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Spatial Use and Habitat Associations of Columbian White-tailed Deer Fawns in Southwestern Oregon

Abstract

Fawns represent a critical life history stage in the dynamics of deer populations, yet little recent information is available on the ecology of neonatal Columbian white-tailed deer (CWTD), a geographically isolated and federally endangered sub-species. We described home ranges, areas of concentrated use, and habitat associations of CWTD fawns in southwestern Oregon during the summers of 1997 and 1998. Spatial use patterns and habitat use within areas of concentrated use were described for 11 radio-marked fawns. Pooled habitat use was described for 24 radio-marked fawns. Areas of concentrated use averaged 2.4 ha, which was 13.3% of mean 95% home range size (18.0 ha). Frequent use of oak-madrone woodland and riparian cover types characterized fawn habitat use patterns. Cover types containing conifers were rarely used and usually not available within home ranges. Although we found no detectable patterns of habitat selection or avoidance among fawns, areas of concentrated use were composed mostly of oak-madrone woodland (35%) and riparian (26%) cover types. Moreover, 74% of concentrated use area was within 200 m of streams. Our results provide useful information on habitat characteristics used frequently by CWTD fawns.

Introduction

Columbian white-tailed deer (*Odocoileus virginianus leucurus*; CWTD) are a sub-species that was once ubiquitous throughout western Oregon and Washington, but now exists as two geographically isolated and federally endangered sub-populations (Smith, 1985a). The Douglas County sub-population of CWTD in southwestern Oregon was listed as endangered in 1967, but has been proposed recently for delisting (U.S. Fish and Wildlife Service 2002).

Although much research on spatial use and habitat associations has been conducted on fawns in other white-tailed deer populations (McCullough 1979, Porath 1980, Ozoga and Verme 1986, Huegel et al. 1986), little recent information exists on the life history characteristics of CWTD neonates. Smith (1982) conducted an extensive study of CWTD ecology approximately 20 yr ago and described habitat use for 45 marked CWTD fawns within the Douglas County sub-population. He concluded that CWTD were strongly associated with riparian areas, oak woodland, and shrub dominated habitats, and that habitat selection by fawns was related primarily to thermoregulation followed by adequacy of escape/hiding cover. Furthermore, he suggested that the extirpation of CWTD from much of its historic range was linked to the reduction of lowland riparian and oak woodland habitats. Inferences on neonatal movement patterns were limited, however, because radio telemetry techniques were not widely used during all years of his study.

The neonatal period represents a critical life stage in deer population dynamics, and the characteristics of this life stage need elucidation (Jackson et al. 1972). Estimates of spatial use such as home range and core areas are useful in determining the areal requirements of a species (Bingham and Noon 1997), and act as surrogates for resource distribution for post-partum females, abundance of fawn hiding cover, or fawn predation risk (Mace and Harvey 1983, Ozoga and Verme 1986). Habitat associations of neonatal deer (and maternal females) are complicated because they are influenced to various degrees by several factors including predation risk, climate exposure, and

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forage availability (Main and Coblentz 1996, Bowyer et al. 1998).

An understanding of macrohabitat associations of CWTD fawns is important to identify the habitat features that characterize fawning and rearing areas. Because CWTD are an endangered species, managers must make informed decisions regarding habitats that may be critical for fawns and postpartum females. Section 3 of the Endangered Species Act 1973 defines critical habitat, in part, as areas within the geographical range of species that contain physical and biological attributes essential to the conservation of a species and which may require special management considerations and protection. From a biological perspective, however, critical habitat is directly associated with an animal's fitness and can only be determined from manipulative studies (White and Garrott 1990). Unfortunately, these manipulative studies are rarely practical, but composition of habitat attributes within areas that receive disproportionate use may give managers useful information for habitat conservation planning (Samuel et al. 1985, Bingham and Noon 1997).

Our objective was to determine spatial use and habitat associations for CWTD fawns in the Douglas County sub-population. We simply described the magnitude and variation of fawn spatial use patterns. Our research questions regarding habitat associations were 1) how variable are patterns of habitat use and selection among fawns? 2) can variation in habitat use be explained by fawn gender, diel period, and fawn age? and 3) what habitat attributes characterize areas of concentrated use?

