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INFLUENCE OF COYOTES ON HABITAT USE BY MULE DEER FOLLOWING A WILDFIRE

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Predators can cause prey to make habitat choices that could affect their survival. We studied the influence of coyote, *Canis latrans*, presence on habitat use by desert mule deer, *Odocoileus hemionus eremicus*. Our study was conducted in 2000 in the Walnut Canyon Enclosure, a 246-ha enclosure on the Three Bar Wildlife Area, central Arizona. We radiotracked six mule deer (5 F, 1 M) in the enclosure with and without coyotes present during 2000 and compared our data with data obtained in the enclosure in 1998 when coyotes were absent. We compared habitat use among four environmental settings: burned and unburned interior chaparral and Sonoran desertscrub. We found evidence of changes in habitat use between years and after coyotes were introduced. Deer increased use of areas with the greatest vegetation cover when coyotes were present.

Key words: Arizona, *Canis latrans*, coyote, fire, habitat use, mule deer, *Odocoileus hemionus*

INTRODUCTION

Habitat availability and quality (Hall et al. 1997) and risk of predation may affect habitat use by ungulates (Pierce et al. 2004). Predator presence can cause prey to alter behavior

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including habitat use, activity times, group size, and vigilance levels (Lima 1988, Lima and Dill 1990, Altendorf et al. 2001). Behavioral changes related to predators may have a greater effect on a prey population than mortality of individuals (Kotler and Holt 1989, Brown et al. 1992, Brown 1999). Habitat alterations such as burning also can alter use of landscapes by ungulates.

Burning can increase nutritional content of plants and result in higher quantity and quality of forage than typical of unburned areas (DeWitt and Derby 1955, Dills 1970, Hobbs and Spowart 1984). Hot fires also can reduce available cover in burned areas, including thermal and security cover (i.e., >75 cm in height that provided shade for mule deer; Tull et al. 2001). Cover is an important factor in determining use of burned areas by deer (Davis 1977). Deer may be inclined to feed in burned areas for higher quality forage but may be more exposed to predators. Deer forage more in burned than unburned areas (Taber and Dasmann 1957, Davis 1977, Klinger et al. 1989), but when using burned areas deer often remain within 200 m of areas with greater cover (Klinger et al. 1989). To determine how predators influence habitat use of ungulates, enclosures can provide the necessary experimental areas.

Fencing that acts as a physical barrier to coyote movement is the most consistent nonlethal control method for coyotes (Wade 1978). Enclosures also provide an opportunity to experiment within a natural setting because habitat and selected animals (e.g., prey and predators) can be excluded or included. The Walnut Canyon enclosure (246 ha) in central Arizona provided an opportunity to study habitat use by mule deer with and without the presence of coyotes.

Coyotes are the primary predators of fawns in the Three Bar Wildlife Area that surrounds the enclosure (LeCount 1977, Horejsi 1982). Fawn survival was negatively affected by the presence of predators and poor vegetation conditions (Smith and LeCount 1976). Thus, if predation is an important factor in habitat use, mule deer should use habitat components with qualities that decrease the risk of predation (i.e., dense vegetation). However, forage (i.e., quality and availability) is also an important driver of habitat use by mule deer (Pierce et al. 2004). If the presence of predators influences habitat use by mule deer, then deer may encounter a tradeoff between choosing habitats with better hiding cover over habitats that have better opportunities for foraging. Nevertheless, in some cases, habitats may provide the least predation risk and the greatest forage opportunities; hence, there would not be a tradeoff (Pierce et al. 2004).

We studied habitat use of mule deer in an enclosure with coyotes in 2000, and compared our results to habitat use by mule deer in the predator-free enclosure during 1998 (Boyd 2001). We hypothesized that coyotes would not change the use of environmental settings used by mule deer following a wildfire.

STUDY AREA

The Walnut Canyon Enclosure (33° 41’ N, 111° 13’ W, Figure 1) was located in central Arizona on the Three Bar Wildlife Area in the Tonto National Forest, 60 km northeast of Phoenix on the eastern slope of the Mazatzal Range. Domestic livestock had not grazed the area since 1947 (Smith and LeCount 1976). The 246-ha predator-resistant enclosure was built in 1970 and was functional during our study. The fence was 2.75-m tall, standard chain-link with a 0.6-m skirt of woven wire attached to the bottom, aligned outside the enclosure (to prevent predators from digging under). Two permanent water sources were available, one each in burned and unburned areas.

Elevations in the enclosure ranged from 790 to 1,130 m. Water drained eastward into Roosevelt Lake. South-facing slopes were xeric and characterized by Sonoran desertscrub vegetation (Turner and Brown 1994) including saguaro (*Carnegiea giganteus)*, jojoba *(Simmondsia chinensis),* catclaw acacia *(Acacia greggii),* and prickly pear *(Opuntia* spp.). North-facing slopes were more mesic and characterized by interior chaparral (Pase and Brown 1994) vegetation including shrub live oak *(Quercus turbinella)*, mountain mahogany *(Cercocarpus* spp.), buckwheat *(Eriogonum* spp.), and false mesquite *(Calliandra eriophylla)*.

