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Cattle or Sheep Reduce Fawning Habitat Available to Columbian White-tailed Deer in Western Oregon

Abstract

We studied responses of Columbian white-tailed deer (*Odocoileus virginianus leucurus*) to cattle and sheep in western Oregon because of viability concerns. We used radio-telemetry, observations from horseback, and searches with a trained dog to determine fawning habitat, dam home ranges, and habitat use by fawns. Dams (n = 12) shifted ($\bar{x}$ = 366 m, $P < 0.05$) their center of activity by establishing disjunct areas of use prior to fawning. Ten dams exhibited their largest Euclidian movement during May–July; 7 females undertook extended ($\bar{x}$ = 1445 m) forays during spring. Three natal sites averaged 1926 m from the center of the dam's annual home-range. Dams avoided ($P < 0.05$) areas with livestock during fawning; 3 fawns were encountered during 243 h of searching (1 fawn/91.4 h) in areas with livestock stocking levels of ≥2.5 animal use month/ha (AUM), whereas 39 fawns were encountered during 275 h of searching (1 fawn/7.1 h) in areas with <2.5 AUM of livestock use. Natal areas (n = 52) were in denser luxuriant vegetation, typically along a permanent stream with greater obstruction to vision. Areas with cattle (*Bos taurus*) or sheep (*Ovis aries*) had lower percent vegetative cover, less diverse herbaceous vegetation, and less concealment cover. Establishing separate home ranges during the fawning season apparently was a response to the presence of livestock or effects of grazing, which reduced the vertical vegetation profile and concealment cover. Dams likely increase fawn survival by selecting sites with nutritious, palatable forage, denser vegetation, and moderate microclimates during parturition and lactation.

Introduction

The Columbian white-tailed deer (*Odocoileus virginianus leucurus*) historically ranged throughout much of western Oregon and southwestern Washington (Smith 1985a). Douglas (1829, 1914) reported it was common in the fertile prairies of the Cowlitz River and the Multnomah (Willamette) River within 160 km of the Pacific Ocean and throughout the central river bottomlands of western Oregon as far south as the Umpqua River valleys. Bailey (1936) and Crews (1939) concluded *O. v. leucurus* occurred as far south as Grants Pass, Oregon. It apparently preferred oak woodlands and mixed prairies of the oak savanna complex, a vegetative association maintained by native Indians with fire (Thilenius 1968). Extensive cultivation of western Oregon since early settlement dramatically altered natural habitats, supplanting most of the native vegetation and leaving only patches of river bottomland associations (Thilenius 1968). Although Jewett (1914) and Bailey (1936) presented evidence that *O. v. leucurus* occurred in the Willamette Valley until late in the 19th century, it has since been extirpated from almost all of its historical range (Smith 1985a). Today, *O. v. leucurus* is limited to 2 remnant populations: 1 along the lower Columbia River and the second in the interior valleys of the Umpqua Basin in Douglas County, Oregon (Smith 1985a). The population along the lower Columbia River has been federally listed as an endangered species since 1967. The Douglas County population was acknowledged and protected by the state of Oregon in 1978 (Smith 1985a), was designated as a discrete population with separate recovery goals (USDI Fish and Wildlife Service 1983), and recently was delisted because population and habitat benchmarks were met (USDI Fish and Wildlife Service 2003).

Smith (1987a) hypothesized that the rapid decline and extirpation of *O. v. leucurus* from the Willamette Valley (<60 years) could be explained by its apparent narrow habitat niche and low tolerance to landscape changes following European settlement. The findings of his study and other investigators (e.g., Thilenius 1968) corroborated

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historical accounts that *O. v. leucurus* was a habitat specialist—an evolved life-history trait that presumably reduced competition with the Columbian black-tailed deer (*O. hemionus columbianus*), a reputed habitat generalist. Although its distribution and abundance in Douglas County has increased over the last 3 decades (largely due to protection from hunting), the current geographic range of *O. v. leucurus* is < 5% of its historical range in western Oregon (Smith 1985a).

Despite uncertainty regarding specific causal factors responsible for its decline and range contraction, there is increasing evidence that *O. v. leucurus* populations require intact lowland woodland habitats and riparian vegetation (Thilenius 1968, Smith 1987a, Ricca 2000, Whitney 2001, Ricca et al. 2003). Loss of habitat for this species likely is exacerbated by increasing overlap with *O. h. columbianus*, the diet and habitat requirements of which seem more conducive to landscapes with more open conditions (Smith 1987a, Whitney 2001). Equally important are potentially significant negative consequences of disturbance caused by increased livestock presence and grazing pressure that accompanied settlement and further development of the Umpqua Valley (Smith 1981, 1985a). If *O. v. leucurus* is a habitat specialist (Smith 1987a), cumulative impacts of decades of livestock grazing and associated land management (e.g., clearing of lowland woodlands) likely have significantly diminished habitat quality (Crews 1939, Scheffer 1940, Suring 1974, Gavin 1978) and limited opportunities for recovery and range expansion (Smith 1985a, Knutson and Naef 1997).

