25. Use, availability and selection[a] of areas greater than 450 m from streams within home ranges of individual elk in the southern Oregon Coast Range (1993-94).

Elk No.	% Use	% Available	95% C.I.	Selection[b]
4.022	5.00	3.78	-2.11-12.1	0
4.061	14.8	26.2	3.28-26.2	0
4.081	18.3	18.7	5.71-31.0	0
4.100	18.0	16.2	5.60-30.5	0
4.120	15.5	34.0	3.51-27.5	-
4.161	32.8	32.5	17.6-48.0	0
4.181	28.3	24.6	13.6-43.0	0
4.232	45.8	43.5	29.4-62.1	0
4.251	22.0	34.7	8.40-35.7	0
4.271	39.0	38.9	23.0-55.0	0
4.291	41.7	44.1	25.6-57.8	0
4.311	45.0	41.9	28.8-61.2	0
4.330	29.0	38.1	14.5-43.6	0
4.370	31.7	33.6	16.5-46.8	0
4.390	43.3	42.3	27.2-59.5	0
4.421	37.7	47.0	22.0-53.4	0
4.532	35.0	33.0	19.5-50.6	0
4.551	11.9	20.2	1.23-22.5	0
4.631	24.1	27.5	9.95-38.3	0
4.651	22.0	24.9	8.40-35.7	0
5.091	21.7	43.9	8.23-35.1	-
4.591	36.7	44.8	21.0-52.4	0
5.071	36.7	27.7	21.0-52.4	0
4.681	26.7	24.1	12.3-41.1	0
5.081	23.3	31.6	9.54-37.1	0
5.052	36.7	40.8	21.0-52.4	0
5.031	15.0	14.7	3.36-26.6	0
5.061	32.8	34.6	17.6-48.0	0
4.611	40.7	39.7	24.5-56.8	0
5.100	18.3	32.8	5.71-31.0	-
5.041	23.3	33.2	9.54-37.1	0
$\bar{x}$	28.2	32.1	14.1-42.3	
SD	11.0	10.3	8.86 12.8	

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 26. Use, availability, and selection[a] of stream distances by 16 elk associated with Road Management Areas during the winter season (January-February) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 128) and 1993-94 (this study) (n = 163).

Stream class (m)	% Use	% Available	95% C.I..	Selection[b]
		1991-92		
0-150	37.0	23.5	26.0-48.1	+
151-300	18.1	22.1	9.31-26.9	0
301-450	14.2	19.4	6.20-22.1	0
451-600	10.2	15.7	3.31-17.2	0
>600	20.5	19.3	11.3-29.7	0
		1993-94		
0-150	18.0	23.4	10.2-25.8	0
151-300	27.3	22.2	18.3-36.4	0
301-450	28.0	19.8	18.8-37.1	0
451-600	16.8	15.9	9.19-24.4	0
>600	9.94	18.7	3.87-16.0	-

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 27. Use, availability, and selection[a] of stream distances by 16 elk associated with Road Management Areas during the spring season (March-April) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 182) and 1993-94 (this study) (n = 189).

Stream class (m)	% Use	% Avaiable	95% C.I..	Selection[b]
		1991-92		
0-150	32.8	23.5	23.9-41.7	+
151-300	20.8	22.1	13.1-28.5	0
301-450	13.7	19.4	7.12-20.2	0
451-600	12.6	15.7	6.26-18.9	0
>600	20.2	19.3	12.6-27.9	0
		1993-94		
0-150	37.7	23.4	28.7-46.7	+
151-300	22.0	22.2	14.3-29.7	0
301-450	14.1	19.8	7.65-20.6	0
451-600	17.3	15.9	10.2-24.3	0
>600	8.9	18.7	3.59-14.2	-

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

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Table 28. Use, availability, and selection[a] of stream distances by 16 elk associated with Road Management Areas during the calving season (May-June) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 186) and 1993-94 (this study) (n = 153).

Stream class (m)	% Use	% Available	95% C.I..	Selection[b]
		1991-92		
0-150	32.8	23.5	23.9-41.7	+
151-300	19.4	22.1	11.9-26.8	0
301-450	13.4	19.4	7.00-19.9	0
451-600	16.1	15.7	9.18-23.1	0
>600	18.3	19.3	11.0-25.6	0
		1993-94		
0-150	31.2	23.4	21.6-40.8	0
151-300	18.2	22.2	10.2-26.2	0
301-450	25.3	19.8	16.3-34.4	0
451-600	11.7	15.9	5.02-18.4	0
>600	13.7	18.7	6.52-20.8	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

APPENDIX C

Table 29. Use, availability and selection[a] of stream distance classes by 16 elk associated with Road Management Areas during the summer season (July-August) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 260)and 1993-94 (this study) (n = 215).

Stream Class (m)	% Use	% Avaiable	95% C.I..	Selection[b]
		1991-92		
0-150	33.3	23.5	25.8-40.9	+
151-300	20.5	22.1	14.1-27.0	0
301-450	16.7	19.4	10.7-22.7	0
451-600	12.4	15.7	7.11-17.7	0
>600	17.1	19.3	11.0-23.1	0
		1993-94		
0-150	30.7	23.4	22.6-38.8	0
151-300	19.1	22.2	12.2-26.0	0
301-450	17.7	19.8	11.0-24.4	0
451-600	15.4	15.9	9.02-21.7	0
>600	17.2	18.7	11.0-23.8	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).

APPENDIX C

Table 30. Use, availability and selection[a] of stream distance classes by 16 elk associated with Road Management Areas during the rut season (September-October) in the southern Oregon Coast Range in 1991-92 (Pope 1994) (n = 117) and 1993-94 (this study) (n = 107).

Stream class (m)	% Use	% Available	95% C.I..	Selection[b]
		1991-92		
0-150	35.0	23.5	23.7-46.4	+
151-300	26.5	22.1	16.0-37.0	0
301-450	15.4	19.4	6.79-24.0	0
451-600	11.1	15.7	3.63-18.6	0
>600	12.0	19.3	4.24-19.7	0
		1993-94		
0-150	29.4	23.4	18.1-40.6	0
151-300	21.1	22.2	11.0-31.2	0
301-450	16.5	19.8	7.35-25.7	0
451-600	18.4	15.9	8.80-27.9	0
>600	14.7	18.7	5.95-23.4	0

[a] (- less than expected, 0 equal to expected, + more than expected).

[b] Selection based on Pearson chi-square and Bonferoni z-statistic (Neu et al. 1974, Byers et al. 1984).