Hot, dry summers and mild winters typified the climate. Average annual rainfall for the area was 47.3 cm (range 30.3 - 99 cm/year; Western Regional Climate Center 1976-2000; http:// www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?az7281). Summer monsoon storms (July-September) produced an average of 12 cm of precipitation (1976-2000), resulting in a brief growing season. During October to April, the area received an average of 33 cm of

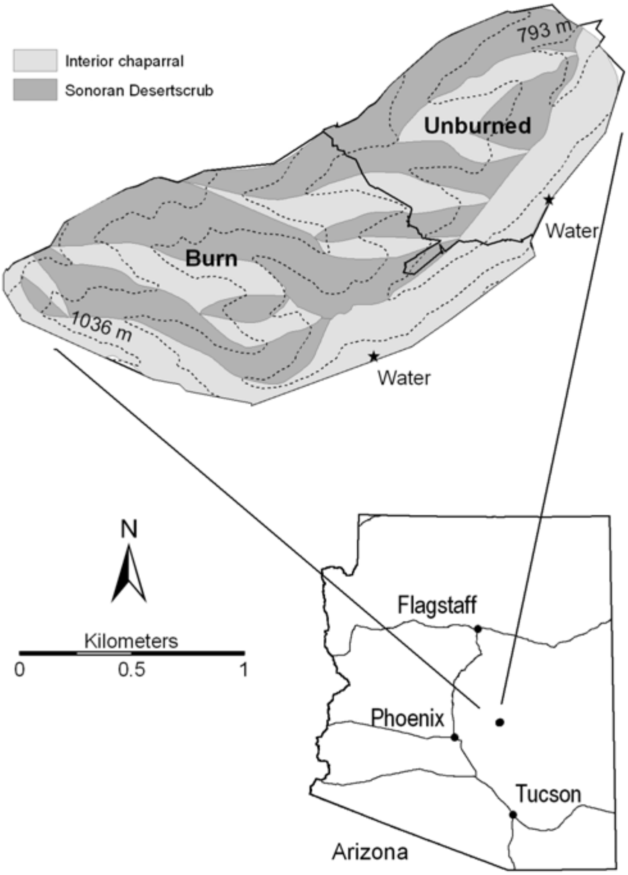

Figure 1. The Walnut Canyon Enclosure, Three Bar Wildlife Area, Arizona with fence, burn boundary, contour lines, and water catchments, 1998 and 2000.

precipitation. Average monthly temperatures ranged from 30°C (July) to 7°C (December). Average maximum monthly temperatures ranged from 16°C (January) to 39°C (July; 1976-2000). The area had frost an average of 67 days/year and occasionally received light snow (<3 cm) (Western Regional Climate Center Roosevelt 1976-2000).

From 28 April to 14 May 1996, the Lone Fire burned about 24,280 ha of Sonoran desertscrub, chaparral, and ponderosa pine *(Pinus ponderosa)*, including most fuels in the western part of the enclosure (159 ha). Most vegetational thermal cover, which also serves as security cover (Tull et al. 2001) in Sonoran desertscrub, was burned. During wet periods, forbs and grasses were abundant but there was minimal woody vegetation taller than 40 cm. Immediately following the fire, standing dead trees and shrubs were rare, and most cacti were dead or damaged (Boyd 2001). However, cacti began regenerating rapidly, resulting in many small cacti within 4 years of the fire. The trunks and large branches of most woody chaparral species survived the fire and regenerated at the base, providing thermal and security cover, and browse.

We walked and measured the perimeter of the burn line in 1998 with a GPS unit to map the area. The ridges in the enclosure ran approximately west to east resulting in slopes that faced north or south. Vegetation associations were closely tied to slope aspect, allowing us to map south-facing slopes as Sonoran desertscrub and north-facing slopes as interior chaparral. Vegetation associations, when combined with the burn line, resulted in four environmental settings: burned and unburned chaparral and burned and unburned desertscrub (Figure 1).

METHODS

We captured and radiocollared (Telonics, Mesa, Arizona, USA) six mule deer (5F, 1M) during 1997-1998 (Boyd 2001). All animals were captured with a net-gun fired from a helicopter (Krausman et al. 1985). The number of deer in the enclosure was 18, 29, 34, and 28 during 1998 through 2001, respectively.

