AN ABSTRACT OF THE THESIS OF

Bret L. Michalski for the degree of Master of Science in Wildlife Science presented on

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Redacted for Privacy

Abstract approved: ______________________

W. Daniel Edge

A wildfire burned over 40,000 ha of conifer and mixed conifer-hardwood forest in the Silver Creek drainage of southwestern Oregon in the fall of 1987 allowing me to assess big game use of a large natural burn. I used fecal pellet group counts to estimate habitat use and effects of forest management activities on Roosevelt elk (*Cervus elaphus roosevelti*) and black-tailed deer (*Odocoileus hemionus columbianus*) within the Silver Fire Recovery Project Area (SFRPA) of the Siskiyou National Forest. Pellet decay rate and differences in observers' abilities to detect deer and elk pellet groups (interobserver variability) were estimated to test validity of pellet group counts. Pellet group persistence was estimated during a 10-month period. There were no differences in pellet group persistence between elk and deer ($P < 0.05$). Observers differed in ability to detect elk ($F = 2.7$; df = 4, 530; $P = 0.03$) and deer ($F = 10.7$; df = 4, 883; $P < 0.0001$) pellet groups. Interobserver variability related to elk pellet groups was low and was attributed to differences in numbers of transects searched by each observer. Two observers

detected greater mean numbers of deer pellet groups than did other observers. I counted 775 elk pellet groups and 3,888 deer pellet groups on four study areas within the SFRPA. I analyzed habitat use for two periods: June to mid-October (summer-fall), and mid-October through May (fall-spring). I used stepwise logistic regression to create models predicting categories of habitat use during each period. Management variables were added to the habitat models to estimate effect of management on predicted categories of habitat use. Total overstory canopy cover was negatively related to deer use during both use periods. Distance to road was the only significant management variable affecting deer habitat use during the fall-spring period ($P = 0.03$). Slash cover had a negative effect on probability of habitat use by deer during the summer-fall period ($P = 0.02$). Elk use was negatively affected by steep slopes and hardwood canopies during both periods, while grass seeding positively affected elk use during both summer-fall ($P = 0.05$) and fall-spring ($P = 0.03$) use periods. Clearcutting had a negative effect on probability of elk use during the fall-spring period ($P = 0.04$).

Factors Affecting Habitat Use by Black-tailed Deer and Roosevelt Elk in the Silver Burn, Southwestern Oregon

by

Bret L. Michalski

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Through many, many kilometers of unbelievably steep slopes and fire hardened brush, through jack-strawed timber, searing heat, hornets, and rattlesnakes, there were many times when I doubted my ability to complete this project. However, much of a person's strength comes from the people behind him, and I was fortunate enough to have many good people behind me.

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Finally and foremost, I wish to thank my parents, Suzan and David Ehreth, for fostering my dreams of becoming a wildlife biologist, and for always believing in me just a little bit more than I did. Thanks Mom and Dad........

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CHAPTER 1
INTRODUCTION

Wildfire has shaped temperate-region forest and grassland habitats for millions of years. This is particularly true in the Siskiyou Province of southern Oregon and northern California, where fire has greatly influenced the mosaic of habitat types and stand ages (Agee 1990, 1991). However, frequency of natural fires in the Siskiyous has been altered by human activities. Relatively frequent fires of moderate intensity have been replaced by infrequent high-intensity fires that may replace all or part of large forest stands (Agee 1991).

In August 1987, a wildfire ignited by lightning in the Silver Creek drainage on the Siskiyou National Forest (SNF) near Grants Pass, Oregon, burned nearly 40,000 ha of old-growth Douglas-fir (*Pseudotsuga menziesii*) and mixed conifer-hardwood forest. Extensive salvage logging was conducted following the fire. New roads were constructed and more than 2,600 ha were seeded with grasses to control erosion. Habitat use and distribution of ungulates within the burn may have been affected by these activities. Roads reduce habitat effectiveness for Rocky Mountain elk (*Cervus elaphus nelsoni*) (Perry and Overly 1976, Lyon 1979, Rost and Bailey 1979), and to a lesser extent Roosevelt elk (*C. e. roosevelti*) and mule deer (*Odocoileus hemionus hemionus*) (Rost and Bailey 1979, Thomas et al. 1979, Witmer and deCalesta 1985). Grass seeding and logging may change the availability and distribution of forage and cover.

Before the fire, Roosevelt elk were restricted to the area near Fish Hook Peak and Indigo Creek (Fig. 1), but in January 1991, 82 elk were introduced into the burn at two locations. Concerns regarding the effects of management activities on elk, both resident and introduced, and black-tailed deer (*O. h. columbianus*), led to the Silver Fire Project (SFP). The project formed as a cooperative effort between Oregon State University, SNF, and the Oregon Department of Fish and Wildlife (ODFW). The Rocky Mountain Elk Foundation provided additional funding.

My objectives were to document habitat use by elk and deer in the variety of habitats created by the fire, and to investigate the effect of management activities on habitat use. Specifically, I investigated the effect of roads, timber harvest, aerial seeding, slash cover, and distance to forest edge on habitat use by deer and elk. Proximity of forest edge influences habitat use by cervids in forest stands interspersed with clearcuts (Reynolds 1966, Hanley 1983), but the effect of distance to edge in large natural openings is unknown. Determining the relationship between distance to forest edge and habitat use was another primary objective of this project. I predicted that habitat use by deer and elk would:

1. increase as distance from roads increased,
2. increase as distance from forest edge increased,
3. be greater for elk in areas that had been aerially seeded, and
4. decrease with increasing slash cover.

Evaluating factors affecting the utility of the pellet group technique as a measure of habitat use was a secondary objective of the SFP. These factors include pellet decay rate and interobserver variability. If many pellet groups decay between collection periods, estimates of habitat use will be biased. Interobserver variability is defined as the variation between at least two observers searching the same plot or transect for pellet groups. Observers may have inherently different abilities to detect pellet groups (Neff 1968, Scott 1976), and if this difference is great it may bias estimates of habitat use. The magnitude of the SFP necessitated the use of multiple volunteers, requiring that I quantify interobserver variability. This estimate of variability would help define response categories reflecting levels of habitat use.

