

Summer Habitat Use by Snowshoe Hare and Mountain Cottontail at Their Southern Zone of Sympatry

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Key words

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The snowshoe hare (*Lepus americanus*) is a habitat specialist with a broad geographic range associated with boreal and subalpine forests in North America (Hall 1981, Hodges 1999a,b). It reaches southern range limits in the Southern Rocky Mountains in northern New Mexico, USA. Here, scant and mostly anecdotal evidence suggests that it is restricted to high-elevation, subalpine conifer forests dominated by Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*; Findley et al. 1975, DeVelice et al. 1986, Pase and Brown 1994). These southwestern forests lack several plant species, including lodgepole pine (*Pinus contorta*), jackpine (*Pinus banksiana*), black spruce (*Picea mariana*), birch (*Betula* spp.), and balsam poplar (*Populus balsamifera*), that, in more northern latitudes, are considered important habitat elements for snowshoe hare, especially in terms of cover (Bittner and Rongstad 1982, Litvaitis et al. 1985, DeVelice et al. 1986, Ferron and Ouellet 1992, Bryant et al. 1994, Pase and Brown 1994, Moir and Fletcher 1996). Methods for managing subalpine forests for snowshoe hare in the Southern Rocky Mountains are particularly important because of a current effort to reintroduce Canada lynx (*Lynx canadensis*), which is a specialized predator of snowshoe hare (Hodges 1999a,b, Colorado Division of Wildlife 2002).

Another leporid, the mountain cottontail (*Sylvilagus nuttallii*), occurs throughout the intermountain region of western North America, also reaching the southern extent of its range in the American Southwest (Hall 1981). Throughout this broad zone of sympatry, the two leporids segregate in ecological distribution with no reports of syntopy (Bittner and Rongstad 1982, Chapman et al. 1982, Chapman and Wilner 1986). The mountain cottontail typically is associated with lower-elevation sagebrush (*Artemisia* spp.)-dominated habitats (Orr 1940, Chapman 1975, 1999, Chapman et al. 1982). However, it is a habitat generalist and at more southern latitudes it also occurs in higher-elevation habitats including juniper (*Juniperus* spp.) and piñon pine (*Pinus* spp.) woodlands and middle-elevation montane conifer forests, which are dominated by ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), and blue spruce (*Picea pungens*; Bailey 1931, Durrant 1952, Findley et al.

1975, Hoffmeister 1986, Fitzgerald et al. 1994, Frey and Yates 1996). Mountain cottontails also occur in subalpine conifer forest in areas of the Southwest and Southern Rocky Mountains where snowshoe hare are absent, such as the White Mountains in east-central Arizona and the Pikes Peak massive in central Colorado (Warren 1910, Armstrong 1972, Hoffmeister 1986).

Findley et al. (1975) reported a specimen each of mountain cottontail and snowshoe hare from Goose Lake, Taos County, New Mexico, USA. This locality is at 3,542 m elevation, which is in the subalpine conifer forest zone. These records suggested that less ecological segregation between snowshoe hare and mountain cottontail might occur in the American Southwest, including the potential for local syntopy. Thus, the purpose of our study was to assess habitat use of snowshoe hare and mountain cottontail in subalpine conifer forests at their southern point of sympatry in the Southern Rocky Mountains.

Study Area

We conducted our study in the subalpine conifer forest zone sensu Dick-Peddie (1993) and Pase and Brown (1994) in Colfax, Mora, Rio Arriba, San Miguel, and Taos counties in north-central New Mexico, USA. This was the highest-elevation forest type, which in New Mexico generally occurred in elevation from timberline (about 3,650 m) down to about 3,000 m, depending on latitude, aspect, and other abiotic factors (DeVelice et al. 1986, Moir 1993, Moir and Fletcher 1996). Diagnostic species included Engelmann spruce and subalpine fir, which together identified the dominant series (i.e., spruce–fir forest; DeVelice et al. 1986, Dick-Peddie 1993, Pase and Brown 1994, Moir and Fletcher 1996). In the lower elevations of this zone, subalpine fir may be absent, and elements of montane conifer forest sensu Dick-Peddie (1993) and Pase and Brown (1994) may be present including white fir, Douglas-fir, and blue spruce. An open canopy woodland series dominated by bristlecone pine (*Pinus aristata*) and limber pine (*Pinus flexilis*) and often admixed with Engelmann spruce was found on warm aspects, ridges, rocky outcrops, and near timberlines (Moir 1993, Pase and Brown 1994). Aspen (*Populus tremuloides*) was an important seral species associated with forest openings (Dick-Peddie 1993, Pase and Brown 1994).