We located radiocollared mule deer from the ground and observed them between dawn and dusk. We split the day into sessions: dawn-0959, 1000-1359, and 1400-dusk. Because diurnal and nocturnal habitat use of desert mule deer is similar, we assumed our daytime observations were sufficient to describe mule deer habitat use (Hayes and Krausman 1993). We collected data in sessions (i.e., more than 1 observation of each radiocollared animal during each time category) so radiocollared deer were similarly represented in the sample. We determined which deer to radiotrack from a computer-generated random list of frequencies. We also recorded incidental sightings of radiocollared and uncollared mule deer and if no collared animals were present, we recorded the information for the first uncollared adult animal observed in the group. When we located groups with more than one collared individual, we recorded the location for only one of the collared individuals based upon what animal was being sought, or if that animal was not present in the group, based upon a computer-generated random list of the collared animals.

We plotted animal locations on a 7.5-minute series United States Geologic Survey topographic map (scale 1:24,000) and determined coordinates with a Universal Transverse Mercator (UTM) grid. For each animal sighting, we recorded date, time category, location (UTM coordinates), plant association, and burn status (burned or unburned). If we could not determine the specific location of deer bedded in dense vegetation after less than one hour of scanning, we abandoned the attempt.

During 2000, we placed three radiocollared coyotes in the enclosure. Coyote numbers were maintained at 2-3 individuals when present from 10 April – 7 September. During the rest of the year (i.e., 1 January – 9 April and 8 September – 31 December) coyotes were absent from the enclosure. We located and observed the coyotes daily with the aid of telemetry.

Because factors other than predators could have affected habitat use by mule deer, we measured vegetation availability. The finite area of the enclosure allowed for accurate measurement of the abundance of the four environmental settings. We measured vegetation canopy cover (e.g., tall shrubs, low shrubs, grass, forbs, bare ground, and other) and thermal cover each quarter on 64, 30-m line transects at 18 randomly selected permanent sites within the enclosure (Boyd 2001). In addition to the permanent sites, we also measured one 30-m line transect at three mule deer locations during each data collection session. When transect lines on microsites crossed into a different environmental setting, we classified the microsite as being in the environmental setting in which the line began (i.e., the environmental setting of the location of the deer). Ordinary confidence intervals were used to compare differences among vegetation characteristics (Johnson 1999). Vegetation data were collected during the middle month of each of four seasons (i.e., winter, January – March; spring, April – June; summer, July – September; and autumn, October – December). We determined percent thermal cover by dividing the total length of thermal cover along a transect, by the length of the transect (Canfield 1941, Ordway and Krausman 1986).

We used chi-square goodness-of-fit tests (Neu et al. 1974, Byers et al. 1984) to compare observed habitat use to expected habitat use between the four available environmental settings by comparing number of observations in the four environmental settings with area (calculated with ARC/INFO; Experimental Systems Research Institute, Redlands, CA, USA) of each setting. We calculated simultaneous 90% Bonferroni confidence intervals to infer selection (i.e., use > availability) and avoidance (i.e., use < availability) when we found evidence of a difference ($P < 0.10$) between expected and observed use (Neu et al. 1974, Byers et al. 1984).

To reduce among-animal variability (White and Garrott 1990), we pooled locations among animals to test for selection and avoidance by classifications of deer (F, M, all mule deer). This type of pooling allowed for inclusion of data from animals whose low frequency observations precluded individual analysis (e.g., animals radiocollared for part of the study, uncollared animals). Results for animals observed less than five times in at least one environmental setting are more speculative than those with larger samples (Manly et al. 1993), but were included to indicate habitat use trends.

We obtained data on mule deer habitat use in the Walnut Canyon Enclosure during 1998 without coyotes (Boyd 2001), and compared habitat use of mule deer in 2000 during coyote-present and coyote-absent periods with the equivalent seasonal periods in 1998.

We measured distances from deer and random locations to the burn boundary with ARC/INFO (Krausman and Etchberger 1995). We compared equal numbers of distances of actual and random locations within each environmental setting with 1-way analysis of variance (ANOVA) and linear contrasts. We used multifactor ANOVA and linear contrasts to test for main effects of season, coyote presence, environmental setting, and gender on distance from the burned boundary. We measured distances between deer and coyote locations and between random pairs of points with ARC/INFO. We compared the random distances to the actual distances with a 2-sample *t*-test. We tested for the main effects of gender and environmental setting on distance between mule deer and coyotes with a multifactor ANOVA and linear contrasts. We used an alpha level of 0.10 for all statistical tests.

RESULTS

We located mule deer 275 times during 2000: 118 times without coyotes present and 157 times when coyotes were present. Mule deer were located 334 times in 1998 (Boyd 2001). When data from 1998 were broken into periods equivalent to our coyote-absent and coyote-present periods, mule deer were located 209 times when coyotes were absent and 126 times when they were present. We only had 1 collared mule deer but collected data from uncollared male deer 12 times in 1998 and 11 times in 2000.