CHAPTER 2
STUDY AREA

The SFP was conducted within the boundaries of the SFRPA (Fig. 1). The area encompassed 17,000 ha of the Silver Burn north of the Kalmiopsis Wilderness Area. Vegetation within the SFRPA was primarily old-growth Douglas-fir, with stands of mixed hardwoods on some south-facing slopes. Hardwood stands were comprised primarily of tan oak (*Lithocarpus densiflorus*), golden chinquapin (*Castanopsis chrysophylla*), madrone (*Arbutus menziesii*), canyon live oak (*Quercus chrysolepus*), and other conifer species including knobcone pine (*Pinus attenuata*), sugar pine (*Pinus lambertiana*), and white fir (*Abies concolor*). Elevations within the area ranged from 300 to 1,500 m. Topography was extremely rugged with steep ridge systems separating tributaries of the Illinois River.

I selected four study areas within the SFRPA based on availability of road or trail access and proximity to known elk populations or elk release sites at Bald Mountain and Lazy Ridge (Fig. 1). Habitat included underburned old-growth Douglas-fir and mixed conifer-hardwood stands, and clearcuts dominated by regenerating tan oak, madrone, *Ceanothus* spp., grasses, and forbs. I selected two of the sites in areas used by resident elk at Fish Hook Peak and along the main stem of Indigo Creek (Fig. 1). Fish Hook Peak was the highest in elevation of the four sites and most different vegetatively from the other three areas. Elevation ranged from 1,000 to 1,500 m. The dominant conifer species above 1,300 m was white fir, with Douglas-fir dominating below 1,300 m. South-facing slopes, which experienced stand-replacement fires, were dominated by snags, residual live trees, and thick stands of Saddler oak (*Quercus sadleriana*). The northwestern slope of Fish Hook Peak was unburned old-growth Douglas-fir. The Indigo Creek study area was a mix of underburned old-growth, mixed conifer hardwood stands, and clearcuts similar to the Bald Mountain and Lazy Ridge sites.

The SFRPA is primarily roadless, containing approximately 23 km of road within 170 km^2. Approximately 3,840 ha of the SFRPA were salvage logged, 1,380 ha by clearcutting. Following salvage operations, approximately 2,600 ha were seeded with a mixture of annual ryegrass (*Lolium* sp.) and vetch (*Vicia* sp.) to aid in erosion control.

Historical uses of the area included timber harvest and outdoor recreation such as hunting and hiking. During the study, big game hunting seasons occurred each fall. An archery season for either-sex deer and bull elk was held during September. Firearms seasons for deer were held in October and the first week of November (35-40 days), and elk seasons were held in two periods in mid-November (5 and 9 days). Deer hunting was allowed by unlimited general license. Elk hunting was restricted to 200-300 hunters/period.