Effects of livestock on behavior or resource selection of deer have received considerable attention. Much of this research, however, has focused on the influence of cattle or sheep on foraging behavior or forage quality and composition (Suring 1974, Bryant et al. 1979, Thill and Martin 1989, Kie et al. 1991, Anderson et al. 1994, Torstenson et al. 2006) or habitat use (Suring 1974, Bowyer and Bleich 1984, Ganskopp and Vavra 1987, Compton et al. 1988, Dusek et al. 1989, Kie et al. 1991, Loft et al. 1991, Coe et al. 2001, Stewart et al. 2002). Relatively few studies have examined direct behavioral responses of reproductive dams to the presence of cattle or sheep within their home range or effects of grazing on vegetative cover and structure (Bowyer and Bleich 1984, Loft et al. 1987, Kie et al. 1991), although some investigators reported a general avoidance of livestock by deer (Suring 1974, Compton et al. 1988, Dusek et al. 1989, Loft et al. 1991, Stewart et al. 2002). Most of what is known about limiting effects of livestock on deer reproduction comes from studies of mule deer (*O. hemionus*); only a few investigators noted the potential impact of livestock grazing on behavior or fawning habitat of *O. virginianus* (Suring 1974; Suring and Vohs 1979; Smith 1985a, 1987a).

Our purpose was to determine if presence of cattle or sheep or livestock grazing and associated land management diminished the capability of populations of *O. v. leucurus* to further recover by limiting essential fawning habitat. Our specific objectives addressed the following questions: 1) Does grazing by cattle or sheep change composition, cover, and vertical profile of vegetation of preferred deer habitats; 2) Do dams respond to the presence of livestock by shifting home ranges; 3) Do dams discriminate suitable fawning habitat based on recent presence of cattle or sheep (including effects of grazing); 4) Does presence of livestock influence the spatial distribution and density of dams during the fawning period; and 5) Is habitat selection by fawns influenced by the presence of cattle or sheep?

Study Area

The study area comprised 2745 ha within the interior lowlands of the Umpqua River Basin in Douglas County, Oregon (43° 15′ 30″ – 43° 19′ 07″ N, 123° 18′ 31″ – 123° 09′ 43″ W). A 27.5-km reach of the North Umpqua River between Glide and Winchester formed the northern boundary of the study area. Topography was typical of the Umpqua and Rogue interior valleys with numerous small mountains and rolling foothills producing a mosaic of small valleys and ridges. Elevation ranged from 135 m above mean sea level along the North Umpqua River to 505 m along a ridge crest that formed part of the southern boundary of the study area (Figure 1).

The earliest detailed accounts of the interior Umpqua Valley noted a prevalence of oak woodlands throughout much of the low-lying interior Umpqua River basin and emphasized that much of the area was burned, a common practice of the Native Americans to encourage deer to frequent certain feeding areas (Douglas 1914). With the arrival of European settlers, many prairies and grasslands that occupied extensive areas of the

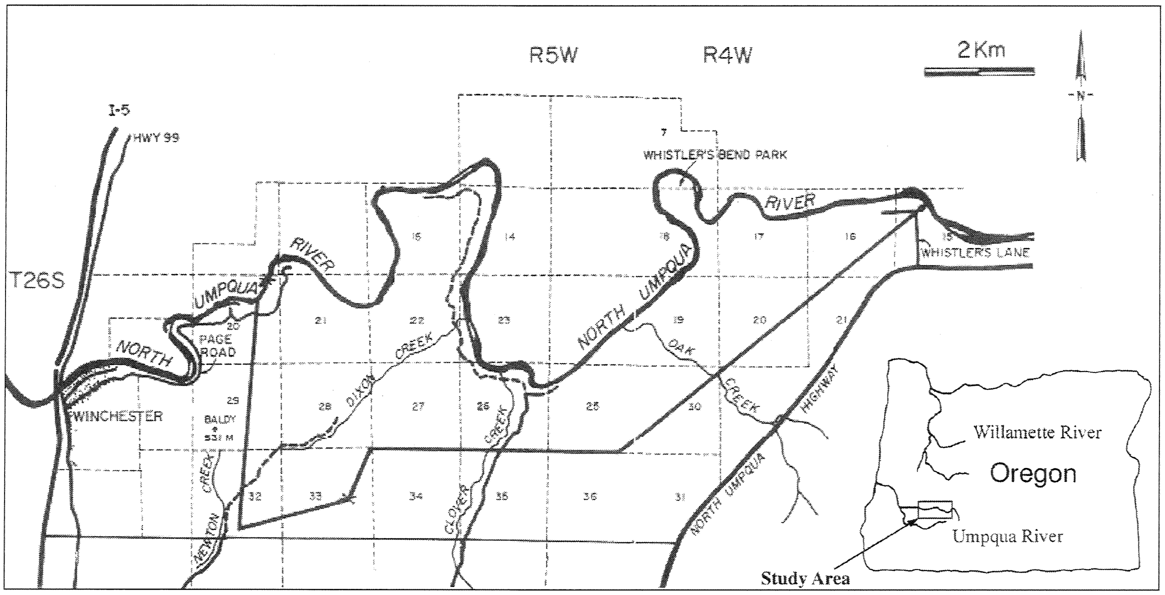

Figure 1. The study area was comprised of 2745 ha of interior lowlands within the Umpqua River Basin, Douglas County, Oregon and included all or portions of several sections in Township 26S, Range 5W and Township 26S, Range 4W. A 27.5 km section of the North Umpqua River between Winchester and Glide was the northern boundary; the southeastern, southern, and western boundary is shown as a continuous, broad black line that connects the northeastern portion near Whistler's Lane to the northwestern portion near the North Umpqua River, just north of Page Road.

interior valleys became forests and woodlands, a consequence of less frequent fire (Nash 1882). Because of the abundance of native grasses, livestock production soon became the primary land use (Nash 1882). An increase in livestock use and farmland development (i.e., clearing or burning) during the years that followed created new grasslands and savannah. By the 1920s, about 90% of the study area was used for grazing with the remaining 10% under cultivation (Crews 1939). The study area was privately owned (except Whistler's Bend County Park and 3 parcels of 81.5 ha managed by Bureau of Land Management), with about 2200 ha in cattle or sheep production. Agricultural development and livestock production intensified during the late 20th century, resulting in increased demand for improved pasture. Burning and clearing were still practiced over much of the study area, which resulted in an 18.3% (183.7 ha) reduction in woodland cover between 1972 and 1980 (Smith 1981, 1985b). Residential development along the North Umpqua River also has increased markedly since 1980; larger tracts have been subdivided and riparian woodlands were lost.