Between 1998 and 2000 when coyotes were absent, female and pooled mule deer decreased use of unburned desertscrub from selection to neutral use (i.e., use = availability; Table 1, Figure 2). When coyotes were present, female mule deer increased their use of burned and unburned chaparral from neutral to selection and decreased use of unburned desertscrub from neutral to avoidance. Male mule deer increased use of burned chaparral from neutral to selection and decreased use of burned and unburned desertscrub from neutral to avoidance. Pooled mule deer decreased use of unburned desertscrub from neutral to avoidance and increased use of burned and unburned chaparral from neutral to selection (Table 2, Figure 3).

The distance of mule deer locations from the burn edge differed from random distances ($F_{7,538}$ = 14.83, $P < 0.001$, ANOVA *F*-test). Mule deer used locations 128 m (90% CI 51 – 204 m) farther from the burn edge in burned chaparral than random locations ($t_{7,538}$ = 2.76, P = 0.006, linear contrast). There was suggestive evidence that distances of mule deer from the burn edge did not differ from random distances in unburned chaparral ($t_{7,538}$ = -1.61, P = 0.108, linear contrast) and burned desertscrub ($t_{7,538}$ = 1.57, P = 0.116, linear contrast). Distances of deer locations from the burned areas did not differ from random distances in unburned desertscrub ($t_{7,538}$ = 0.75, P = 0.455, linear contrast). Distances of mule deer locations to the burn edge were not affected by season ($F_{3,265}$ = 1.66, P = 0.177, multifactor ANOVA). The distance of mule deer locations to the burn edge were affected by sex ($F_{1,265}$ = 30.66, $P < 0.001$, multifactor ANOVA) and coyote presence ($F_{1,265}$ = 6.29, P = 0.013, multifactor ANOVA). Locations of male mule deer averaged 329 m (90% CI 231 – 428 m) farther from the burn edge than locations of female mule deer (t_{265} = -5.54, $P < 0.001$, linear contrast). Locations of mule deer when coyotes were present averaged 301 m (90% CI 102 – 500 m) farther from the burn line than locations when coyotes were absent (t_{265} = -2.51, P = 0.013, linear contrast).

Pooled mule deer and coyote locations averaged 287 m (90% CI 140 – 435 m) farther apart than the random pairs of locations (t_{208} = 3.20, $P < 0.002$, two-sample *t*-test). Gender of mule deer ($F_{1,99}$ = 3.38, P = 0.069, multifactor ANOVA) and environmental setting ($F_{3,99}$ = 16.13, $P < 0.001$, multifactor ANOVA) affected the distance between mule deer and coyotes. We found no difference between the distance of female mule deer to coyotes and the distance between random pairs (t_{166} = 1.05, $P < 0.293$, two-sample *t*-test). Male mule deer were 267 m (90% CI 26 – 508 m) farther from coyotes than female mule deer. Deer locations in burned chaparral were 270 m (90% CI 57 – 483 m) farther from coyotes than deer locations in other environmental settings. Deer locations in unburned chaparral were 620 m (90% CI 379 – 861 m) closer to coyotes than deer locations in other environmental settings. Deer locations in burned desertscrub were 1,088 m (90% CI 788 – 1,436 m) farther from coyotes than deer locations in other environmental settings. Deer locations in unburned desertscrub were 738 m (90% CI 354 – 1,122 m) closer to coyotes than deer locations in other environmental settings.

Table 1. Bonferroni Confidence Intervals for the proportion of actual use relative to availability of environmental settings by desert mule deer (females and males) in the Walnut Canyon Enclosure, Arizona, 1998 and 2000 without coyotes present (+ = use > availability, - = use < availability).

				Burned				Unburned			
				Chaparral (31.6% of total area)		Desertscrub (33% of total area)		Chaparral (17% of total area)		Desertscrub (18.4% of total area)	
Year Animal	*n*	x_3^2	*P*-Value	Act. use	90% C.I.	Act. use	90% C.I.	Act. use	90% C.I.	Act. use	90% C.I.
1998											
All F deer	163	37.31	<0.001	0.356	0.272-0.440	0.117	0.061-0.173(-)	0.245	0.170-0.320	0.282	0.203-0.361(+)
All M deer	46[a]	16.99	<0.001	0.587	0.424-0.750(+)	0.152	0.033-0.271(-)	0.087	0.000-0.180[b]	0.174	0.049-0.299
All deer	209	40.51	<0.001	0.407	0.332-0.484(+)	0.124	0.073-0.175(-)	0.211	0.148-0.274	0.258	0.190-0.326(+)
2000											
All F deer	93	25.22	<0.001	0.419	0.305-0.534	0.086	0.021-0.151(-)	0.247	0.147-0.348	0.247	0.147-0.348
All M deer	25[a]	22.99	<0.001	0.760	0.569-0.951(+)	0.080	0.000-0.202(-)[b]	0.080	0.000-0.202[b]	0.080	0.000-0.202[b]
All deer	118	34.73	<0.001	0.492	0.388-0.595(+)	0.085	0.027-0.142(-)	0.212	0.128-0.296	0.212	0.128-0.296

[a] <5 observations in ≥1 environmental setting.