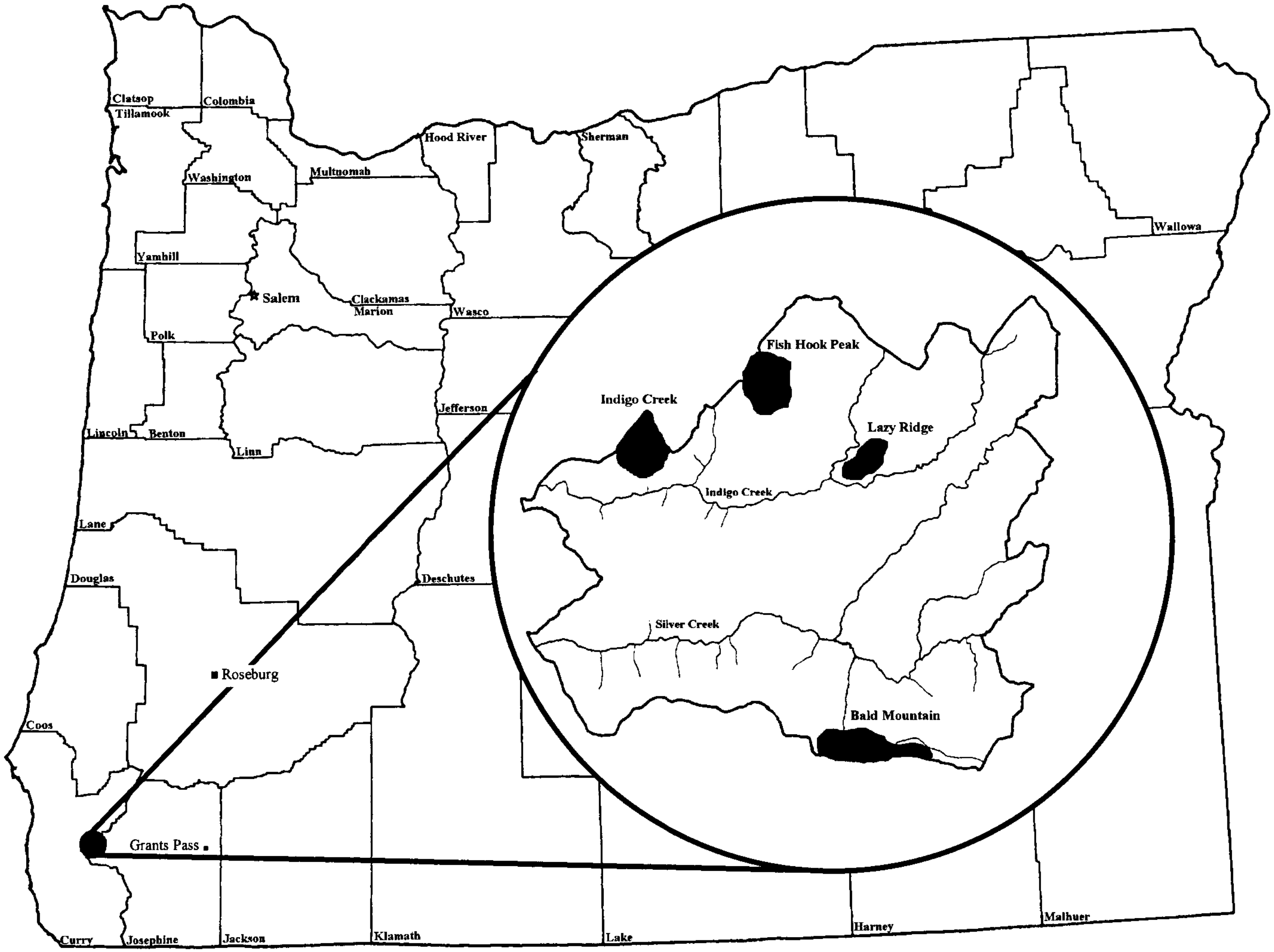

Figure 1. Location of the Silver Fire Recovery Project Area, and study areas (in black) for the Silver Fire Project, southwestern Oregon.

CHAPTER 3
PELLET DECAY RATE AND INTEROBSERVER VARIABILITY

METHODS AND MATERIALS

Pellet Decay Rate

I evaluated pellet group persistence by placing 68 deer and 46 elk pellet groups at 12 locations within the four study areas. I placed pellet groups collected from three locations in western Oregon at two locations at Bald Mountain and Indigo Creek, three locations at Lazy Ridge, and five locations at Fish Hook Peak. I used pellets that had greenish cast to the underside or interior of the group, appeared moist, lacked visible insect damage, and contained at least 50 pellets. All pellet groups were placed in August 1992.

I permanently marked three 15-m transects at each of 12 locations with wooden stakes, and placed two to five pellet groups at 1-m intervals along each transect. I recorded overstory canopy at each site as either open ($\leq$50%) or closed (>50%). Type of pellet group (hard or soft), species (deer or elk), and origin of group were also recorded. I defined hard pellet groups as those that were separated into discrete pellets and not adhering to one another. In soft pellet groups, most of the pellets adhered together although individual pellets were usually discernable. During subsequent monitoring, I estimated pellet group persistence by stretching a tape measure between the stakes and determining if each pellet group was present or absent. I considered groups present if any pellets were visible within a 0.5-m radius of the point where the group was originally placed. Pellet groups were monitored in September and October of 1992, and June of

1993. In November 1992, heavy snowfall prevented further monitoring of pellet groups until all snow had melted in early summer of 1993.

I used logistic regression to determine if the variables overstory canopy, pellet type, species, and collection location influenced the probability of a pellet group persisting through the collection period. One-way analysis of variance was used to determine if there were differences between the proportion of hard elk, soft elk, hard deer, and soft deer pellet groups remaining.

Interobserver Variability

I estimated interobserver variability by comparing the mean number of pellet groups found in a segment (pellet groups/segment) by each observer during the study using one-way analysis of variance. A segment was 100 m long by 1.5 m wide, constituting a 150-m^2 fixed plot. There were 273 segments searched four times by 15 observers. Only five observers, who had searched more than 40 segments each, were compared to ensure that each observer had an opportunity to search a representative sample of segments. Variability was compared separately for elk and deer pellets. If interobserver variability was small, no differences in mean number of pellet groups/segment would be expected among observers. Differences among individual means would indicate possible observer-related bias, and would require modifying response categories to minimize the effect of observer biases on estimates of habitat use.

RESULTS

Pellet Persistence

I monitored 68 deer and 46 elk pellet groups. Of these, 19 deer and 23 elk groups were considered soft. Hard elk pellets had the greatest proportion persisting (91.3%), whereas hard deer pellets had the smallest proportion persisting (73.5%) (Table 1). However, the four categories of pellet types did not differ in the mean number of groups persisting through the monitoring period ($F = 1.07$; df = 3, 110; $P > 0.37$). Overstory canopy, pellet type, species, and collection location could not be used to predict probability of a pellet group persisting (logistic regression, $P \geq 0.51$).

Interobserver Variability

Observers varied both in the mean number of deer ($F = 10.7$; df = 4, 883; $P < 0.0001$) and elk ($F = 2.7$; df = 4, 530; $P = 0.03$) pellet groups seen/segment (Table 2). Variation in the number of deer pellets counted was higher than for elk (Table 2). Observers one and two did not differ in the number of deer pellet groups counted, but both counted more pellet groups than the other observers (F-protected t-test, $P < 0.05$). Observer one saw significantly fewer elk pellet groups/segment than observers two and four, who saw the highest mean number of pellets/segment.

Table 1. Proportion of black-tailed deer and Roosevelt elk pellet groups surviving a 10-month monitoring period during the Silver Fire Project, southwestern Oregon, 1993.

Pellet type	Number placed	Number surviving	Proportion surviving (%)
Deer			
Soft[a]	19	15	79
Hard[b]	49	36	73
Elk			
Soft	23	19	83
Hard	23	21	91

[a] A pellet group in which most pellets adhere to one another.

[b] A pellet group in which most pellets are free of one another.

Table 2. Number of elk and deer pellet groups counted/segment by five observers during the Silver Fire Project, southwestern Oregon, 1991-1993.

Species and observer[a]	n[b]	Range	Mean[c]	Standard error
Deer				
1	400	0-28	3.4 A	0.18
2	83	0-31	3.3 A	0.55
3	258	0-13	2.2 B	0.15
4	76	0-11	2.0 B	0.26
5	71	0-8	1.4 B	0.23
Elk				
2	45	0-9	1.07 A	0.27
4	57	0-7	0.96 A	0.21
3	133	0-8	0.63 A B	0.12
5	56	0-4	0.59 A B	0.15
1	244	0-8	0.52 B	0.07

[a] Observers are ranked from largest to smallest mean.

[b] n = number of segments searched over entire study.

[c] Means with like letters do not differ ($P < 0.05$).