Study Area

We monitored CWTD within the lower North Umpqua River watershed in Douglas County, Oregon. The study area was bordered approximately by the towns of Roseburg to the south, Glide to the east, and Sutherlin to the north. Interstate 5 formed the western boundary. Elevation ranged from 165 to 595 m. Rainy winters and hot dry summers characterized the climate. Monthly average temperatures during our study ranged from 5.4°C in December to 21.1°C in August. Average annual precipitation was 108.1 cm, and ranged monthly from 0.5 cm in July to 24.3 cm in December (Western Region Climate Center, Reno, Nevada). Snowfall was rare.

Smith (1982, 1985b) provided an extensive description of plant communities and species composition in the study area. Whereas some stands of continuous deciduous hardwood/mixed-conifer forest and undisturbed riparian areas were present, vegetation communities most often represented a relatively disturbed environment due to past or current history of fire management, grazing, agricultural conversion, and housing development. Essentially, a mosaic of finely interspersed Oregon white oak (*Quercus garryana*), California black oak (*Q. kelloggii*), madrone (*Arbutus menziesii*), and grassland plant associations intersected by numerous riparian drainages characterized the study area. Large expanses of coniferous forest were rare, and smaller conifer stands normally were logged previously and regenerating. Rural housing or residential development bordered or intersected many parts of the study area.

Methods

Fawns were captured by hand between late May and early July 1997-1998. Three capture techniques were employed: 1) drives along transects, 2) observing behaviors exhibited by females, and 3) opportunistic encounters. We attempted to search all cover types to obtain random samples of marked fawns. Captured fawns were fitted with expandable breakaway radio-collars equipped with mortality sensors. We estimated ages of fawns by measuring hoof growth (Haugen and Speake 1958) and degree of umbilicus scabbing. Fawns were not weighed because we wanted to minimize overhandling that may result in abandonment (Livezey 1990).

We located fawns three to five times per week during diurnal, crepuscular, and nocturnal periods. We tracked fawns in a systematic random fashion to ensure that all fawns would be located at different times. We relied heavily on obtaining visual or estimated visual (i.e., homing in) locations to avoid problems associated with radio telemetry error. When triangulations were necessary ($n = 23$), we were usually within 200 m of the signal and used a bearing standard deviation of 5.78° to construct error ellipses. Successive locations of individual fawns were at least 12 hr apart to maintain temporal independence (White and Garrott 1990). We located fawns as early as 0400 to as late as 2300 PST to ensure adequate representation of diurnal and nocturnal movements (Beyer and Haufler 1994). A location was recorded as biased and discarded if a fawn fled the area because of observer presence and we were unable to determine its location before it fled. Triangulated locations whose error ellipse exceeded the size of the cover type containing the location were also discarded. Cover type, location type (visual, estimated visual, or triangulation), and diel period were also recorded. Diel periods were defined as crepuscular (2 hr before and after sunrise or sunset), diurnal (2 hr after sunrise to 2 hr before sunset), and nocturnal (2 hr after sunset to 2 hr before sunrise). We plotted all locations in the field on 1:24000 USGS topographic maps. Although we continued to locate and monitor fawns that remained alive for the life of the radio-collar, only locations obtained between the date of capture and mid-September (i.e. summer months) were used for spatial use and habitat association analyses. This resulted in a scope of inference to approximately the first three to four months of life.

Cover types and streams were delineated from scanned 7.5 minute ortho-photo quadrangle maps. Minimum cover type patch size was 1-ha. Cover types listed in Table 1 were categorized based upon a modification of detailed descriptions of percent coverage and species composition (Smith 1982,1985b). Streams were buffered to produce 5–100 m distance to stream classes (≤ 100 m, 101–200 m, 201–300 m, 301–400 m, > 400 m).

Spatial Use

We calculated estimates of spatial use for 11 fawns with greater than 20 locations each. Fixed kernel density estimators with bandwidths calculated using least squares cross validation (Seaman and Powell 1996) were used to estimate 99% and 95% utilization distributions, or home ranges, with the

TABLE 1. Description of cover types used to analyze habitat associations of Columbian white-tailed deer fawns in southwestern Oregon, summer 1997-1998.