Methods

We collected habitat data as part of a study to document the distribution of snowshoe hare in New Mexico during July–August

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2001 and May–August 2002 (Malaney 2003). We surveyed leporids using spotlighting and trapping. We conducted spotlighting by driving a vehicle along roads using a hand-held spotlight and vehicle headlights. Trapping provided a means of assessing more interior forests because roads and other disturbances can cause edge effects for many animals, including leporids (Ferron et al. 1998, Ortega and Capen 2002, Keinath and Hayward 2003). We trapped concurrently in areas used for spotlight surveys following previous protocols (Keith et al. 1968, Dolbeer and Clark 1975, Malaney 2003). We set traps every 100 m along 1,000-m transects situated perpendicular to a road and where the road was 100 m between the fifth and sixth trap.

We recorded standard locality data and obtained Global Position System (GPS) coordinates at each leporid observation or collection point. We euthanized voucher specimens with a firearm or chloroform as described by the American Society of Mammalogists (ASM) guidelines for euthanasia (ASM Animal Care and Use Committee 1998). We prepared specimens as standard skin-and-skeleton vouchers, with frozen tissues, and deposited them in the Eastern New Mexico University Natural History Museum. Capture and collection of leporids was performed under State of New Mexico scientific collecting permit issued to J. K. Frey (permit 2868).

At each point locality where we collected or observed a leporid, we collected habitat variables following Litvaitis et al. (1985), Litvaitis (1990), and Higgins et al. (1996). We estimated aspect of the sample area using a compass, canopy cover in the 4 cardinal directions using a convex-spherical densitometer, and elevation using a GPS unit. We converted aspect to a heat-load index where the coolest slope (northeast facing) was given a score of zero, the warmest slope (southwest facing) received a score of 1, and with the scale represented by a decimal between these scores (Beers et al. 1966, McCune and Grace 2002). We visually estimated percentage of ground cover of softwood stems (conifer trees and shrubs), hardwood stems (deciduous trees and shrubs), herbaceous plants, moss, downed limbs and stems, and bare ground, in a 1-m² plot. Preliminary analyses indicated no significant difference ($P < 0.05$) between visual estimates and grid measurements of ground cover (Malaney 2003). We identified trees and recorded diameter at breast height (dbh) and distance of the nearest tree from the point locality.

We used a random azimuth to establish the first of 4 15-m perpendicular transects radiating from the point locality with 3 additional transects at 90°, 180°, and 270° in relation to the random azimuth. At the end of each transect, we recorded the percentages of ground cover and canopy cover using the same methods. We measured lateral foliage density (LF) for each of 5 0.5-m increments above the ground (i.e., LF1, LF2, LF3, LF4, and LF5) using a 0.3 m × 2.5-m-density profile board set at the end of each transect and viewed from the point locality (Nudds 1977). We determined foliage density for LF1–5 by estimating the percentage (to the nearest 5%) of that section covered by foliage. We evaluated woody plants between 0.25 m on either side of the transect and below 2 m in height. We classified limbs as <7.5 cm diameter and determined stem densities by counting all living and dead stems by species for each limb. We excluded stem densities of encountered shrubs, which included willow (*Salix* spp.), common juniper (*Juniperus communis*), Rocky Mountain maple (*Acer*