DISCUSSION

Fecal pellet group counts are widely used in assessing habitat use by ungulates (Roberts and Tiller 1985, Loft et al. 1988, Edge and Marcum 1989, Klinger et al. 1989). However, the utility of the technique is influenced by factors such as pellet group decay rate and variation in observers' abilities to detect pellet groups. Without assessment of these factors, it is impossible to estimate the potential biases that may result from using pellet group counts to measure habitat use.

Pellet Persistence

The high persistence of both deer and elk pellet groups over the 10-month monitoring period suggests that pellet numbers are good indicators of pellet deposition during this time period. Overstory canopy, pellet group type, and species were not useful in determining survival probability of pellet groups. However, other factors may affect the disappearance of pellet groups. Slope, weather patterns, insects, fungi, and moisture content of the pellet may play important roles in determining the survivability of a group (Fisch 1979, Harestad and Bunnell 1987). All pellet groups placed in this experiment were dried by warm weather in late August and September 1992. November snowfall may have protected existing pellet groups from rain and insects. Had groups been deposited after snowfall, spring snow-melt would have moved some, and individual pellets may have been widely dispersed. Both black-tailed deer and Roosevelt elk move to elevations below the zone of deep snow (>30 cm), so it is unlikely that many pellets are deposited on top of deep snow. Pellets on steep slopes may be more likely to roll off of transects, but I suggest the number of groups rolling onto transects probably reduces this bias.

Because amount and duration of snow cover and rainfall are both temporally and spatially variable in the Siskiyou Province, it is impossible from this experiment to determine the effects of weather and pellet moisture on pellet persistence. However, these results suggest that the length of deposition periods (the amount of time between successive pellet collections) do not exceed the expected life of most pellet groups as recommended by Harestad and Bunnell (1987). The deposition period spanned 4.5 months for the summer-early fall period, and approximately 7.5 months during the fall-spring period.

Interobserver Variability

My results suggest that there are differences in observers' abilities to detect pellet groups, and these differences are inconsistent across species. The large size of elk pellets and pellet groups makes them much more visible than deer pellet groups, and this was reflected in interobserver variability. Variability in elk pellet groups seen/segment was relatively small, and I believe that differences were because of discrepancies in sample size (number of segments searched) and assignment of observers to particular transects. Observers with relatively small sample sizes searched more transects in the Fish Hook Peak area, which had higher densities of elk pellet groups than other study areas. Observers with sample sizes >80 searched more transects in the Bald Mountain and Indigo Creek areas, resulting in these observers seeing fewer elk pellet groups/segment.

The range of deer pellet group numbers seen/segment was quite variable. All sample sizes were large (>70 segments/observer), and the high variability in numbers of deer pellet groups counted may be an indicator of the relative difference in detectability between elk and deer pellet groups. My analysis suggests that interobserver variability is of greater concern when estimating numbers of deer pellet groups than elk pellet groups. Studies of deer habitat use that use pellet group counts by multiple observers will be less sensitive to effects of explanatory variables. I suggest that future studies use as few observers as possible, and that all observers be tested on pellet group visual acuity before data collection begins. Acuity could be tested by placing known numbers of pellet groups along transects in a variety of habitats, then allowing each potential observer to count detected pellet groups. Those observers with low ability to detect pellets should not be used, or correction factors should be developed to account for visual acuity. To further reduce observer bias, I suggest using ranks of pellet group numbers found by transect to generate categories of use. This would require a standard number of segments/transect.

I maintain that pellet group counts remain a useful technique in studying ungulate-habitat relationships. It is more cost-effective and easier to employ than radio-telemetry studies. However, researchers must be aware of sources of potential bias such as interobserver variability, and try to reduce these biases. Carefully planned and administered studies using pellet group counts will provide habitat use information useful for ungulate management.

CHAPTER 4
FACTORS AFFECTING HABITAT USE BY ELK AND DEER

METHODS AND MATERIALS

Habitat Use

I estimated relative habitat use by deer and elk by analyzing distribution of fecal pellet groups. The use of pellet group counts to determine habitat preference has been criticized for various reasons (Neff 1968, Collins and Urness 1981). Variations in defecation rates, uncertainty in pellet decay rates, and variation in fecal deposition rates between habitats all have been cited as sources of potential bias. However, Leopold et al. (1984) suggested that pellet group counts were good relative measures of habitat use. When compared with radio telemetry, the technique has been shown to be a good relative indicator of habitat preferences for both elk (Edge and Marcum 1989) and deer (Loft and Kie 1988). Radio telemetry was not a viable alternative in this project because of the roadless nature of the project area, and the prohibitive cost and inherent danger of obtaining aerial locations. Pellet group counts remain a commonly relied-on technique to evaluate habitat use by cervids (Roberts and Tiller 1985, Loft et al. 1988, Edge and Marcum 1989, Klinger et al. 1989).

I created 21 permanent belt transects in the summer of 1991, from which I immediately removed pellet groups. Transect starting points were subjectively placed throughout the study areas. I used subjective placement to avoid hazardous terrain and to allow for sufficient length of transects. Transects ranged from 200 to 2,000 m and were 1.5 m wide. Each transect was divided into 100-m long segments, each constituting a 150-m^2 fixed plot. The 21 transects contained a total of 273 segments. I marked transects with surveyor flagging and log-marking paint delineating the center of the transect line at intervals of 2-10 m.

Pellet groups were counted and cleared in October 1991 and 1992, and in June 1992 and 1993. One person walked each transect from beginning to end, scanning the ground in an approximate 1.5-m-wide swath. Observers used a 1.5-m staff with a mark in the center to determine if a detected pellet group was within the transect. Pellet groups were removed from the transect after tallying to prevent double counting on subsequent runs. I defined a pellet group as ≥10 pellets.