Cover Type	Canopy cover	Typical plant species and general characteristics
Grassland	Shrub: < 25% Tree: < 5 %	Tall fescue (*Lolium arundinaceum*), perennial ryegrass (*Lolium perenne*), dogstail (*Cynosurus echinatus*), subterranean clover (*Trifolium subterraneum*). Included grazed pastures and prescribed fire was occasionally applied.
Grass shrub	Shrub: > 25% Tree: < 5%	Poison oak (*Toxicodendron diversilobum*), wild rose (*Rosa* sp.), hawthorne (*Crataegus* sp.), blackberry (*Rubus* sp.). Also included clear-cuts.
Oak-madrone savanna	Shrub: <5% Tree: > 5 and < 50%	Oregon white oak (*Quercus garryana*), California black oak (*Q. kelloggii*), madrone (*Arbutus menziesii*).
Oak-madrone savanna shrub	Shrub: > 25% Tree: > 5 and < 50%	Same species as oak-madrone savanna and grass shrub.
Oak-madrone woodland	Shrub: variable Tree: > 50%	Same as oak-madrone savanna. Oaks were more common on mesic sites, whereas madrone was more common on xeric sites. Understories were characterized by poison oak and wild rose.
Oak-madrone conifer	Shrub: variable Tree: > 50%	Same as oak-madrone woodland, plus Douglas-fir (*Pseudotsuga menziesii*) and western red cedar (*Thuja plicata*). Conifer canopy cover > 25 and < 90%. Understories are usually poorly developed.
Conifer	Shrub: variable Tree > 50%	Conifer canopy cover > 90%. Usually monotypic Douglas-fir stands with poorly developed understories.
Riparian	Shrub: variable Tree: variable	Oregon ash (*Fraxinus latifolia*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), Oregon white oak, common rush (*Juncus effusus*), sedge (*Carex* sp.). Narrow strips generally consisting of areas between 10 and 50 m of a stream.
Yard	Shrub: variable Tree: variable	Areas within 50 m of human development. Houses, gardens, lawns, small orchards and tree farms.

program KERNELHR (Seamen et al. 1998). Areas of concentrated use were estimated using the KERNELHR subroutine PLOTCNTR (Seaman et al. 1998). PLOTCNTR estimates an area of concentrated use by calculating the average observation density of all locations in a given set and then determines the contour where the observation density is greater than average. The average observation density is calculated as the sum of the linear array of the observed densities divided by the number of observed locations. This methodology avoids subjective and arbitrary contour selections, and each area of concentrated use is based solely on the density of locations for an individual fawn. We refrained from calling areas of concentrated use core areas because they were not tested against a null distribution of bivariate uniform locations within the home range (Samuel et al. 1985, Bingham and Noon 1997). Differences by sex were not tested because of the small sample size of fawns with spatial use estimates; therefore only descriptive statistics are reported.

Habitat Associations

We determined cover type use by pooling all fawn locations. We could not measure habitat use for individual fawns because of the relatively small mean number of locations per fawn (20 ± 6), which would have resulted in insufficient power to detect individual habitat use patterns (White and Garrott 1986). A chi-square test was used to determine if frequency of use was equal among all cover types. Differences in cover type use by sex, diel period, and neonatal/post-neonatal period were tested with chi-square contingency tables. The neonatal period was the date of capture through 15 July (ca. 45 days for most fawns), and the post-neonatal period was 15 July through 1 September. These natal periods served as a surrogate for fawn age, and 15 July was chosen as the cutoff date because we assumed most fawns had been borne and alive for at least 1 mo (see results). Conifer cover types were never used and were deleted from chi-square analyses. We calculated the precision of cover type use estimates with 95% confidence intervals for proportions (Ramsey and Schafer 1997).