Temperatures along the interior Umpqua Valley were moderate; mean monthly maximum temperature was 20.2 °C in August, and mean monthly minimum temperature was 4.9 °C in January (United States Department of Commerce 1955–1980). The mean annual temperature (12.1 °C) remains fairly consistent from year to year; however, annual precipitation may vary considerably (55.9 cm in 1978 versus 90.4 cm in 1979). Annual precipitation averaged 84.1 cm during 1955–1979 with 67.8 cm during October–March, producing wet winters and semi-drought summers. Snow cover was uncommon and rarely persisted for more than a few days.

Natural vegetation along the lowlands of the North Umpqua River is classified as *Quercus* Woodland Community, which is typical of the Interior Valley Zone of western Oregon (Franklin and Dyrness 1973). The *Quercus* Woodland Community represents a diverse array of vegetative associations, ranging from the sparsely stemmed stands of oak-savannas with predominantly grass understories, to dense forests (70–90% canopy cover) with well-developed mid-stories. Smith (1985a) provided a detailed description of the study area with a quantitative characterization of plant assemblages among habitat types across the study area. Black-tailed deer occurred throughout the study area, but were more common in areas with lower densities of Columbian white-tailed deer (Smith 1987a). Cattle and sheep occurred across most of the study area with stocking rates typically exceeding 2.5 animal use months (AUM; 1 cow and calf or 5 sheep) per hectare (Holechek et al. 1989) during spring through autumn; about 400 ha in the western one-third of the study area had no cattle and only a few (<20) sheep for personal use.

Methods

Capture, Handling, and Marking Deer

Columbian white-tailed deer (hereafter deer) were captured and marked during May 1978–August 1980. We used multiple techniques to capture deer, including remote injection of an immobilizing drug with metal cylindrical darts and a Cap-Chur gun (Palmer Chemical and Equipment Co., Inc., Douglasville, GA), live-trapping with a 3-sided drop-gate panel trap (Oregon Department of Fish and Wildlife), and a trained dog (German short-haired pointer; Smith 1981) to locate neonates. Tranquilizer darts with nicotine salicylate or a combination of ketamine hydrochloride and xylazine hydrochloride were fired at yearling or adult deer ≤40 m from a vehicle. Selected dosages were 2.0 mg/kg, 2.5 mg/kg, and 5.5 mg/kg for xylazine hydrochloride, ketamine hydrochloride, and nicotine salicylate, respectively (Day et al. 1980). A trained dog was used to locate deer that were darted. After handling, deer were kept under constant surveillance from a distance until each was able to walk away. Also, during June 1979–March 1980, 6 panel traps baited with a mixture of corn, oats, barley, apples, and unprocessed molasses were deployed and checked daily (Smith 1981). Deer in traps were tranquilized with a combination of ketamine hydrochloride and xylazine hydrochloride.

We captured fawns by systematically searching the study area with a trained dog, observing the behavior of older females and follow-up searches (Downing and McGinnes 1969), and rushing fawns that were nursing. Young fawns (<1 week postpartum) remained bedded while the dog was 'on point' and subsequently were restrained with a 1-m diameter circular net. Older fawns fled and on command the dog pursued and restrained them in one of two ways: 1) by lying on top of the fawn or "mouthing" its neck (similar to the way dogs retrieve game birds) after it dropped to the ground; or 2) by shepherding the fawn until we could restrain it with a circular net. We took every precaution to prevent injury or reduce excessive stress; many of the procedures we followed are included in the animal care guidelines established by the American Society of Mammalogists (Gannon et al. 2007). None of our marked fawns died as a direct result of capture or handling, nor was there any evidence that subsequent fawn mortality was in any way attributable to capture or handling (Smith 1981). The location of each capture was plotted on a 3.5 × 3.5-cm aerial photograph (1 cm = 120 m).

Sex, age, general physical condition, and several morphological measurements were recorded for all captured deer. Age determination for fawns followed Haugen and Speake (1958). Tooth development and wear were used to estimate the age of older deer (Severinghaus 1949); we chose June 1 as the anniversary date for classifying the age of deer. All captures were ear-tagged with numbered, color-coded Allflex livestock tags (Vet Brand, Inc., Union City, CA). Color and placement of tags facilitated gender and age determination; numbers uniquely identified individuals. Deer > 6 months of age were fitted with a white polyvinylchloride collar bearing large, red luminous numerals of reflectant tape that uniquely marked individuals (Smith 1981). Fawns captured during 1979–1980 were fitted with a motion-sensitive mortality transmitter (Model number LT24-2TSHD-MS, Telemetry Systems, Inc., Thiensville, WI) configured onto an expandable collar that deteriorated and typically fell off before the transmitter batteries failed (12-14 weeks). We used a model RT20-A receiver and a model A-147-4 Cush Craft 4-element antennae (Telemetry Systems, Inc.) to locate radiocollared fawns.