glabrum), currants (*Ribes* spp.), raspberries (*Rubus* spp.), snowberries (*Symphoricarpos oreophilus*), and shrubby cinquefoil (*Potentilla fruticosa*), from subsequent analyses. Preliminary analyses indicated the frequency of occurrence of each shrub at each locality was rare to uncommon (i.e., each species was present at 3.3–36.7% of localities; mean = 16%); 28% of localities had no shrubs; 80.0–100% (mean = 93.1%) of shrub occurrences accounted for 30 or fewer stems (compared with the overall mean stem density of 310); none was a significant correlate of lateral foliage density, and none was significantly different between mountain cottontail and snowshoe hare locations. For each tree species, we recorded the number and diameter at breast height of each tree that had at least a portion of the trunk within the belt transect and that had a diameter at breast height greater than 7.5 cm (Litvaitis et al. 1985, Litvaitis 1990). We excluded limber pine and Douglas-fir diameter at breast height from subsequent analyses because we recorded trunks on transects at single localities.

We assessed all data for normality with a Shapiro–Wilk test (Shapiro and Wilk 1965, SPSS 1999, Zar 1996). We used Pearson and Spearman correlations to assess relationships among parametric and nonparametric variables, respectively (Zar 1996). We used 2-tailed *t*-tests and Mann–Whitney *U* tests to test for differences in each variable between snowshoe hare and mountain cottontail localities for parametric and nonparametric variables, respectively (SPSS 1999, Zar 1996). We excluded bristlecone pine diameter at breast height from these analyses because no trunks occurred at snowshoe hare locations.

We examined variables for linearity and deemed them suitable for analysis using multivariate ordination techniques (McCune and Grace 2002). We excluded the number of trees of each species and the mean diameter, breast height, of each tree species from multivariate analyses because we did not find trunks of each species on most transects and because numbers of trees exhibited highly significant positive correlations ($P \leq 0.002$) with stem density for each species. For principal components analysis, we considered the ratio of the number of samples to the number of variables (2.7:1) suitable for descriptive purposes (McGarigal et al. 2000). We did not rotate the variables, and we only extracted components that had eigenvalues ≥ 1.0 because these usually sufficiently describe the variance within the variables (Chatfield and Collins 1980, Johnson and Wichern 1992, McGarigal et al. 2000). We considered loadings with a minimum absolute value of 0.40 to describe patterns (McGarigal et al. 2000). We retained components for interpretation based on the scree plot criterion (McGarigal et al. 2000, McCune and Grace 2002).

We used direct discriminant function analysis to explain any difference in habitat between the species (McGarigal et al. 2000, McCune and Grace 2002). All possible pair-wise correlations revealed high correlations (i.e., $r > 0.7$) among several lateral foliage densities; all other correlations were < 0.6 . Thus, we removed all lateral foliage variables except LF2 from discriminant analyses to avoid the potential for multicollinearity problems in the dataset (McGarigal et al. 2000). We used a chi-square transformation of the overall Wilks' lambda to test for differences in the group centroids (SPSS 1999). We used stepwise selection of variables to identify the most discriminatory variable accounting for any variation between snowshoe hare and mountain cottontail

Table 1. Descriptive statistics and tests of means for habitat variables that differed significantly at snowshoe hare and mountain cottontail localities in subalpine conifer forest in northern N.M., USA, during the summers of 2001 and 2002. Parametric statistic was the 2-sample *t*-test and nonparametric statistic was the 2-sample Mann–Whitney *U* test with normal approximation (*Z*).