We tested for selection of cover types and distance to stream classes within fawn home ranges (i.e., third-order selection) (Johnson 1980). Use of cover types and distance to stream classes within areas of concentrated use was estimated by first pooling areas of concentrated use and then calculating the mean percent composition by area of cover types and distance to stream classes. Availability was defined as the mean percent composition by area of cover types and distance to stream classes within 99% fixed kernel home ranges. Variance for use and availability estimates was calculated with 95% confidence intervals for proportions. We tested for selection of cover types and distance to stream by comparing 95% confidence intervals for areas of concentrated use (used areas) to 99% fixed kernel home ranges (available areas). Selection was inferred if confidence limits for availability did not overlap estimates of mean use. This selection analysis used the individual marked animal as the sample unit. Sample sizes were the number of fawn home ranges containing a particular cover type or distance to steam class. We pooled 1–11 fawns to estimate mean percent composition of a cover types, and 5 - 9 fawns for distance to stream classes, because not all cover types or distance to stream classes were available to fawns within their home range.

Results

We captured and radio collared 24 fawns: 16 (5 males, 11 females) in 1997, and 8 (5 males, 3 females) in 1998. The mean date of capture was 15 June (SE = 1.4 days), although fawns continued to be captured through 3 July. Mean age at capture was 5.7 ± 0.7 days for 20 fawns that could be aged accurately. After removing locations with observer bias and excessive telemetry error, we obtained a total of 413 locations from 11 fawns to describe spatial use and habitat selection, and 469 locations from all fawns to describe habitat use.

Spatial Use

Based on an average of 38 locations per fawn, mean 95% and 99% home range size was 18.0 ± 4.8 ha and 24.3 ± 6.9 ha. Mean area of concentrated use size was 2.4 ± 0.7 ha. On average, areas of concentrated use were found near the 71 ± 1.5% contour of observed location densities, and encompassed an area that included only 13.3 ± 0.9% of the 95% utilization distribution area (Table 2). Variability in spatial use among fawns was evident as coefficients of variation for spatial use estimates were relatively high (CV 95% home range = 94%, CV 99% home range = 88%, CV area of concentrated use = 94%).

TABLE 2. Individual estimates and descriptive statistics for 99% and 95% fixed kernel home ranges and areas of concentrated use for 11 Columbian white-tailed deer fawns in southwestern Oregon, summer 1997-1998.

Deer ID	Sex	No. locations	99% home range area (ha)	95% home range area (ha)	Concentrated use area (ha)	Concentrated use area contour (%)	Concentrated use : 95% home range area (%)
1130	female	30	19.5	14.9	1.2	69.6	7.9
1150	female	31	9.1	7.0	0.7	67.1	9.6
1750	female	44	29.7	22.9	3.6	78.9	15.7
1820	female	57	11.6	7.8	1.1	69.5	14.6
1890	female	43	41.4	30.0	3.6	61.8	11.9
1140	male	30	17.0	11.7	1.8	76.2	15.4
1240	male	25	11.6	8.7	1.4	74.6	15.7
1260	male	41	14.5	15.1	1.5	66.4	9.7
1790	male	54	86.3	60.4	8.5	68.6	14.1
1830	male	27	6.3	4.7	0.7	74.6	15.4
1860	male	31	19.9	15.1	2.4	73.4	15.8
mean		38	24.3	18.0	2.4	71.0	13.3
SE		3	6.9	4.8	0.7	1.5	0.9
range		25 – 57	6.3 - 86.3	4.7 - 60.4	0.7 - 8.5	61.8 - 78.9	7.9 - 15.8