Movements, Home Range, and Habitat Use

Marked deer were observed from horseback, during nighttime spotlight and early morning censuses, and while engaged in other fieldwork during June 1978–December 1980. Deer were observed with a 20× spotting scope mounted on a wooden rifle stock with a strap. The location of each deer was plotted on 3.5- by 3.5-cm aerial photographs (scale: 1 cm = 120 m); date, time and activity were recorded. Sightings of marked deer that were ≤60 min of a previous observation were excluded to reduce interdependence among observations. Based on our observations, we believe that a yearling or adult deer was capable of moving to any portion of its seasonal home range in 60 min. All locations were assigned X-Y coordinates obtained from a master grid system and used to estimate home range and center of activity (i.e., geometric center of the convex polygon). We estimated home range by drawing the smallest convex polygon encompassing all observations (Jennrich and Turner 1969), which can be subject to a sample size bias (Smith 1983). However, we estimated the minimum sample size beyond which home range increased negligibly by plotting number of locations against home-range size. Only deer with ≥20 independent observations during a season or ≥32 independent observations over ≥9 months during a year were included in corresponding analyses. We tested the hypothesis that livestock presence influenced spatial dynamics of deer ranges (Loft et al. 1991) by comparing centers of activity among seasons and between years. We used Wilcoxon Mann-Whitney 2-sample tests (Steele and Torrie 1980:542) to compare Euclidian distance between centers of activity of seasonal and annual home ranges. Nonparametric tests have lower statistical power than parametric counterparts (Daniel 1978) and because we wanted to err on the side of caution by reducing the likelihood of not detecting significant effects, we selected 0.10 as a comparison-wise error rate to reduce the probability of a Type II error (Zar 1999).

To test the hypothesis that livestock presence or grazing reduced the probability of a female selecting a site to fawn, we used a trained dog to systematically search similar habitat types with and without cattle or sheep. We used a Chi-square contingency table analysis (Zar 1999) to determine if the success rate of locating fawns was independent of livestock presence.

We used ground-based telemetry to monitor radio-marked neonates daily for the initial 2 weeks following capture and at least twice weekly until transmitters failed or fell off. We used sampling procedures of Smith (1985a) to quantify vegetation structure and composition of capture sites of fawns and an equal number of random sites. We also recorded distance from the base of a tree, slope, aspect, distance from a permanent water source, and if there was any evidence of cattle or sheep. Subsequent observations of fawns were classified according to 10 available habitat types (Smith 1985b, 1987a). Based on previous findings (Bowyer and Bleich 1984), we tested the hypothesis that natal areas differed from what was available across the study area by comparing attributes of capture and random sites using Wilcoxon Mann-Whitney 2-sample tests (Steele and Torrie 1980:542). We used the procedures of Neu et al. (1974) to determine if relative frequencies of neonatal captures and observations of fawns among habitat types were random; 95% *C.I.* determined if any habitats were preferred or avoided.

We made at least 3 assumptions that possibly influenced our findings. The first was typical of any observational study and related to bias that likely occurs in observing animals in areas with different amounts of visual obstruction. That bias could have influenced the locational data used to calculate home ranges and direct observations of habitat use by older (>3 mo) fawns. Interestingly, observations recorded on horseback probably were less biased because the horse regularly perceived and facilitated the rider's detection of deer that were obstructed by vegetation. Also, we assumed that we had sufficient statistical power to discern differences between habitats used relative to availability (Alldredge and Ratti 1986). Because we recorded relatively few observations per fawn among 10 habitat types, there was a higher likelihood of a Type II error in multiple comparisons of use versus availability. However, Oak-conifer and Conifer were the only habitat types that were not either avoided or preferred. Still, fawns in our study may have been more selective in their habitat use than was suggested from our analysis. Finally, we assumed that the relative amount of each habitat type across the study area was a realistic estimate of its availability (Johnson 1980). In our study, total area of each habitat type was probably a good estimate of availability with the possible exception of grasslands and oak-savannas. Deer avoided using parts of the study area that were >25 m from escape cover (Smith 1981). Thus, the ecological value of each of those habitat types to *O. v. leucurus* was likely underestimated because availability was overestimated.

Unless specified otherwise, we selected an alpha of 0.05 as the experiment-wise error rate. For multiple comparisons, we adjusted comparison-wise error rates by dividing alpha by the number of comparisons to protect the experiment-wise error rate (Wright 1992, Zar 1999).

Results

Movement and Home Range Dynamics

We fitted 12 females with numbered collars. We monitored their movements for an average of 14 months (range 9–28), recording an average of 63 locations (range 32–104) per deer. Longest Euclidian distances between any two locations for individual dams were 0.9–2.6 km. Annual home ranges were typically linear and relatively stable; average distance between centers of activity from year to year was 157 m (13–647 m). Mean Euclidian distance between seasonal centers of activity ($\bar{x}$ = 153 m; 23–940 m) was similar, except between spring and autumn when six of 10 females (2 females had insufficient data) exhibited their largest displacement ($\bar{x}$ = 366 m; 23–940 m). Three of the four remaining females occurred in areas without cattle or sheep, averaging 41 m (23–75 m) shifts in center of activity during this period. The mean seasonal displacement of those three females (75 m; 23–154 m) was substantially less (t = 2.41, df = 54, $P < 0.02$) than eight females whose home ranges overlapped parts of the study area with ≥2.5 AUMs of livestock use ($\bar{x}$ = 199 m; 21–940 m).