Variable definition	Snowshoe hare ^a		Mountain cottontail ^a		Statistic	<i>P</i> ^b
	\bar{x}	SD	\bar{x}	SD		
Elevation	3,186.60	86.599	3,099.69	135.172	<i>Z</i> = -2.44	0.015*
Distance (m) to the nearest tree	1.28	0.517	2.46	3.134	<i>Z</i> = -3.35	≤0.001***
Mean % softwood ground cover	8.48	7.136	3.03	6.051	<i>Z</i> = -3.96	≤0.001***
Mean % hardwood ground cover	7.88	7.085	4.69	5.890	<i>Z</i> = -2.01	0.044*
Mean % herbaceous ground cover	16.84	10.617	40.60	23.121	<i>Z</i> = -4.03	≤0.001***
Mean lateral foliage density 0.5–1.0 m aboveground	61.40	21.941	50.07	19.114	<i>t</i> = 2.08	0.043*
Mean lateral foliage density 1.0–1.5 m aboveground	59.54	22.395	44.89	17.210	<i>t</i> = 2.74	0.009**
Mean lateral foliage density 1.5–2.0 m aboveground	61.80	21.822	46.18	21.510	<i>t</i> = 2.75	0.008**
Mean lateral foliage density 2.0–2.5 m aboveground	61.73	23.868	44.89	23.551	<i>t</i> = 2.71	0.009**
Mean number of <i>Abies lasiocarpa</i>	2.52	2.771	0.43	0.917	<i>Z</i> = 3.85	≤0.001***
Mean number of <i>Abies lasiocarpa</i> stems	145.05	113.552	79.16	98.525	<i>Z</i> = -2.25	0.025*
Mean dbh of <i>Abies lasiocarpa</i> (<i>n</i> = 17, 9)	11.52	3.196	20.58	10.708	<i>Z</i> = -2.19	0.029*
Mean number of <i>Pinus aristata</i> stems	0		20.33	51.029	<i>Z</i> = -2.35	0.019*

^a Sample sizes were *n* = 25 for snowshoe hare and *n* = 35 for mountain cottontail unless otherwise indicated.

^b Significant *P* values: * *P* < 0.05, ** *P* < 0.01, and *** *P* ≤ 0.001.

habitats (McGarigal et al. 2000). We used Wilks' lambda to rank the variables in ability to discriminate by passing the tolerance tests (0.05 to enter; 0.10 to remove; McGarigal et al. 2000). We used SPSS 10.0 for Windows (SPSS 1999) for statistical procedures.

Results

We documented 25 snowshoe hare and 35 mountain cottontail localities, which included 4 instances of syntopy (see Malaney 2003 for locality details). The proportion of snowshoe hare versus mountain cottontail localities documented in interior forest (31.1 and 3.2%, respectively) versus along roads (68.9 and 96.7%, respectively) was significantly different (*P* ≤ 0.001; Fisher's exact test; see Zar 1996). Based on univariate analyses, 13 habitat variables exhibited significant differences between snowshoe hare and mountain cottontail localities (Table 1).

The principal components analysis extracted 6 principal components, which accounted for 68.36% of the total variation in snowshoe hare and mountain cottontail habitats. Based on the scree plot criterion, we retained 2 principal components for interpretation, which together accounted for 41.34% of the variation in habitat. On component 1 (eigenvalue [EV] = 5.683; 25.83% of variation) high positive factor loadings included LF1–5, subalpine fir stem density, elevation, canopy cover, and Engelmann spruce stem density. High negative loadings included herbaceous ground cover and distance to the nearest tree. In dense, closed-canopy forest reduced sunlight inhibits growth of herbaceous ground cover, whereas in more open forests, such as at edges or in the bristlecone pine woodland series, increased light penetration results in greater herbaceous cover (Pase and Brown 1994). Thus, this component represents a foliage density gradient of sites at high elevation with closed-canopy spruce–fir forest to sites with open forest and much herbaceous ground cover. On this component, most (68.0%) of snowshoe hare locations had positive loadings; none had scores < -1.0 (Fig. 1). In contrast, scores for mountain cottontail locations were distributed widely on this component, although none had a score < 1.34 (Fig. 1).

Component 2 (EV = 3.412) accounted for 15.51% of the total

habitat variation. High positive loadings included heat index (i.e., aspect), aspen stem density, herbaceous ground cover, and bristlecone pine stem density. High negative loadings included canopy cover, ground cover of downed limbs and stems, and moss ground cover. This component represents an aspect gradient of sites on southwest-facing aspects with aspen and bristlecone pine forests and much herbaceous ground cover to sites on northeast-facing aspects with closed canopy forest and much downed wood and moss ground cover. Southwest-facing aspects (high heat index) receive more direct sunlight and are more xeric. This promotes herbaceous species and aspen that require light as well as relatively arid-adapted bristlecone pine (Moir 1993, Pase and Brown 1994, Bartos and Campbell 1998). In contrast, northeast-facing aspects are relatively shady, cool, and moist, which promotes the growth of spruce–fir forests that accumulate relatively large amounts of woody debris ground cover, have more moss ground cover, and have relatively little herbaceous growth. On this component the species exhibited broad overlap. However, most (76.0%) snowshoe hare locations had negative scores (Fig. 1).