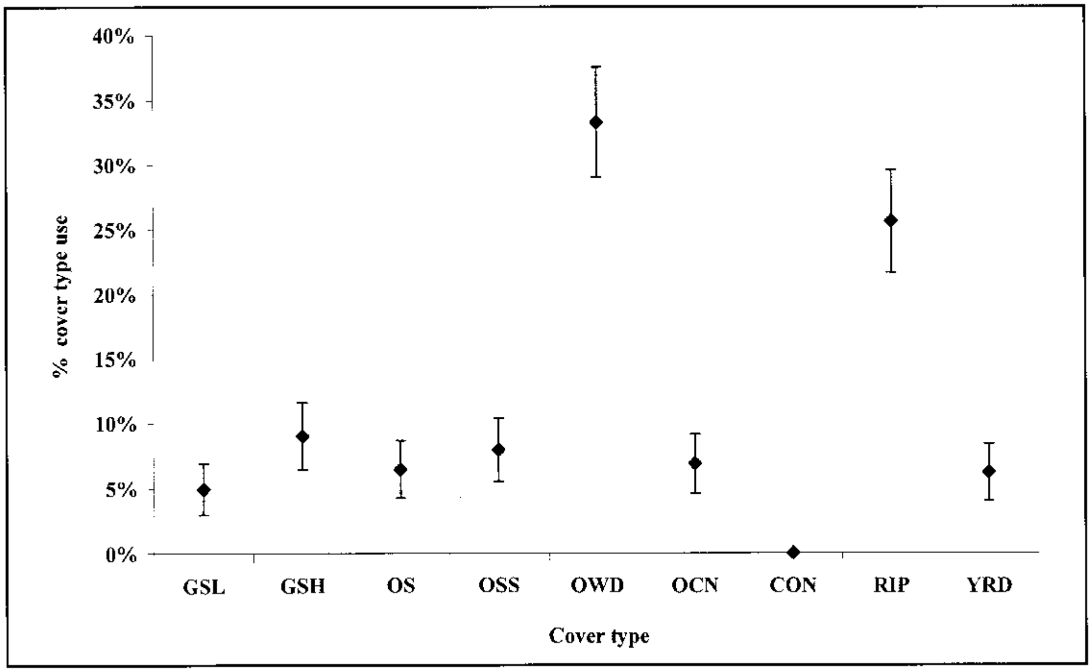

Figure 1. Mean percentage (and 95% confidence intervals) of Columbian white-tailed deer fawn locations (n = 469) by cover type in southwestern Oregon, summer 1997-1998. GSL = grassland, GSH = grass shrub, OS = oak-madrone savanna, OSS = oak-madrone savanna shrub, OWD = oak-madrone woodland, OCN = oak-madrone conifer, CON = conifer, RIP = riparian, YRD = yard.

Habitat Associations

Frequency of use differed among cover types when all fawn locations were pooled ($\chi^2 = 308.7$, $P < 0.0001$). Oak-madrone woodland was the most frequently used cover type (33%) followed by riparian (26%). All other cover types were used < 10% of the time except conifer, which was never used (Figure 1). Cover type use varied by sex ($\chi^2 = 82.1$, $P < 0.0001$). Female use of grass-shrub was 17% compared to no use by males. Conversely, males used oak-madrone woodland (42%) and yards (12%) more frequently than females (25% and 1%). Cover type use varied by diel period with sexes pooled ($\chi^2 = 17.83$, $P = 0.01$). Higher use of riparian areas occurred during crepuscular/nocturnal periods (34%) compared to diurnal periods (21%), while slightly higher use of yards occurred during diurnal periods (8%) compared to crepuscular nocturnal periods (3%). Cover type use did not differ significantly between neonatal and post neonatal periods with sexes pooled.

Oak-madrone woodland (35%) and riparian (26%) cover types constituted the largest average percentage of areas of concentrated use. Less than 10% of average concentrated use areas comprised other cover types. Conifer cover types were absent from all areas of concentrated use and composed < 3% of home range area (Figure 2). Areas of concentrated use were near streams, as 52% and 74% of their cumulative area was within 100 m and 200 m of a stream. Less than 20% of average concentrated use areas comprised distance to stream classes > 201 m (Figure 2). However, use and availability were variable among individual fawns. Thus, selection for particular cover types and distance to stream classes was not detected because confidence limits for availability within 99% home ranges overlapped estimates of mean use in areas of concentrated use for all cover types and distance to stream classes (Figure 2).

Discussion

Spatial Use

Ostensibly, the relatively small home ranges and areas of concentrated use of CWTD fawns in this study reflected their sedentary nature during the early stages of life (Jackson et al. 1972). Furthermore, only a small percentage of fawn home ranges were used most of the time because areas of concentrated use were 13% of home range size but contained 71% of all locations (Table 2). Relatively similar spatial use patterns were observed among CWTD adult females (Ricca 2000). It is also noteworthy that the average area contour delineating areas of concentrated use in this study was 71%, which is substantially greater than the 50% contour that is often arbitrarily chosen to delineate core areas. These results suggest that core areas should be determined quantitatively from observed distributions of animal locations instead of arbitrary delineations.