Habitat Characteristics

I measured habitat, topographic, and management variables at 11-m intervals along each transect, or from topographic maps in the laboratory (Table 3). I determined horizontal cover using a 2.0- x 0.3-m cloth density cover panel made from four alternating black and white rectangles (Nudds 1977). At four locations within each segment, I recorded horizontal cover readings in two random directions. The cover panel was erected 15 m away from one observer while a second observer categorized the visibility of each of the four rectangles in the cover panel. Visibility categories ranged from one (rectangle 0-20% obscured) to five (rectangle 80-100% obscured). Overstory canopy closure was the average of canopy measured at eight points within each segment using a spherical densiometer (Lemmon 1956). I measured all other vegetative cover variables using the line intercept technique. Three 15-m line-intercept transects were positioned down the center of each segment. Total cover of each shrub species, forbs, annual grass, perennial grass, and slash <0.1 m diameter (including downed wood) were measured and summed for each of the intercept transects, sampling a total of 45 m of each 100-m segment. Preferred forage shrubs were defined as those exhibiting visible browsing by deer on all study areas, and included all members of the genera *Ceanothus* and *Rubus*, plus big-leaf maple (*Acer macrophylum*), Rocky Mountain maple (*A. glabrum*), bitter cherry (*Prunus emarginata*), and myrtle (*Umbellularia californica*). Using topographic maps I determined distance to road, permanent water, and forest edge, seeding status of segment (seeded or unseeded), and elevation. Distance to water was excluded from the final analysis because field observations indicated that unmapped permanent and semipermanent water sources were available in all study areas.

Statistical Analysis

I pooled pellet group counts from two June and two October transect runs, representing late fall-winter-spring and summer-early fall habitat use. Frequency distributions were generated by collection period to create response categories of relative habitat use. Elk pellet group numbers were divided into three response categories of high, moderate, and low use (Table 4). Because interobserver variability was higher for deer than for elk pellet groups, I divided deer pellet group numbers into two categories of high and low use (Table 4). Response categories contained different numbers of pellet groups among study areas and use periods (Table 4), but I used the same relative frequency of pellet group numbers within each response category among study areas and use periods.

I analyzed data from 273 segments to estimate deer habitat use. Only transects that received elk use on at least two collection occasions were used in the elk analysis, resulting in 168 segments used to estimate elk habitat use. Stepwise logistic regression was used to create models from habitat variables that predicted the probability of a given category of habitat use within a segment. I used an alpha level of 0.10 to add and retain variables to the models. I forced management variables into these habitat models to estimate their effect on predicted habitat use. Management variables were added after creation of a habitat model, rather than letting the computer select a model from habitat and management variables, to obtain *P*-values for the contribution of management variables to the model.

Table 3. Habitat and management variables measured for each segment during the Silver Fire Project, southwestern Oregon, 1991-1992.

Variable	Units and resolution	Source
Topographic		
Elevation	20 m	Map
Aspect	45°	Center of segment
Distance to edge	50 m	Map or aerial photo
Slope	1°	Segment, 8 readings
Vegetative cover		
Horizontal	Cover class	Cover panel, 8 readings/segment
Total shrub	0.1 m	15-m line-intercept[a]
Forage shrub	0.1 m	15-m line-intercept[a]
Annual grass	0.1 m	15-m line-intercept[a]
Perennial grass	0.1 m	15-m line-intercept[a]
Management		
Seeding status	Seeded or unseeded	Map
Distance to road	50 m	Map
Harvest treatment	Clearcut or partial cut or uncut	Segment
Slash cover	0.1 m	15 m line-intercept[a]

[a] There were three 15-m line-intercept transects/100-m segment.

Table 4. Number of pellet groups and relative percent of total pellets defining habitat use categories for black-tailed deer and Roosevelt elk by study area during the Silver Fire Project, southwestern Oregon, June 1991-June 1993.

	Use category and period					
	Low		Moderate		High	
Study area and species	Fall-Spring	Summer-Fall	Fall-Spring	Summer-Fall	Fall-Spring	Summer-Fall
Deer						
Bald Mountain	0-7 (84)[a]	0-6 (86)			≥8 (16)	≥7 (14)
Lazy Ridge	0-12 (90)	0-3 (85)			≥13 (10)	≥4 (15)
Fish Hook Peak	0-17 (89)	0-14 (85)			≥18 (11)	≥15 (15)
Indigo Creek	0-18 (87)	0-13 (87)			≥19 (13)	≥14 (13)
Elk						
Bald Mountain	0 (44)	0 (48)	1 (33)	1 (33)	≥2 (23)	≥2 (19)
Fish Hook Peak	0 (60)	0 (49)	1-2 (29)	1-2 (36)	≥3 (11)	≥3 (15)
Indigo Creek	0 (58)	0 (83)	1 (29)	1 (8)	≥2 (13)	≥2 (9)

[a] Percent of total pellet groups counted/season within a study area.

RESULTS

Deer

I counted 3,888 deer pellet groups on the four study areas; 1,048 were counted during transect creation. Fish Hook Peak had both the most pellet groups and the highest average density of pellet groups/segment (Table 5). Indigo Creek had the next highest pellet density, followed by equal densities on Bald Mountain and Lazy Ridge (Table 5).

The habitat use models contained different variables depending on season, with only one variable occurring in both models. Both models fit the data (fall-spring: $\chi^2 = 18.0$, df = 18, $P = 0.46$; summer-fall: $\chi^2 = 20.0$, df = 20, $P = 0.46$). Four variables (canopy closure, cover 0.5-1.0 m above ground, total forb cover, and east aspect) were significant predictors of habitat use during the fall-spring period and two variables (canopy closure and south aspect) predicted summer-fall use (Table 6). Total overstory canopy negatively influenced probability of high habitat use, and was the variable that best predicted probability of high use for both fall-spring ($\chi^2 = 8.3$, df = 4, $P = 0.004$) and summer-early fall ($\chi^2 = 12.1$, df = 2, $P = 0.0005$) collection periods. Although study areas differed with respect to some variables (Appendix A), area was not a significant factor influencing deer use ($P > 0.10$).