The discriminant analysis resulted in an eigenvalue of 1.604 and canonical correlation of 0.785, which accounted for 100% of the variation. Despite the overlap in habitat that was evident in a histogram of canonical scores, the Wilks' lambda indicated a highly significant difference in the group centroids (Fig. 2; Wilks' lambda = 0.38, $\chi^2 = 46.89$, *df* = 18, *P* ≤ 0.001). The high percentage (88.3%) of original groups correctly classified also supported this difference. Misclassification of mountain cottontail localities (14.3%) occurred more frequently than snowshoe hare localities (8.0%). The stepwise discriminant analysis revealed herbaceous ground cover as the best discriminating variable based on its high, standardized canonical coefficient (1.36) and its high positive correlation (0.67) to the total canonical structure. Other significant discriminating variables that improved the model included (in order of importance) Douglas-fir stem density, ground cover of downed limbs and stems, and Engelmann spruce stem density. The percentage of cross-validated groups correctly

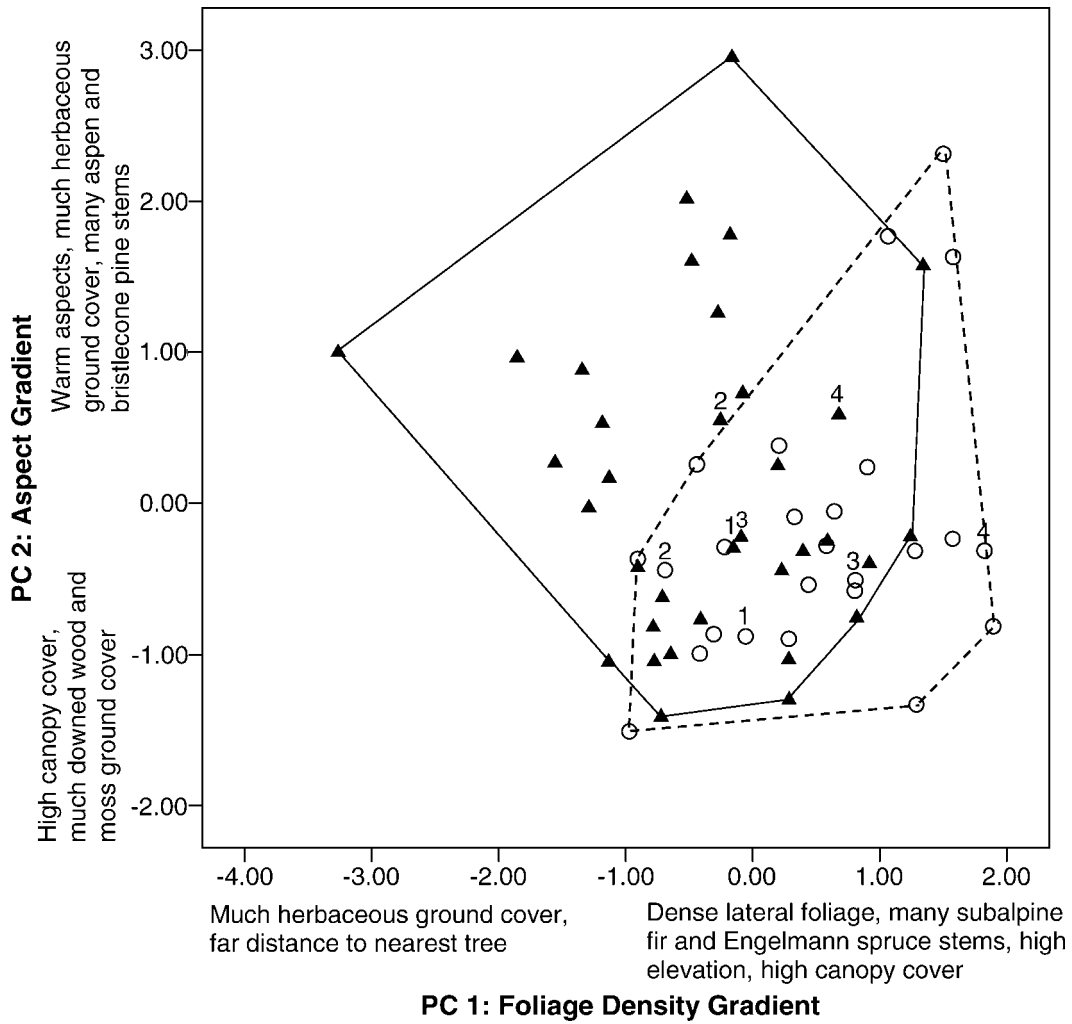


Figure 1. Relationship of snowshoe hare (open circles and dotted line) and mountain cottontail (closed triangles and solid line) locations in the subalpine forest zone in northern N.M., USA, during the summers of 2001 and 2002 on principle components (PC) 1 (foliage density gradient) and 2 (aspect gradient). Numbers above symbols correspond to syntopic localities, including 1) Vermejo, Colfax County; 2) Valle Vidal, Colfax County; 3) Osha Mountain, Colfax County; and 4) Chuchillo de Fernando, Mora County, N.M., USA.

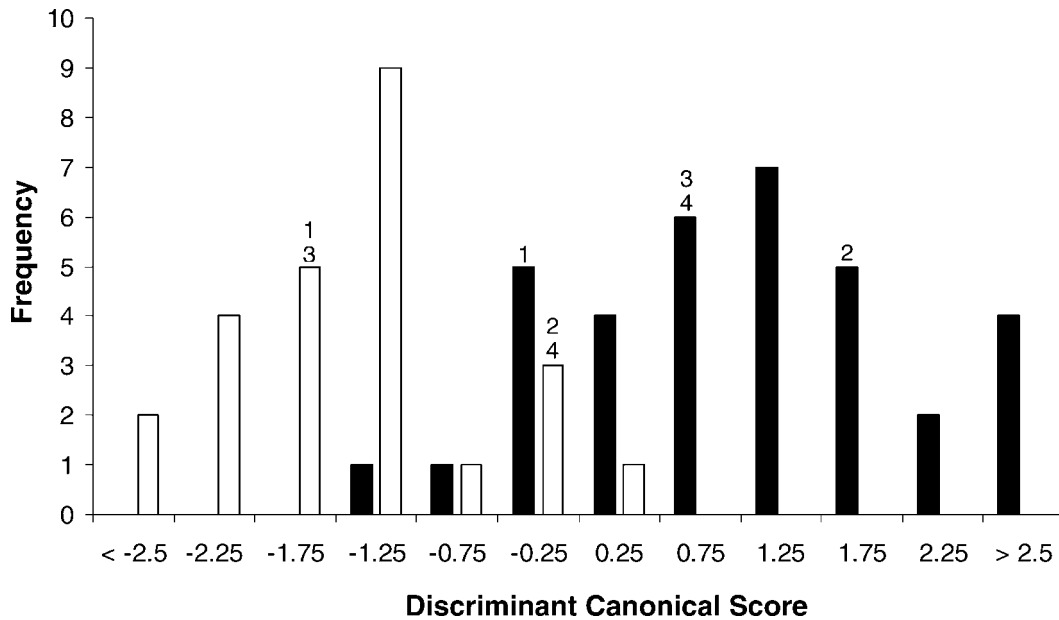


Figure 2. Canonical scores of snowshoe hare (white bars) and mountain cottontail (black bars) habitats in the subalpine forest zone in northern N.M., USA, during the summers of 2001 and 2002. Numbers above the bars correspond to syntopic localities, including 1) Vermejo, Colfax County; 2) Valle Vidal, Colfax County; 3) Osha Mountain, Colfax County; and 4) Chuchillo de Fernando, Mora County, N.M., USA.