Seven adult females took extended forays during the period 25 April–20 May in either 1979 or 1980, which represented an average displacement of 1.45 km from their annual center of activity. Three of those females established separate home ranges during the fawning period; their centers of activity averaged 1.93 km (1.55–2.31 km) from their annual center of activity. One female moved away from her home range within 24 hours following the arrival of sheep into a lambing pasture, which was near the center of her home range. Based on the density and distribution of natal areas (Figure 2), numerous females (unmarked and marked) incorporated a narrow band of Closed Oak (*sensu* Smith 1985b) along the river in their home range prior to parturition during 1978–1980.

Natal Areas and Habitat Use

We captured 42 fawns; encounter rate was an order of magnitude lower ($\chi^2 = 26.7$, $P < 0.001$) in areas with higher stocking levels than areas with little or no livestock use. Three neonates were encountered during 243 h of searching (1 fawn/91.4 h) in portions of our study area with livestock stocking levels of ≥2.5 animal use month/ha (AUM), whereas 39 fawns were encountered during 275 h of searching (1 fawn/7.1 h) in areas with <2.5 AUM of livestock use. Sixty-nine percent of capture sites occurred in areas without cattle or sheep, which comprised about 12% of the study area. Typical natal areas (i.e., capture sites of fawns <1 week old) averaged 146.2 m (SE = 13.5) from permanent water, supported a mostly Oregon white oak (*Quercus garryana*) canopy,

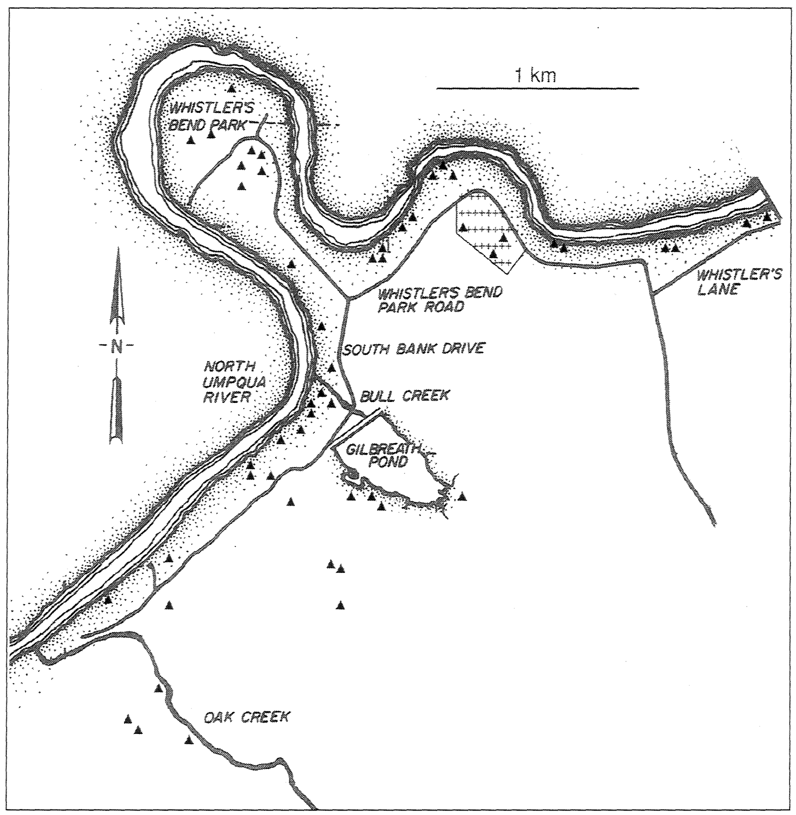

Figure 2. Distribution of white-tailed deer (*Odocoileus virginianus leucurus*) natal areas (▲) within the interior valleys of the Umpqua River Basin, Douglas County, Oregon, 1978–1980. Stippled (•) area along the North Umpqua River was Closed Oak habitat, a mostly *Quercus garryana* canopy with a dense understory of *Rhus diversiloba* and herbaceous vegetation; Shrub habitat was mostly dense patches of *Rhus diversiloba* with little overstory (Smith 1985*b*). The area north/west of South Bank drive had no livestock use because of a fence along south/east side of the road. Stippled (+) polygon south of Whistler's Bend Park road was *Quercus* woodland surrounded by a fence that excluded livestock.

TABLE 1. Microsite characteristics of Columbian white-tailed deer (*Odocoileus virginianus leucurus*) natal areas (capture sites of fawns < 1 week old, $n = 52$) and randomly selected (stratified by habitat type) sites ($n = 100$) within the interior valleys of the Umpqua Basin, Douglas County, Oregon, 1978-1980. (SE is given in parentheses)

Site type	Canopy cover (%)	Tree density (ha)	Distance to tree (m)	Herb cover (%)	Shrub cover (%)	Distance to water (m)	Obstruction to vision
Natal	83.8	944	3.95	61.1	36.9	146	9.7
	(1.87)	(99)	(0.23)	(2.20)	(2.70)	(13.5)	(0.72)
Random	42.7	555	25.1	66.6	12.4	378	14.4
	(2.1)	(118)	(1.65)	(1.78)	(0.41)	(71.3)	(0.55)