[b] 0.000 was used in place of a negative lower limit.

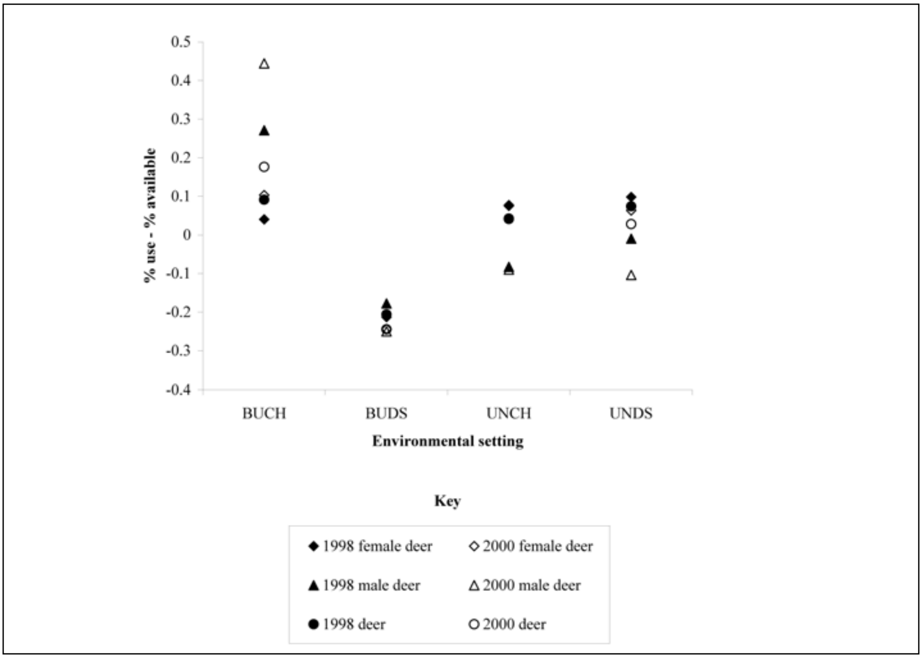

Figure 2. Percent use by mule deer minus percent of available burned chaparral (BUCH), burned desertscrub (BUDS), unburned chaparral (UNCH), and unburned desertscrub (UNDS) without coyotes present, Walnut Canyon Enclosure, Arizona, 1998 and 2000.

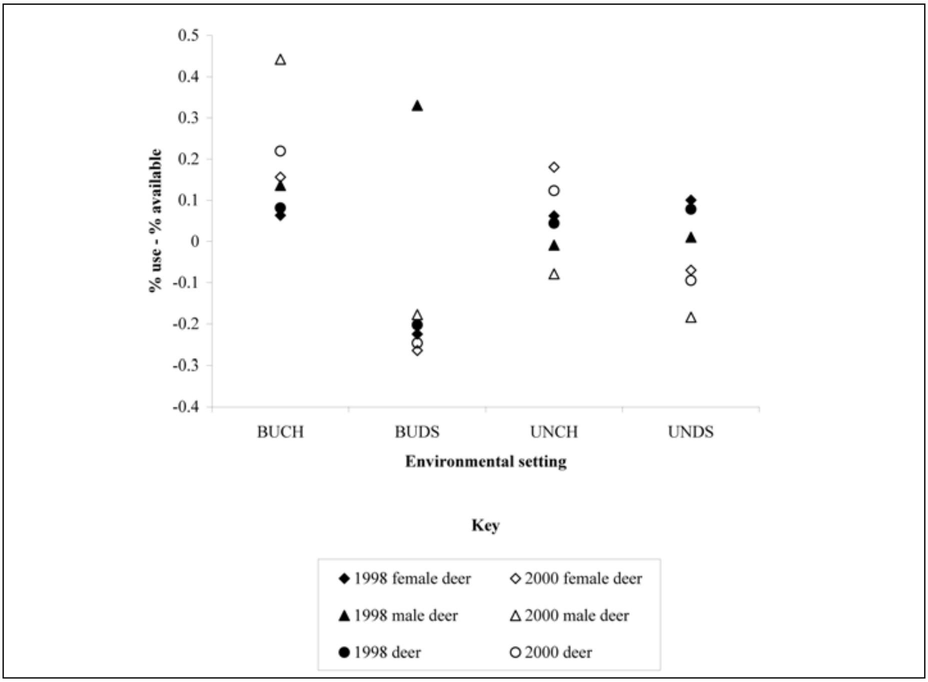

Figure 3. Percent use by mule deer minus percent of available burned chaparral (BUCH), burned desertscrub (BUDS), unburned chaparral (UNCH), and unburned desertscrub (UNDS) with coyotes present during 2000 and without coyotes present during the equivalent period in 1998, Walnut Canyon Enclosure, Arizona, 1998 and 2000.