Table 2. Significant correlation coefficients with lateral foliage density variables, including LF1 (0–0.5 m aboveground), LF2 (0.5–1.0 m aboveground), LF3 (1.0–1.5 m aboveground), LF4 (1.5–2.0 m aboveground), and LF5 (2.0–2.5 m above ground).

Variable	LF1 ^a	LF2 ^a	LF3 ^a	LF4 ^a	LF5 ^a
LF2	0.83***				
LF3	0.66***	0.86***			
LF4	0.56***	0.80***	0.86***		
LF5	0.59***	0.75***	0.78***	0.91***	
Elevation	0.30*	0.32*	0.28*	0.29*	0.33**
Diameter (dbh) of nearest tree	−0.36**	−0.41***			
Distance to nearest tree					−0.28*
Softwood ground cover			0.27*		
Hardwood ground cover	0.28*	0.38**	0.41***	0.41***	0.44***
Herbaceous ground cover			−0.34**	−0.38**	−0.31*
Bare ground cover				0.26*	
Canopy cover				0.26*	0.26*
Subalpine fir density	0.41***	0.57***	0.51***	0.58***	0.62***
Subalpine fir stem density	0.29*	0.38**	0.41***	0.47***	0.43***
Engelmann spruce density			0.31*	0.26*	
Engelmann spruce stem density			0.30*		
Aspen density	0.31*	0.34**			0.29*
Aspen stem density	0.26*	0.29*		0.30*	0.37***
Aspen dbh			0.49*		
Douglas–fir stem density		−0.26*			

^a Significant *P* values: * *P* < 0.05, ** *P* < 0.01, and *** *P* ≤ 0.001.

classified varied little among models, successively containing 1 (73.3%), 2 (75.0%), 3 (76.7%), or all 4 variables (80.0%).

Discussion

Mountain cottontail occupied a broad range of habitats within the subalpine conifer forest zone, which resulted in considerable habitat overlap and syntopy with snowshoe hare. However, discriminant function revealed significant habitat differences between the species. Mountain cottontails commonly used open forests with much herbaceous ground cover. For example, localities with negative scores on component 1 and positive scores on component 2 represented sites with high heat-index aspects dominated by open forests of aspen or bristlecone pine with much herbaceous ground cover. There was a disproportionate representation of mountain cottontail in these habitat associations, while only a single snowshoe hare locality was in this quadrangle of the principal components plot (Fig. 1). Further, we found mountain cottontails in the lower elevation spruce–fir forest habitats that included Douglas–fir, but never found snowshoe hare in these habitats (Table 1).

Snowshoe hare nearly exclusively used high elevation, closed-canopy spruce–fir forests with high horizontal foliage cover, especially above LF1. Other studies also have demonstrated that snowshoe hare prefer stands that provide dense, horizontal understory foliage cover, such as provided by shrubs, dense trees, or tree stands of ages that provide more lateral cover (Wolff 1978, 1980, 1981, Wolfe et al. 1982, Litvaitis et al. 1985, Hodges 1999a,b). Our data indicated that shrubs were not an important component of this cover. Rather, dense lateral foliage at all strata was associated with subalpine fir tree and stem densities (Table 2). Further, foliage densities at higher lateral strata (LF3–5) were positively correlated with Engelmann spruce tree and stem densities (Table 2). These factors indicate the importance of

high-elevation, closed-canopy spruce–fir forests (especially subalpine fir) to snowshoe hare. However, aspen trees also may contribute to, or provide, requisite cover (Table 2). For example, the 3 snowshoe hare localities with outlying positive scores on component 2 were from an extremely dense, monotypic stand of young aspen (small diameter spindly trees, <5 m tall) that appeared to be postfire pioneers (see Pase and Brown 1994, Malaney 2003).