had greater obstruction to vision indices (smaller numerical values), and occurred on microsites with little or no (<20%) incline and a northern exposure (Table 1). Neonate capture sites averaged 3.95 m (SE = 0.23) from the base of a tree (dbh >10 cm) in herbaceous vegetation that averaged 38.2 (SE = 3.6) cm in height. Dominant herbaceous species were dogtail (*Cynosurus echinátus*) and perennial ryegrass (*Lolium perenne*); fescue (*Festuca arundinácea*), orchard grass (*Dactylis glomerata*), and sedges (*Carex* spp.) and rushes (*Juncus* spp.) occurred in more mesic sites. Dominant shrub species were poison oak and wild rose (*Rosa eglanteria*). A disproportionate ($P < 0.05$) number of neonatal captures (40%) occurred in Closed Oak, which represented only 8.7% of the study area. However, capture sites were underrepresented (2.8%; $P < 0.05$) in Grassland, which comprised 33.6% of available habitat (Table 2). Remaining capture sites occurred among Open Oak (20%), Oak-savanna (11.4%), and Madrone (2.8%), which were used according to availability; Oak-conifer (5.7%) and Oak-madrone (2.8%), which were avoided; and Riparian (8.6%), which was preferred ($P < 0.05$).

TABLE 2. Habitat availability (proportion of study area, p_{ia}) and relative frequency (p_{io}) of fawn Columbian white-tailed deer (*Odocoileus virginianus leucurus*) observations with 95% confidence intervals among ten habitat types (Smith 1985*b*, 1987*a*), Douglas County, Oregon, May 1978–December 1980. Habitat types for which the value of p_{ia} falls outside the 95% confidence interval were either 'preferred' (p_{ia}< 95% interval) or 'avoided' (p_{ia} > 95% interval) by fawns; the proportion of observations in remaining habitat types paralleled corresponding habitat availabilities (Neu et al. 1974).

Habitat type	Proportion of study area (p_{ia})	Relative frequency (p_{io})	95% family confidence interval
Grassland	0.336	0.076	$0.041 \leq p_{io} \leq 0.111$
Shrub	0.044	0.170	$0.120 \leq p_{io} \leq 0.220$
Oak-savanna	0.132	0.147	$0.100 \leq p_{io} \leq 0.194$
Open oak	0.171	0.225	$0.172 \leq p_{io} \leq 0.280$
Closed oak	0.087	0.136	$0.090 \leq p_{io} \leq 0.182$
Oak-conifer	0.113	0.085	$0.048 \leq p_{io} \leq 0.122$
Oak-madrone	0.061	0.020	$0.002 \leq p_{io} \leq 0.039$
Madrone	0.014	0.038	$0.015 \leq p_{io} \leq 0.063$
Riparian	0.031	0.078	$0.042 \leq p_{io} \leq 0.114$
Conifer	0.011	0.025	$0.004 \leq p_{io} \leq 0.046$

We recorded 448 locations of radiocollared fawns (range: 8–13 per fawn) during June–August. Fawn locations for the remainder of the year were almost all (a few telemetry locations in early September) direct observations of marked and unmarked individuals from horseback (Table 3). Fawns preferred Shrub, Open Oak, Closed Oak, Madrone, and Riparian habitats while avoiding Grassland and Oak-madrone; Oak-savanna, Oak-conifer, and Conifer were used in proportion to availability (Table 2). Seasonally, fawns exhibited

TABLE 3. Relative frequency of fawn Columbian white-tailed deer (*Odocoileus virginianus leucurus*) observations among 10 habitat types and across four seasons within the interior valleys of the Umpqua River Basin, Douglas County, Oregon, May 1978–December 1980. (Sample sizes are given in parentheses.)

Habitat type	Jun–Aug (448)	Sep–Nov (533)	Dec–Feb (786)	Mar–May (759)
Grassland	0.036	0.098	0.075	0.089
Shrub	0.193	0.109	0.155	0.223
Oak-savanna	0.096	0.174	0.161	0.143
Open oak	0.241	0.217	0.205	0.250
Closed oak	0.084	0.098	0.199	0.116
Oak-conifer	0.096	0.076	0.075	0.098
Oak-madrone	0.012	0.043	0.006	0.027
Madrone	0.044	0.033	0.056	0.009
Riparian	0.169	0.109	0.043	0.036
Conifer	0.024	0.043	0.025	0.009

greater use of Shrub and Open Oak during spring and summer (Table 3), whereas Closed Oak received significantly greater use during winter (comparison of proportions in independent samples—Snedecor and Cochran 1980:124). Grasslands were used least frequently during summer, a period when Riparian experienced a significant increase in use (Table 2). Similar shifts in frequency of use occurred in Oak-conifer habitat during late spring and summer and in Madrone during winter and summer.

Discussion

We examined the question of whether the presence of livestock reduces the capability of populations of Columbian white-tailed deer (*O. v. leucurus*) in southwestern Oregon to further recover (i.e., increase population size and range expansion) by limiting reproduction and the availability of suitable fawning habitat. We did this by comparing structure and composition of vegetation between grazed and ungrazed sites, examining direct responses of dams to the presence of sheep or cattle, and quantifying the spatial dynamics of dams, the spatial and habitat distribution of natal areas, and habitat selection by fawns, all relative to the presence of livestock. Grazing reduced the vertical profile and ground cover of vegetation, gravid females avoided livestock and areas with livestock, the presence of livestock caused a shift in deer use and population density of sites without livestock, and the response of individual dams to livestock occurred at multiple spatial scales. Our study is the first to report evacuation of established home ranges by female deer during spring to establish disjunct ranges in areas without livestock.