Table 2. Bonferroni Confidence Intervals for the proportion of actual use relative to availability of environmental settings by desert mule deer (females and males) in the Walnut Canyon Enclosure, Arizona, 1998 and 2000 with coyotes present during 2000 (+ = use > availability, - = use < availability).

				Burned				Unburned			
				Chaparral (31.6% of total area)		Desertscrub (33% of total area)		Chaparral (17% of total area)		Desertscrub (18.4% of total area)	
Year Animal	*n*	x_3^2	*P*-Value	Act. use	90% C.I.	Act. use	90% C.I.	Act. use	90% C.I.	Act. use	90% C.I.
1998											
All F deer	95	23.03	<0.001	0.379	0.268-0.490	0.105	0.035-0.175(-)	0.232	0.135-0.329	0.284	0.180-0.388
All M deer	31	3.58	0.310	0.452	0.252-0.652	0.194	0.035-0.353	0.161	0.013-0.309	0.194	0.035-0.353
All deer	126	23.95	<0.001	0.397	0.299-0.495	0.127	0.061-0.193(-)	0.214	0.132-0.296	0.262	0.174-0.350
2000											
All F deer	123	62.21	<0.001	0.472	0.371-0.572(+)	0.065	0.015-0.115(-)	0.350	0.253-0.446(+)	0.114	0.050-0.178(-)
All M deer	33[a]	30.84	<0.001	0.758	0.590-0.925(+)	0.152	0.012-0.291(-)	0.091	0.000-0.203[b]	0.000	(-)
All deer	157	74.55	<0.001	0.535	0.446-0.624(+)	0.083	0.034-0.132(-)	0.293	0.212-0.374(+)	0.089	0.038-0.140(-)

[a] <5 observations in ≥1 environmental setting.

[b] 0.000 was used in place of a negative lower limit.

Deer consistently selected sites that had more thermal and security cover than permanent plots (Figure 4). Burned and unburned chaparral provided the greatest amount of thermal and security cover for deer microsites. Grasses and forbs followed similar patterns across the seasons in all 4 environmental settings (Figure 5, Figure 6). Greater grass and forb growth occurred in burned chaparral and desertscrub than the unburned areas (Figure 5, Figure 6). Browse (i.e., combined low and tall shrubs) was most abundant in unburned desertscrub, although unburned chaparral contained the highest amount of low shrubs (Figure 7).

DISCUSSION

Two important potential influences on habitat use by mule deer in the Walnut Canyon Enclosure during 2000 were the presence of coyotes during a portion of the year and occurrence of a drought during winter, spring, and summer (Western Regional Climate Center 1976-2000) especially during June, July, and August.

We found evidence of annual differences in habitat use of mule deer. Female mule deer decreased use of unburned desertscrub slightly between 1998 and 2000. Unburned desertscrub provided some of the lowest amounts of forbs and grasses during 2000 (Figure 5, Figure 6). During the wet year of 1998, the amount of forbs and grasses available in unburned desertscrub may have been adequate for deer. As the extremely dry winter of 1999-2000 progressed, deer may have spent more time consuming browse species that were plentiful in chaparral or herbaceous forbs and grasses that were more prevalent in burned environmental settings.

Coyote presence during 2000 also appeared to have affected habitat use by mule deer. Coyotes were present in the enclosure for the birthing season (i.e., July-August; LeCount 1977), a time when female mule deer should have been particularly vigilant for predators. When coyotes were present during our study, female mule deer selected burned and unburned chaparral. Female mule deer also decreased use of unburned desertscrub, though they also reduced use of unburned desertscrub during 2000 without coyotes present in the enclosure. Male mule deer decreased use of all desertscrub and increased use of burned chaparral when coyotes were present. The observed increase in selection of chaparral could be indicative of deer seeking areas of greatest thermal and security cover during the warmest seasons, or could be indicative of deer seeking areas where vegetation provided escape and hiding cover from coyotes. Unburned desertscrub provided high quantities of browse, but lacked thermal and security cover and herbaceous forage. The nutritional quality of forage in burned areas was not higher than that in unburned areas (O’Brien 2002, O’Brien et al. 2006) and probably did not instigate the shift in environmental setting use by mule deer.

Deer appear to perceive open areas as areas with greater risk of predation (Altendorf et al. 2001). The interior chaparral in the enclosure was much less open than the Sonoran desertscrub, even in burned areas where 4 years of growth created large thickets. Deer selected sites with high amounts of thermal and security cover compared to available thermal and security cover, possibly driven by ambient temperature or predation risk. Tull et al. (2001) found it difficult to distinguish if the use of bedding sites with high amounts of thermal cover were driven by thermoregulatory needs, hiding cover, or protection of fawns. Davis (1977) reported that cover was the most important factor in habitat selection by mule deer and elk, *Cervus canadensis*, in burned and clear-cut areas in Wyoming.