Variability in spatial use estimates among fawns in this study was similar to estimates reported for other white-tailed deer in Texas (Carroll and Brown 1977) and Michigan (Ozoga and Verme 1986), and mule deer (*Odocoileus hemionus*) in Montana (Riley and Dood 1984) and Washington (Steigers and Flinders 1980). Home range and movements of neonates are largely maternally controlled and variation could be attributed to maternal age (Ozoga and Verme 1986). Spatial use estimates also reflect resource distribution (Mace and Harvey 1983). Accordingly, variation in fawn home range size may have represented different availability of hiding cover for fawns or high quality forage for lactating maternal females, which resulted in different movement patterns among individuals.

Habitat Associations

Fawns in this study used primarily oak-madrone woodland and riparian cover types (Figure 1). These observed patterns of cover type use corroborate those estimated by Smith (1982), and were also similar to those exhibited by adult females (Ricca 2000). However, variability in cover type composition within areas of concentrated use and home ranges, suggested a degree of plasticity in fawn/maternal female habitat use, and selection was not evident (Figure 2).

Some variation in habitat use was explained by fawn gender and diel period. For example, male fawns never used grass-shrub but female fawns used it 17% of the time. This higher use of grass-shrub cover types by females supports previous observations of relatively frequent use of this cover type (Smith 1982). Use of riparian areas was also higher during crepuscular-nocturnal periods than diurnal periods in our study. Adult females frequently used open foraging habitat at night (Ricca 2000), so maternal females may have hid their fawns in denser and more secure riparian areas before foraging at night. Fawns should use open cover types more frequently as they mature and begin following their mothers, but we found no differences in habitat use between neonatal and post-neonatal periods. Fawns either continued to follow a hider strategy (Lent 1974) during this time, or maternal females continued to use the same habitats used for parturition.