Movement and Home-Range Dynamics

Adult females with home ranges that overlapped parts of the study area with livestock moved their center of activity seasonally and made exploratory forays during spring prior to parturition; 3 of 7 dams established ranges during the fawning season that were spatially separated from their annual home range. Females that occurred in parts of the study area with little or no livestock use had substantially smaller shifts in seasonal ranges and selected parturition sites within their annual home range. Female *O. virginianus* typically reduce home- range size, become less social, and segregate from other members of their family group for several weeks prior to and following parturition (Bertrand et al. 1996). However, establishing a disjunct fawning range has not been previously reported (Smith 1991).

A similar pattern of space use by *O. v. leucurus* relative to livestock disturbance was reported in a study that substantially overlapped our study area (Ricca 2000). Nearly all *O. v. leucurus* females (n = 18) in this study had home ranges established in areas with little or no livestock use. The space used by female *O. v. leucurus* varied little among seasons; only 25% of female home ranges shifted between spring and summer. Although 60% of the females in this study shifted core areas between spring and summer, shifts in area of concentrated use occurred within established home ranges; most females did not change their broader scale (95% home range) use of space (Ricca 2000).

Along the lower Columbia River, *O. v. leucurus* used areas with a greater percentage of cover (22–27%) than areas with little interspersed cover (8%; Suring 1974). Deer actively avoided close associations with livestock on the refuge; they rarely fed within 30 m of grazing cattle, and their use of pasture with low cattle stocking rates (<2.2 cows/ha) was significantly greater than those with higher stocking rates. However, the distance between annual centers of activity for individual deer rarely exceeded 300 m. For *O. hemionus*, Loft et al. (1991) reported that females reduced their use of habitats preferred by cattle and increased their use of habitats avoided by cattle. The effect of grazing by cattle occurred at 2 scales: selection of home range, and selection of habitats within the home range, with the greatest effect occurring during late summer when availabilities of forage and cover were least. Bowyer and Bleich (1984) also observed higher mule deer use on ranges without cattle.

We think exploratory forays and shifts in center of activity made by *O. v. leucurus* dams prior to fawning in our study were a response to the presence of livestock or to the cumulative effects of grazing of available habitat (Dusek et al. 1989). Similarly, adult female *O. virginianus* avoided areas grazed by cattle and sheep year round along the Yellowstone River in eastern Montana; riparian cover was the single most important factor affecting deer density distribution (Dusek et al. 1989). Riparian and oak woodlands were the most frequently used cover types by *O. v. leucurus* along the North Umpqua River (Ricca 2000), especially fawns (Ricca et al. 2003), with the highest use occurring in areas without livestock. Several other investigators concluded that distributions of *O. virginianus* rely on woody communities (Compton et al. 1988, Sparrowe and Springer 1970, Wiggers and Beasom 1986).

In our study, dams whose spring ranges overlapped sheep or cattle actively avoided livestock (especially sheep) or areas that were being grazed. Most underwent significant shifts in their center of activity, whereas others moved as much as 2.3 km ($\bar{x}$ = 1.93 km) during the fawning season to establish a separate area of intensive use away from livestock. At least 1 female responded immediately to the presence of sheep by establishing a home range for fawning beyond fenced areas that enclosed sheep or cattle (Figure 2). Within 24 h after sheep were brought into a lambing pasture, this dam moved away for about 8 weeks, during which time her 2 fawns were born and became old enough to accompany her. She returned to her annual home range after the sheep were moved from their lambing pasture. Similarly, *O. virginianus* in Montana left and avoided preferred habitat following the movement of livestock into those areas and did not return to those parts of their home range until cattle were removed (Compton et al. 1988). In areas where land free of cattle grazing was lacking, the home ranges of *O. hemionus* became larger (Kie et al. 1991). Consequences to fitness of shifting or enlarging home ranges are hard to quantify, but individual deer that leave preferred habitat or move to unfamiliar or less suitable sites presumably experience a lower nutritional plane because of lower quality forage (Bowyer and Bleich 1984).

Habitat Use

We were unable to directly compare habitat use by neonates between areas "with" and "without" livestock, largely because dams chose fawning sites without livestock. Indeed, we located only 3 fawns in portions of the study area with livestock and one of those fawns was abandoned, leaving too small a sample for such a comparison. Consequently, the vast majority of fawn capture sites (~70%) were in dense woodlands without cattle or sheep. Typical natal sites were <150 m from permanent streams, had the lowest obstruction to vision scores (most concealment), and were beneath a closed oak canopy. Radio-marked fawns also occurred more often than expected in habitats with denser vegetation; Shrub was the only preferred habitat without a closed overstory (Table 2). Similarly, Ricca et al. (2003) reported areas of concentrated use by *O. v. leucurus* fawns were <200 m from streams, in denser habitats, and had few if any conifers. They did not detect any patterns of habitat selection or avoidance, which might have been a consequence of a small number (11) of radio-marked fawns. However, habitat use was heavily biased toward oak-hardwood (i.e., madrone) and riparian cover types (Ricca et al. 2003). Suring (1974) reported dams on the Columbian White-tailed Deer National Wildlife Refuge selected closed canopy forest for fawning, avoiding pastures or other areas with little hiding cover.

Habitat use by fawns largely reflects choices of dams because young *O. virginianus* are either placed in hiding cover between feeding bouts (neonates) or remain closely associated with their mothers (Smith 1991). After marked fawns in our study began accompanying dams (at heel), their habitat use largely paralleled that of female family groups (Smith 1981). Only during the initial few weeks postpartum were there any obvious differences in habitat use between fawns and older deer. During that period, dams forage in habitats with less hiding cover, but typically remain solitary (Bertrand et al. 1996) and close enough to defend fawns against potential predators (Smith 1987b). Fawns, however, rely on dense understory vegetation for hiding cover (Loft et al. 1987). Sites that dams choose for parturition and fawn hiding cover during periods between nursing bouts have consequences for the security of fawns (Bowyer and Bleich 1984, Loft et al. 1987, Kie et al. 1991, Main and Coblentz 1996) and the nutritional plane of lactating females (Suring 1974), both of which can affect fawn survival, juvenile recruitment, and population growth.