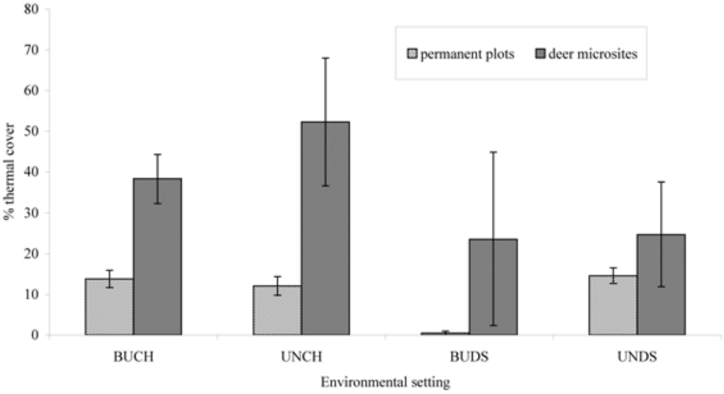

Figure 4. Percent thermal cover with 90% confidence intervals at permanent vegetation plots and mule deer microsites in burned chaparral (BUCH), unburned chaparral (UNCH), burned desertscrub (BUDS), and unburned desertscrub (UNDS) in the Walnut Canyon Enclosure, Arizona, 2000.

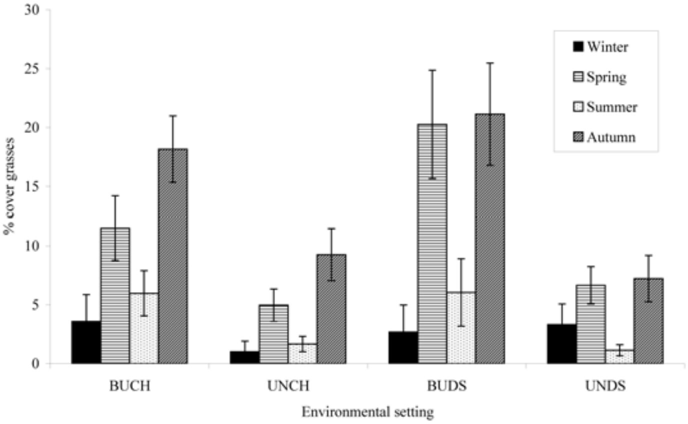

Figure 5. Percent grass cover with 90% confidence intervals at permanent vegetation plots in burned chaparral (BUCH), unburned chaparral (UNCH), burned desertscrub (BUDS), and unburned desertscrub (UNDS) in the Walnut Canyon Enclosure, Arizona, 2000.

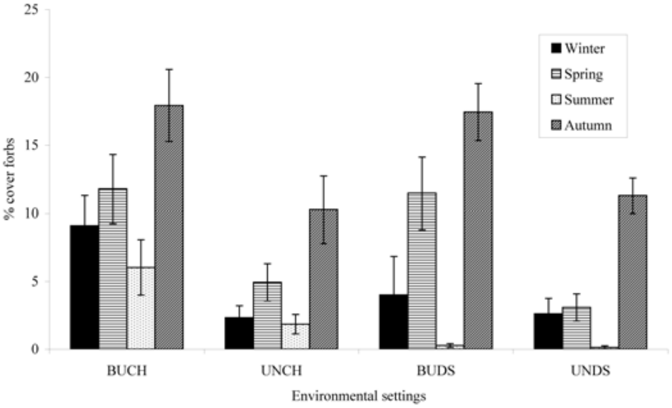

Figure 6. Percent forb cover with 90% confidence intervals at permanent vegetation plots in burned chaparral (BUCH), unburned chaparral (UNCH), burned desertscrub (BUDS), and unburned desertscrub (UNDS) in the Walnut Canyon Enclosure, Arizona, 2000.