Younger, second-growth forests typically provide dense understory horizontal foliage cover (Bittner and Rongstad 1992, Hodges 1999b). Similarly, we found that snowshoe hare localities had significantly smaller subalpine fir diameter at breast height and significantly more subalpine fir stems as compared with mountain cottontail localities (Table 1). Further, we found significant negative correlations between diameter at breast height of the nearest tree with aspen stem density ($r_s = -0.29$, $P = 0.023$) and LF1–2 (Table 2). Although these patterns suggest that younger forests provided greater horizontal cover, the relationship between tree diameter at breast height and its contribution to horizontal cover was ambiguous. For example, we found no significant relationship between diameter at breast height and stem density for any tree species and a significant positive correlation between aspen diameter at breast height and LF3 (Table 2). Reason for the ambiguous relationship between diameter at breast height and horizontal cover might be due to recording diameter at breast height only for those trees with a diameter at breast height >7.5 cm; we counted trunks of sapling trees <7.5 cm diameter, breast height, as limbs with stems (Litvaitis et al. 1985, Litvaitis 1990, Higgins et al. 1996).

Snowshoe hare are post-Pleistocene relicts in subalpine conifer forests in the Southern Rocky Mountains (Findley et al. 1975, Nagorsen 1985, Halanych et al. 1999). Conversely, it is unknown whether mountain cottontail were historical components of this forest zone. Natural variation in southwestern subalpine forests may have allowed both species to occur in this zone with snowshoe hare restricted to high-elevation spruce–fir forests on cool aspects and mountain cottontail occupying bristlecone pine woodlands on warm aspects, openings in spruce–fir forest created by fire, and the lower edge of spruce–fir forest that includes Douglas–fir.

Alternatively, we hypothesize that mountain cottontail only recently invaded subalpine forests, and especially spruce–fir forests, because of anthropogenic habitat alteration, such as caused by logging, fire, and roads, that have resulted in finer-scale openings and early successional stages (e.g., Allen 1989, Keith and Surrendi 1971, Ferron et al. 1998). Several observations support this hypothesis. First, Bailey (1931) did not consider mountain cottontail to occur any higher in elevation than the lower edge of mixed-conifer forest (ca 2,400 m), considerably lower than the subalpine forest. The first record of mountain cottontail in the subalpine conifer forest zone in northern New Mexico was the Goose Lake specimen, which was collected in 1956. In our study, mountain cottontails were associated with herbaceous ground cover, aspen, and bristlecone pine, all of which are considered seral species in subalpine conifer forests (Moir 1993, Pase and Brown 1994). Further, mountain cottontails were significantly more likely to use roadside-edge habitat, and we documented all syntopic localities during roadside surveys, which suggests that syntopy

often occurs at the interface between forest edge and denser, interior forest. Clear-cut or heavily logged areas were present at each syntopic locality. At these localities, each species used consistently different microhabitats with mountain cottontail occupying the logged areas and snowshoe hare occupying the uncut or lightly cut areas (Figs. 1 and 2; see Malaney 2003 for additional details). Other studies also found that snowshoe hare avoid recently logged areas and may not use areas of clear-cuts for 30 years postharvest (Conroy et al. 1979, Ferron et al. 1998).

Our results may only apply during the warmer months. Warren (1910) reported snowshoe hare at a relatively low elevation (1,981 m) in Gunnison County, Colorado, USA, during winter. Thus, possibly one or both of these species may experience seasonal changes in distribution and habitat associations.

Management Implications

To benefit snowshoe hare in the American Southwest, we recommend management actions that reduce forest canopy openings and increase horizontal and canopy cover in spruce–fir forests, especially as provided by subalpine fir. We caution that management developed in more northern latitudes to benefit snowshoe hare (e.g., rotational stand management, clear cutting areas directly adjacent to dense canopy sites, and thinning dense sites to create more open habitat) are, likely, inappropriate in the American Southwest because they stimulate early successional

stages, which promote mountain cottontail rather than snowshoe hare (Adams 1959, Brocke 1975, Conroy et al. 1979). We recommend that additional studies are needed in the Southern Rocky Mountains to better understand habitat relations of these species and their response to natural and anthropogenic habitat modifications.

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