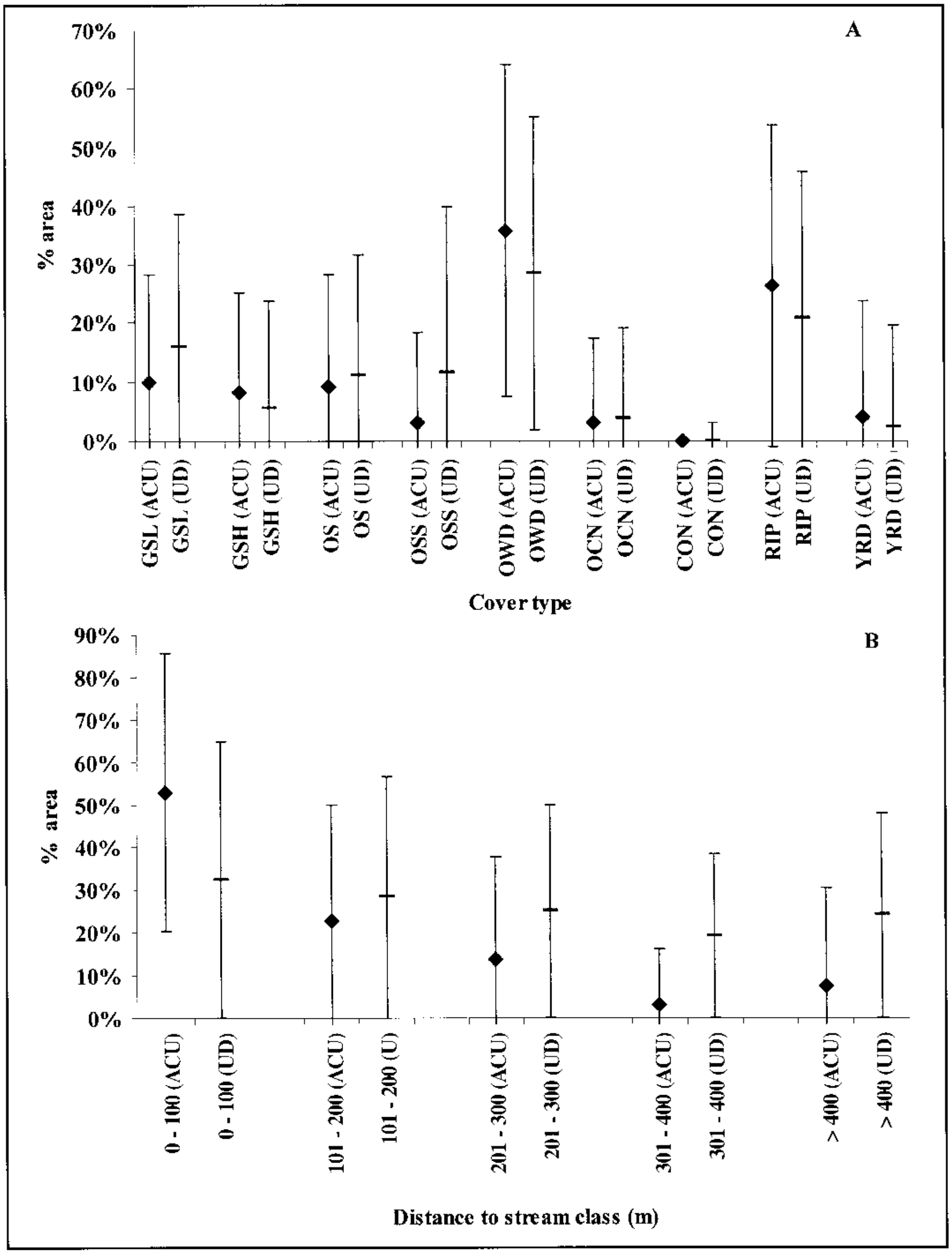

Figure 2. Mean percent composition (and 95% confidence intervals) of cover types (A) and distance to stream classes (B) within pooled areas of concentrated use and 99% fixed kernel utilization distributions for 11 Columbian white-tailed deer fawns in southwestern Oregon, summer 1997-1998. (ACU) = area of concentrated use, (UD) = 99% utilization distribution, GSL = grassland, GSH = grass shrub, OS = oak- madrone savanna, OSS = oak-madrone savanna shrub, OWD = oak-madrone woodland, OCN = oak-madrone conifer, CON = conifer, RIP = riparian, YRD = yard.

Habitat use by fawns and maternal females may represent trade-offs between minimizing predation risk and climatic exposure, against maximizing forage acquisition (Main and Coblentz 1996, Bowyer et al. 1998). June temperatures can exceed 32°C, to which fawns are vulnerable because of their high surface to volume ratio. Thermal cover is defined as vegetative overstories that minimize energetic costs associated with thermoregulation (Demarchi and Bunnell 1993). Although the fitness benefits of thermal cover have been questioned (Hobbs 1989), associations between thermal cover and habitat selection have been inferred in other studies of deer neonates (Fox and Krausman 1994, Bowyer et al. 1998). In this study, the broadleaf overstories of oak-madrone woodlands and riparian areas likely provided neonates relief from excessive heat. In addition, relatively frequent use of riparian areas and habitats < 200 m from streams within areas of concentrated use may indicate greater availability of free water and succulent, high quality vegetation that is important for lactation (Bowyer 1991).

We found no patterns of selection for particular cover types and distance to stream classes (Figure 2), so inferences regarding their relative biological importance are limited. However, our study was designed to examine selection of habitats within home ranges (third-order), yet selection can also occur at higher levels such as selection of a home range (second-order) or geographic range (first-order) (Johnson 1980). Selection is also difficult to detect when resources are ubiquitous within a home range (Johnson 1980). Selection for riparian and oak-madrone cover types may not have been detected because they were relatively common within home ranges. Conversely, low availability of conifer and oak-madrone-conifer within home ranges suggested that these cover types may not have been selected at the home range level. Also, our study lacked sufficient power to detect selection because of the low number of radio-collared fawns (White and Garrott 1986). Thus, lack of selection within home ranges does not necessarily equate with lack of importance. Future studies should evaluate selection of home ranges and the resources they contain across the local range of Douglas County CWTD.

Because such a high frequency of spatial use occurs within a relatively small area, it is plausible to assume that areas of concentrated use for fawns contain resources that contribute to survival and reproductive success of CWTD during this crucial life history stage. Oak-madrone woodlands and habitats within 200 m of streams may represent areas of increased biological importance. Although areas of concentrated use may not provide all necessary resources (Buchanan et al. 1998) and we have no direct measure of fitness, our results will aid managers in determining habitat conservation strategies for this endangered species in a less-arbitrary fashion (Bingham and Noon 1997).

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