Livestock grazing denudes hiding cover and alters the vegetative characteristics of preferred habitats (Loft et al. 1987, Kie et al. 1991); the presence of livestock can elicit habitat and home range shifts that markedly increase the density of deer within a limited amount of suitable habitat (Compton et al. 1988, Dusek et al. 1989). Habitat selection by dams during spring is influenced by the requirements of offspring; thus, site characteristics that enhance fawn survival (e.g., security, palatable forage) are highly preferred during and following parturition (Main and Coblentz 1996). As optimum fawning habitat becomes less available and dams concentrate into remaining patches, subordinate females likely are forced to use less suitable sites (Bertrand et al. 1996).

In our study area, a vast majority of Grassland habitat (815 of 922 ha) experienced a rotational grazing schedule by cattle and sheep (Smith 1985b). Not surprising, Grassland had the smallest ratio of use to availability among available habitat types, and dams whose home range overlapped a relatively large portion of Grassland habitat vacated those ranges during the fawning period. A visible reduction of hiding cover likely increases risk of predation on fawns (Kie et al. 1991), which can proximately impact recruitment rates and ultimately reduce the productivity of local populations (Bowyer and Bleich 1984). The effect of concentrating dams into limited fawning habitat is uncertain; dams typically have smaller home ranges during this time (Bertrand et al. 1996). Still, competition for nutritious forage and higher predation rates (a likely consequence of higher fawn density and increased predation success) could take a toll on fawn survival and recruitment.

In our study, dams concentrated within a narrow band of dense oak woodland (Closed Oak) along the North Umpqua River to have their fawns (Figure 2), typically remaining throughout the lambing period until the autumn green-up (Smith 1981). For dams that chose parturition sites with recent grazing or the presence of sheep or cattle during the fawning period, we did not document the survival of a single fawn into the autumn population. Those sites typically had little overstory and understory vegetation, less hiding cover, and were further from the river.

Young fawns typically are vulnerable to intense predation pressure (Smith 1991). During a three-year study along the lower Columbia River, radio-marked fawns experienced predation rates as high as 86% during the initial ten weeks postpartum (USDI Fish and Wildlife Service 1983, 1998). In a three-year study that overlapped our study area, Ricca et al. (2002:1259) reported consistently low survival (0.14 to 7 months of age) of fawns, with predation as the most frequent (57%) cause of proximate mortality. In our study, we saw red foxes (*Vulpes vulpes*) on multiple (≥3) occasions coursing through portions of the study area with relatively little woodlands, undergoing what appeared to be a systematic search of relatively few microsites with notably denser vegetative cover. Although predation by red fox was never observed, we found the remains of *O. virginianus* fawns at the entrance of fox dens on multiple (≥5) occasions. Interestingly, we never encountered evidence of fawn predation in preferred fawning habitat when searching with a dog or while conducting other field work.

Clearly, oak woodlands and riparian forests play a crucial role in the life history of *O. v. leucurus* in western Oregon, tied to population demography in multiple ways (Ricca 2000; Ricca et al. 2002, 2003; Smith 1985a). Population density is positively correlated with available woodland cover (Smith 1987a) and as we found in our study, successful reproduction and recruitment seemingly depend on dense woodlands near or along streams. Also, because *O. v. leucurus* in southwestern Oregon apparently relies on lowland woodlands along streams as corridors for dispersal, clearing those areas or continued grazing by livestock likely rendered those habitats unsuitable (Crews 1939, Scheffer 1940, Gavin 1978, Suring and Vohs 1979, Compton et al. 1988), with negative consequences for range expansion (Smith 1985a, Knutson and Naef 1997).

Implications for Conservation

Our results suggest that the presence of sheep or cattle and associated land management can impede further recovery of Columbian white-tailed deer populations in western Oregon through indirect and direct effects on population demography (i.e., limiting the availability of essential fawning habitat). The general conclusion from this and numerous other studies is that grazing reduces concealment cover and the quantity and quality of palatable forage, which increases predation risk to fawns, causes shifts in the use of habitat and space, and can concentrate dams within a limited amount of suitable fawning habitat. Also, because *O. v. leucurus* in southwestern Oregon apparently relies on lowland woodlands along streams as corridors for dispersal, clearing those areas or continued grazing by livestock renders those habitats less suitable, with consequences for range expansion.

In addition, our findings are consistent with the hypothesis that *O. v. leucurus* in southwestern Oregon has a narrow habitat niche and thus it is particularly sensitive to disturbances that reduce lowland woodlands, especially riparian forests.

Furthermore, this sensitivity likely contributed to the rapid decline and subsequent extirpation of *O. v. leucurus* populations across most of its historical range, renders it less competitive with *O. hemionus columbianus* in modified landscapes, and reduces opportunities for successful repatriation. Conservation efforts should focus on restoration of the *Quercus* woodland community, especially the plant associations along streams and rivers. Our findings suggest that reducing the grazing pressure of sheep or cattle or the land use associated with producing improved pasture (e.g., clearing of oak woodlands) is fundamental to restoring *O. v. leucurus* habitat.

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