When I added management variables to the model, only distance to road was significant ($\chi^2 = 4.9$, df = 9, $P = 0.03$) during the fall-spring period (Table 7). Slash cover negatively influenced deer habitat use during the summer-fall period ($\chi^2 = 5.7$, df = 7, $P = 0.02$) (Table 7). The fall-spring model classified 82.4% of segments into the correct use category; the summer-fall model classified 80.5% of segments correctly.

Elk

I counted 775 elk pellet groups during the study period; 348 were found during transect creation. As with deer, Fish Hook Peak had both the greatest number and density of elk pellet groups. Ten pellet groups were detected during creation of the transects on Lazy Ridge, but no pellet groups were found during subsequent pellet collections (Table 5). Fish Hook Peak had greater numbers of pellet groups during the summer-fall period, whereas more groups were found during the fall-spring collection period at Indigo Creek.

Eight variables (slope, cover >0.5-1.0 m above ground, cover >1.0-1.5 m above ground, annual grass cover, perennial grass cover, hardwood canopy, conifer canopy, and east aspect) were significant predictors of habitat use during the fall-spring period, and 5 variables (slope, elevation, forb cover, perennial grass cover, and hardwood canopy) were predictors during the summer-fall period (Table 8). Both models fit the data (fall-spring: $\chi^2 = 14.8$, df = 17, $P = 0.61$; summer-fall: $\chi^2 = 7.5$, df = 14, $P = 0.92$). Increasing slope negatively influenced elk use during both fall-spring ($\chi^2 = 13.8$, df = 8, $P = 0.0002$) and summer-fall periods ($\chi^2 = 5.2$, df = 5, $P = 0.02$). Hardwood canopy negatively influenced elk use during both fall-spring ($\chi^2 = 11.1$, df = 8, $P = 0.0009$), and summer-fall periods ($\chi^2 = 3.9$, df = 5, $P = 0.05$). Elevation had a positive influence on elk use during the summer-fall period ($\chi^2 = 3.2$, df = 5, $P = 0.07$). Although study areas differed with respect to some variables (Appendix A), area was not a significant factor influencing elk use.

Seeding status of the segment was the only management variable that was significant during both collection periods (Table 9). Areas that had been seeded had a higher probability of moderate or high elk use than unseeded areas. Distance to roads and slash cover did not influence elk use during either period. Clearcutting had a negative effect on probability of moderate or high elk use during the fall-spring period ($\chi^2 = 4.3$, df = 13, $P = 0.04$). The fall-spring model classified 78.3% of segments into the correct use category; the summer-fall model classified 76.3% of segments correctly.

Table 5. Summary of black-tailed deer and Roosevelt elk pellet groups found by study area and season during the Silver Fire Project, southwestern Oregon, June 1991-June 1993.

	Pellet groups found by collection period					Totals			Density
Study area by species	Pre-existing	October 1991	June 1992	October 1992	June 1993	Summer-fall	Fall-spring	All periods	Mean pellet groups/ segment
Deer									
Bald Mountain	358	158	208	190	235	348	443	1,149	10.2
Lazy Ridge	132	30	138	56	114	86	252	470	9.8
Fish Hook Peak	482	247	415	377	287	624	702	1,808	22.0
Indigo Creek	76	46	114	102	123	148	237	461	15.4
Totals	1,048	481	875	725	759	1,206	1,634	3,888	14.2
Elk									
Bald Mountain	92	32	55	30	40	62	95	249	2.2
Lazy Ridge	10	0	0	0	0	0	0	10	0.2
Fish Hook Peak	188	81	53	57	35	138	88	414	5.1
Indigo Creek	58	1	23	6	14	7	37	102	3.4
Totals	348	114	131	93	89	207	220	775	2.8

Table 6. Variables selected by stepwise logistic regression for predicting black-tailed deer habitat use during fall-spring and summer-fall periods in the Silver Burn, southwestern Oregon, 1991-1993.

Variable by period	Association[a]	*P*-value
Fall-Spring		
Overstory canopy cover	–	0.004
Cover: 1.0-1.5 m	+	0.08
Total forb cover	+	0.02
East aspect	–	0.10
Summer-Fall		
Overstory canopy cover	–	0.0005
South aspect	+	0.07

[a] Probability of high use increases as positive variables increase. Probability of use decreases as negative variables increase.

Table 7. Influence of management variables on predicted habitat use by black-tailed deer in the Silver Burn, southwestern Oregon, 1991-1993.

Variable by period	Association[a]	P-value
Fall-Spring		
Distance to road	–	0.03
Seeding status	+	0.99
Partial cut	–	0.20
Clearcut	+	0.81
Slash cover	–	0.14
Summer-Fall		
Distance to road	+	0.15
Seeding status	–	0.55
Partial cut	–	0.75
Clearcut	+	0.26
Slash cover	–	0.02

[a] Probability of high use increases as positive variables increase. Probability of use decreases as negative variables increase.

Table 8. Variables selected by stepwise logistic regression for predicting Roosevelt elk habitat use during fall-spring and summer-fall periods periods in the Silver Burn, southwestern Oregon, 1991-1993.

Variable by period	Association[a]	*P*-value
Fall-Spring		
Slope	–	0.0002
Cover: 1.0-1.5 m	–	0.008
Cover: 1.5-2.0 m	+	0.034
Annual grass cover	+	0.002
Perennial grass cover	+	0.040
Conifer canopy[b]	–	0.030
Hardwood canopy[b]	–	0.0009
East aspect[b]	–	0.060
Summer-Fall		
Slope	–	0.02
Elevation	+	0.07
Forb cover	+	0.002
Perennial grass cover	+	0.03
Hardwood canopy[b]	–	0.05

[a] Probability of medium or high use increases as positive variables increase. Probability of use decreases as negative variables increase.

[b] Indicator variable-segments either possess the variable attribute or they do not.

Table 9. Influence of management variables on predicted habitat use by Roosevelt elk in the Silver Burn, southwestern Oregon, 1991-1993.