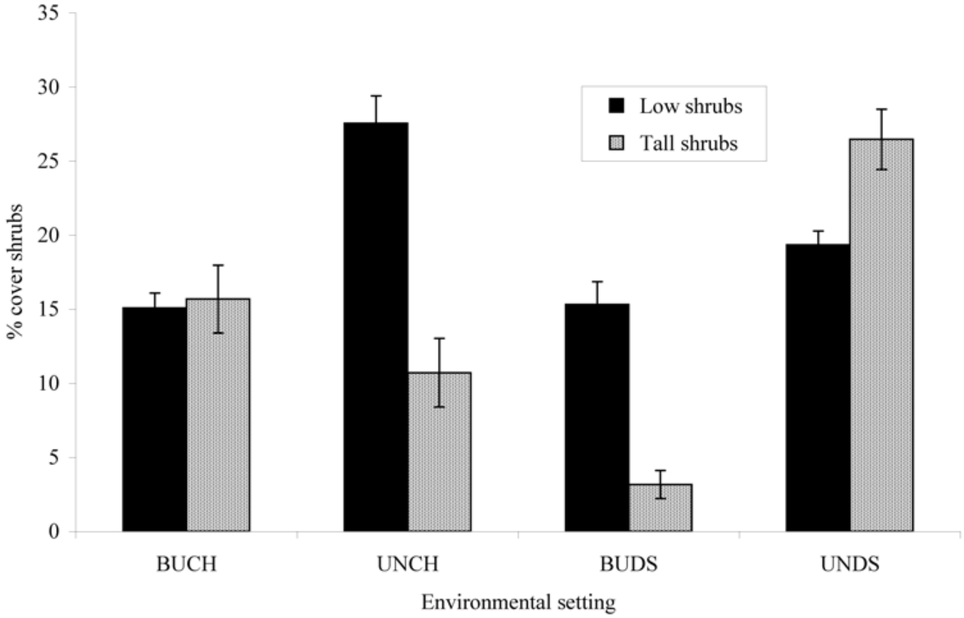

Figure 7. Percent shrub cover with 90% confidence intervals at permanent vegetation plots in burned chaparral (BUCH), unburned chaparral (UNCH), burned desertscrub (BUDS), and unburned desertscrub (UNDS) in the Walnut Canyon Enclosure, Arizona, 2000.

Jenks et al. (1994) determined that female deer selected areas with high biomass in the summer and males dispersed among all available habitats. Female mule deer in our study chose areas with the greatest thermal and security cover (and greatest biomass), burned and unburned chaparral. Grasses and overall shrub cover were equal or more abundant in the desertscrub environmental settings. However, forbs were more abundant during summer in chaparral, possibly because the shade and mesic environment allowed forbs to persist longer in chaparral than in desertscrub.

Male mule deer used all available habitats as expected during the equivalent coyote-present period in 1998, which also coincided with summer. However, male mule deer selected burned chaparral during all of 2000 and during the equivalent period without coyotes in 1998. Male mule deer were already selecting burned chaparral, particularly areas in the highest elevation of the enclosure (C. S. O'Brien, unpublished data), before coyotes were introduced into the enclosure, so we do not believe this habitat shift indicated male mule deer were avoiding coyotes. However, caution needs to be applied to these results because of the small sample size of males in the study.

Coyotes in our study predominantly used unburned chaparral, mostly occupying a large wash during daylight hours. This was consistent with the distance from coyotes of mule deer in each environmental setting. Mule deer in unburned areas were closer to coyotes than the distances predicted by random paired points and mule deer in burned areas were further from coyotes than the distances predicted by random paired points. The use by male deer of high elevations in the burned chaparral created greater distances between males and coyotes. Although females selected burned chaparral more when coyotes were present, the distance between female mule deer and coyotes were not different than the distances between random paired points. The discrepancy between the distances of male and female deer from coyotes was probably due to female mule deer selection of unburned chaparral when coyotes were present. The unburned chaparral was closer to most coyote locations than distances between random paired points. By selecting unburned chaparral, female mule deer may have been selecting cover from predators over higher quality forage (Pierce et al. 2004).

MANAGEMENT IMPLICATIONS

Managers often use prescribed burning to improve habitat for particular wildlife species, but the benefits of burning are not always well understood or quantified (Peek 1989). Before the introduction of non-native grasses, Sonoran desertscrub probably was not exposed to large, hot fires, a consequence of relatively low fuel loads. The Arizona uplands division of Sonoran desertscrub is the most arboreal desertscrub and regularly occurs on slopes where it merges with chaparral or semi-desert grasslands (Turner and Brown 1994). The proximity of desertscrub to areas with greater adaptation to fire may predispose this division of Sonoran desertscrub to more frequent fires. In Arizona, the Sonoran desertscrub biotic community often provides habitat for mule deer and white-tailed deer, *O. virginianus*.

Einarsen (1946) suggested that burned areas in more mesic landscapes than our study areas were excellent habitat for black-tailed deer, *O. h. columbianus,* after the first growing season provided adequate cover and food. Our data indicate this may be true in chaparral, but desertscrub may require many more growing seasons to replace lost thermal and security cover. Burning appears to have increased forb and grass growth in desertscrub and chaparral at least 4 years after the fire. The interior chaparral recovered more rapidly than desertscrub and provided a similar amount of thermal and security cover in burned and unburned areas within 4 years after the fire. Thermal and security cover appears to be important for mule deer, possibly for thermoregulation and hiding or escape cover. Managers should consider the need for thermal and security cover areas and forage needs of deer, when prescribed burns are planned. Deer that live primarily in desertscrub could be highly impacted by burning if other habitat components become unavailable.

Coyote presence affected habitat use by mule deer. Both male and female mule deer selected areas with greater levels of thermal and security cover when coyotes were present. Managers should consider the impact of coyote presence on mule deer when evaluating the carrying capacity of a particular area or mule deer use of recently burned areas. The habitat perceived to be available by mule deer might be decreased by behavioral decisions based upon predator presence.

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