Variable by period	Influence[a]	*P*-value
Fall-Spring		
Distance to road	–	0.79
Seeding status	+	0.03
Partial cut	–	0.27
Clearcut	–	0.04
Slash cover	+	0.79
Summer-Fall		
Distance to road	+	0.41
Seeding status	+	0.05
Partial cut	–	0.27
Clearcut	–	0.43
Slash cover	–	0.74

[a] Probability of medium or high use increases as positive variables increase. Probability of use decreases as negative variables increase.

DISCUSSION

Black-tailed deer use a wide variety of habitats, from chaparral hills in the Coast Range of California (Taber and Dasmann 1958) to old-growth sitka spruce (*Picea sitchensis*) and hemlock (*Tsuga heterophylla*) forests in British Columbia and southeastern Alaska (Schoen and Kirchoff 1990, Kremsater and Bunnell 1992). Roosevelt elk are more specific in their habitat requirements, selecting habitats that provide grass and herbaceous forage (Mereszczak et al. 1981, Witmer and deCalesta 1983, Grenier 1991). My results generally agree with past studies.

Deer

Black-tailed deer are generalists both across their range and within habitat regions and exhibit relatively little specificity in habitat requirements. My models of habitat use by deer in the Silver Burn contain few variables. Availability of habitats and the general nature of the response categories may account for the simplicity of these models. The SFRPA provides deer with the elements needed to survive across an array of habitats, necessitating little specificity in habitat selection. In addition, interobserver variability required that fairly broad response categories be used in this analysis. Broad response categories reduced the sensitivity of the technique to subtle effects of habitat variables, and thus micro-habitat variables affecting use were difficult to detect.

Canopy closure was the only variable selected for both use periods to predict use by deer. An inverse relationship between canopy closure and deer use is consistent with the findings of other studies (Rost and Bailey 1979, Smithey et al. 1985, Loft et al. 1988). Seeding of annual grasses would not be expected to improve habitat use by deer because their diet is comprised primarily of browse and forbs (Crouch 1979, Kie et al. 1984, Leslie et al. 1987). Timber harvest generally increases available browse through increased sunlight and shrub cover (Taber and Hanley 1979) and would affect forage availability for deer more than seeding of annual grasses. The lack of any positive or negative effects from different timber harvest types was probably related to a high correlation between harvest type and overstory canopy closure.

Deer response to roads did not support my predictions. I suggest the effect of distance to roads could not adequately be tested in this study because of the length of the collection periods (4.5 months for summer-fall, 7.5 months for fall-spring), and the nature of the study areas. There is little documentation of the effects of road density on habitat effectiveness for black-tailed deer. Most of the negative effects of roads would be expected to occur during periods of high traffic volume and human disturbance, i.e., immediately before and after hunting seasons. Effects of a four-week hunting season probably would not be detected during a 7.5-month use period. In addition, because of the remoteness of the study areas, road use may be relatively low even during hunting seasons. Between 1988 and 1992, an average of only 0.30 deer/km^2 were harvested annually in the Chetco Management Unit (ODFW 1989, 1990, 1991, 1992, 1993), which encompasses the SFRPA. Harvest may have been even lower in the SFRPA, where road density is approximately 0.13 km/km^2; this is very low compared to heavily logged areas in the Pacific Northwest. I suggest that traffic volume and hunting pressure may be below the level at which they negatively impact habitat use by deer over long periods.

There is no clear explanation for slash cover having a significant negative effect on habitat use by deer during the summer-fall period. Results from studies on effects of logging slash have varied. Ffolliott et al. (1977) found greater deer and elk use in ponderosa pine (*Pinus ponderosa*) openings where slash had been piled and burned, but noted that residual slash did not provide a barrier to movement. Lyon (1976) reported that average slash depth rather than slash coverage was important in determining the effect of slash on use of clearcuts. Because I measured only slash cover and not slash depth, it is difficult to interpret these results. If slash cover were positively related to slash depth then my results concur with Lyon (1976).

Elk

Elk inhabit a narrower range of habitats than deer in the Siskiyou Mountains, thus elk habitat models contained more variables than deer models. Interobserver variability was lower with elk than with deer pellet groups, allowing narrower response categories. These two factors may have allowed for better detection of responses to explanatory variables.

Steep slopes reduced the probability of high use by elk during both use periods. Both Rocky Mountain and Roosevelt elk have demonstrated an affinity for gentle slopes and an avoidance of steep slopes in other studies (Marcum 1975, Hershey and Leege 1982, Irwin and Peek 1983, Witmer and deCalesta 1983).

Roosevelt elk preferred hardwood stands during three of four seasons and two of three seasons on two study areas in the central Oregon Coast Range (Witmer and deCalesta 1983); however, I found that elk avoided hardwood stands in the Siskiyous during both use periods. Differences in species of hardwood and understory species probably account for this difference. Witmer and deCalesta (1983) did not report which hardwood species were present, but noted that they tended to be associated with riparian areas. Common riparian tree species in western Oregon are big-leaf maple and red alder (*Alnus rubra*), which are often associated with herbaceous and grass understory. In Washington, elk in the western Cascades selected mesic sites that grew more grasses and forbs than more xeric upland sites (Hanley 1984). Hardwood stands in the SFRPA are usually located on dry south-facing slopes and have little grass or herbaceous understory. Thus they provide little forage for elk and little incentive for elk to use them over long periods.

Two of the horizontal cover variables were significant in predicting use category, but with opposite signs. These results are confounded by the nature of shrub growth in open areas following the fire. Given the broken, rugged topography in the Silver Burn and the condition of cover growth since the fire, adequate horizontal cover may be present in most areas used by elk within the burn.

Elk consistently have been found to avoid areas with open roads (Perry and Overly 1976, Lyon 1979, Rost and Bailey 1979, Thomas et al. 1979, Witmer and deCalesta 1985), but roads in the SFRPA did not negatively affect elk habitat use. Topography and vegetation can reduce the negative effect of roads on elk habitat use (Perry and Overly 1976, Lyon 1979, Edge and Marcum 1991). Closed or lightly traveled roads also seem to have little or no effect on habitat use (Marcum 1976, Witmer and deCalesta 1985). At least 7 km of the approximately 23 km of road in the SFRPA are permanently closed to public entry and receive only occasional administrative use. Although there is possibly a short-term effect of open roads during the hunting season, pellet group counts representing use over a 7.5-month period were unlikely to detect effects lasting two to three weeks.

Forage variables such as grass and forb cover were significant in predicting category of elk use. The positive effect of grass seeding on probability of elk use is logical given the food habits of elk. Elk rely heavily on grass and herbaceous forage and supplement their diet with browse (Hanley 1984, Leslie et al. 1987). The significance of increasing perennial grass cover as a predictor of habitat use during both use periods suggests the distribution of forage in the SFRPA is a key factor in predicting elk use. The effect of grass cover may also be important when comparing the relative habitat suitability surrounding elk release sites on Bald Mountain and Lazy Ridge. I found elk pellets on Lazy Ridge during transect creation, but no pellets were found subsequently. In contrast, elk pellets were found during all collection periods surrounding the Bald Mountain release site. The habitat data suggest a marked difference in the availability of grass forage between the two sites, with much more grass available at the Bald Mountain site (Appendix A). This is a critical finding in evaluating the suitability of habitat for elk in the Siskiyous.

Forage availability is also the probable reason for elevation positively influencing elk use during the summer-fall period. During late summer and early fall, higher elevations on Bald Mountain and Fish Hook Peak were cooler and moister than lower elevations, and probably supported more herbaceous and grass forage.

I expected elk and deer use to decline as distance from forest edge increased (Hanley 1983); however, I found no relationship between distance to edge and use by either elk or deer. In the Silver Burn, vigorous regrowth of stump-sprouting species such as tan oak, Saddler oak, and madrone have created greater cover in openings than in forested stands. Low human disturbance in the Silver Burn may also account for a lack of edge effects.

MANAGEMENT RECOMMENDATIONS

I make no specific recommendations regarding management of deer habitat within the SFRPA based on the results of this study. The attraction of deer to openings in the forest canopy is not a new finding. As time since the burn increases, shrub growth and new forests will mature and reduce the suitability of the burn for deer. However, because lightning-caused fire is an integral part of forest succession in the Siskiyous, it is likely that portions of the Silver Burn will periodically reburn, creating open canopy habitat favored by deer.

Historically, Roosevelt elk inhabited river valleys and adjacent foothills where there was abundant grass forage (Jenkins 1984), and probably were not distributed through the Siskiyous as deer are. Today, distribution of forage in the interior of the Siskiyous is probably the most critical factor limiting elk distribution. In this area, elk do not use steep slopes lacking abundant grass forage. I do not contend that these results support widespread seeding of exotic grasses. Rather, I take the forage-related results to be an indication of limited resource availability. Elk released on Bald Mountain have remained in the vicinity of the release site, whereas elk on Lazy Ridge have moved off the ridge and into a neighboring drainage. Distribution of forage may be responsible for these different responses by transplanted elk. I recommend further research into the availability of permanent forage in all areas within the Siskiyous targeted for elk management or reintroduction.

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APPENDIX

Appendix A. Mean, standard error, *F*-, and *P*-values by study area for variables measured during the Silver Fire Project, southwestern Oregon, June 1991-June 1993.

	Mean (SE)					
Variable	Bald Mountain	Lazy Ridge	Fish Hook Peak	Indigo Creek	*F*	*P*-value
Slope (degrees)	27.9 (0.6)	26.8 (1.0)	26.4 (0.6)	25.4 (1.6)	1.6	0.19
Canopy cover[a]	9.5 (0.7) A[b]	17.4 (0.7) B	10.4 (0.7) A,C	12.7 (1.5) C	16.1	0.0001
Cover 0.0-0.5 m above ground	4.2 (0.1)	4.0 (0.1)	4.0 (0.1)	3.9 (0.2)	1.5	0.22
Cover >0.5-1.0 m above ground	3.6 (.01)	3.7 (0.1)	3.4 (0.1)	3.4 (0.2)	2.1	0.1
Cover >1.0-1.5 m above ground	3.0 (0.1) A,C	3.5 (0.1) B	2.8 (0.1) A	3.3 (0.2) B,C	6.1	0.0005
Cover >1.5-2.0 m above ground	2.6 (0.1) A	3.4 (0.1) B	2.6 (0.1) A	3.1 (0.2) B	9.8	0.0001
Shrub cover[c]	13.2 (0.6) A	11.5 (1.0) A	13.4 (1.0) A	6.3 (1.1) B	7.7	0.0001
Forage shrub cover[c]	1.5 (0.2) A	1.0 (0.3) A	3.3 (0.4) B	0.5 (0.1) A	12.4	0.0001
Forb cover[c]	3.4 (0.4) A	0.3 (0.1) B	2.4 (0.3) C	1.0 (0.3) B	13.1	0.0001
Annual grass cover[c]	1.2 (0.2) A	0.0 (0.0) B	0.1 (0.0) B	0.3 (0.1) B	15.2	0.0001
Perennial grass cover[c]	0.3 (0.1) A	0.1 (0.1) A	1.6 (0.3) B	0.8 (0.2) A	12.4	0.0001
Elevation (m)	909 (9) A	852 (24) B	1,331 (8) C	681 (41) D	291	0.0001
Aspect (degrees)	179 (11)	217 (12)	175 (11)	172 (8)	2.4	0.07
Distance to road (m)	534 (49) A	508 (42) A	443 (38) A	216 (21)	5.2	0.002
Distance to edge (m)	419 (28.6)	644 (63)	142 (11)	415 (34)	34.6	0.0001
Slash cover[c]	2.3 (0.2)	2.0 (0.3)	2.8 (0.3)	3.0 (0.5)	2.4	0.07

[a] Mean number of densiometer grid squares occupied by canopy. Multiply by 4.04 to convert to % canopy closure.

[b] Means followed by like letters are not different ($P \leq 0.05$)

[c] Mean cover (m) along 45-m line intercept.