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INFLUENCES OF SEASONS ON BOBCATS IN IDAHO

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Abstract: We studied a bobcat (*Felis rufus*) population in the Frank-Church River of No Return Wilderness (RNRW), Idaho, during 1982–85, to determine the influences of seasons on bobcat use of space, elevation, habitat, and prey. We fitted 30 of 35 captured bobcats with radio collars and collected 1,372 daytime telemetry locations. Weighted bivariate normal estimates of home-range sizes for 7 resident adults were smaller ($P < 0.05$) in winter (22.7 km^2) than in summer (88.1 km^2). In winter bobcats used lower elevations ($\bar{x}$ = 1,365.5 m), south–southwest aspect (61% use), rocky terrain (79% use), and open areas (73% use) where snow depth was less, temperatures were mild, and voles (*Microtus* spp.), their principal prey, were most abundant. During summer bobcats used higher elevations ($\bar{x}$ = 1,852.6 m) and a variety of forest habitats, timber stand densities, terrain, and aspects. During winters when snow depth was >20 cm, bobcats were more vulnerable to trapping. We recommend that harvest be controlled and populations closely monitored in areas where bobcat densities are low and where bobcat behavior is influenced by winter conditions.

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Regional bobcat populations differ in habitat use, diet, spatial requirements, and density (McCord and Cordoza 1982, Fuller et al. 1985, Litvaitis et al. 1986*b*). At northern latitudes, winter conditions and site productivity (Harestad and Bunnell 1979) may influence bobcat density (Berg 1979) and home-range size (Fuller et al. 1985). Snow depth influences bobcat travel patterns (McCord 1974), use of habitats (Bailey 1974, Hamilton 1982), and natural (Petraborg and Gunvalson 1962, Major 1983, Litvaitis et al. 1986*a*) and man-caused mortality (Petraborg and Gunvalson 1962).

We studied a bobcat population in RNRW in central Idaho from 1982 through 1985 to determine seasonal influences on bobcat use of space, habitats, and prey, and to assess the influences of winter conditions on the vulnerability of bobcats to trapping.

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STUDY AREA

Our 1,500-km^2 study area was located on the Big Creek drainage of the Middle Fork of the Salmon River within the 9,025-km^2 RNRW of central Idaho. The RNRW is managed by the U.S. Forest Service as an unroaded wilderness with access limited to travel by foot, horse, boat, or small aircraft.

The study area was characterized by deep, narrow canyons with elevations ranging from 1,036 to 3,048 m. Mean annual precipitation was 80 cm at 1,545 m elevation and 49 cm at 1,036 m on the Salmon River. Snow remained at higher elevations (>1,545 m) from November through April, with south aspects at lower elevations remaining snow free for much of the winter. Temperatures ranged from −29 to 37 C.

The study area was dominated by Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) forest associations (Steele et al. 1981). Subalpine fir (*Abies lasiocarpa*) and white bark pine (*Pinus albicaulis*) associations were common at elevations >1,830 m. Lodgepole pine (*Pinus contorta*) was a dominant seral tree species.

METHODS

We captured bobcats during winter in box traps and number 2 leg-hold traps (Woodstream

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Corp., Lititz, Pa.) and equipped them with radio collars (Telonics, Inc., Mesa, Ariz.) to determine seasonal influences on their use of space and habitat. We compared trapping efforts between years by analyzing the number of trap days/animal captured. Animals were anesthetized with ketamine hydrochloride (Ketaset, 22.2 mg/kg body wt) and confined in box traps to allow recovery for 2–12 hours before release. We marked bobcats with ear tags and tattoos in the lip and ear, and recorded their weight, sex, and relative age (kitten <1 yr, ad >1 yr) based on tooth condition, body size, and association with adult female. We equipped adult bobcats (≥4.5 kg) with transmitters prior to release and monitored their movements.

We defined seasons phenologically as summer (1 May–31 Oct) when snow was absent and winter (1 Dec–31 Mar) when snow was present below 1,545 m. Observations made during April and November were deleted from analysis because these were transition periods between seasons and too few observations were made during these periods.

We used telemetry locations of bobcats to evaluate home-range size and habitat use. We located bobcats during daylight hours from the ground at 1–5 day intervals and by aerial telemetry every 7–15 days. During summer, only aerial telemetry was used to evaluate home-range size and habitat use to minimize influences of bias from infrequent ground monitoring in the remote and rugged study area. During winter, bobcats were restricted by snow to areas accessible for ground telemetry; therefore, aerial and ground locations were used in calculations. We approached within 500 m of bobcats and used triangulation to determine ground telemetry locations. Accuracy of ground and aerial locations was within 3 ha and was determined by placing and subsequently relocating transmitters in the field.

We evaluated seasonal spatial requirements of bobcats using the weighted bivariate normal estimates of home-range size (Samuel and Garton 1985). Home-range sizes were calculated only for adults that had equal numbers of locations during summer and winter to minimize the influences of sample size on seasonal home-range estimates. We used the weighted bivariate normal method because it is more accurate than nonstatistical estimators of home-range size when the number of locations are few (Jennrich and Turner 1969, Anderson 1982, Samuel and Garton 1985). Because home-range sizes were calculated with <50 locations, we report estimates only with $P < 0.10$ fit to bivariate normal distribution to ensure against Type II errors (Samuel and Garton 1985). Estimates are not intended to be compared to other studies where different methods were used to calculate home-range size. The Wilcoxon signed ranks test for paired samples was employed to test seasonal difference in home-range size.

Bobcat density was estimated for a 420-km^2 core area where most bobcats were marked with radio collars. We used home-range size and overlap of marked bobcats to determine density and assumed unmarked animals occupied areas between home-range areas of instrumented animals if spatial distribution indicated a vacancy existed. We were able to estimate numbers of bobcats on the study area during the winter by identifying radio-collared and unmarked bobcats from telemetry and daily track surveys. We surveyed a distance of 1,470 km/winter on foot while checking bobcat traps.

We recorded elevation and aspect for each bobcat location from 7.5 minute U.S. Geological Survey topographic maps. We recorded amount of rock, overstory stand density, and forest cover type for the 3-ha area around each telemetry location. Two categories of rocky terrain were identified based on ocular estimates: ≤25 or >25% rock outcropping. Categories of overstory stand density included open (where estimated $\bar{x}$ distance between tree stems was >50 m) and timbered (where $\bar{x}$ distance between tree stems was ≤50 m). We used the 4 major categories of forest cover types in the region based on overstory and understory plant species composition (Steele et al. 1981): mesic (riparian, Douglas fir–Arnica [*Arnica cordifolia*], Douglas fir–ninebark [*Physocarpus malvaceus*], Douglas fir–pinegrass [*Calamagrostis rubescens*]), Douglas fir–wheatgrass (*Agropyron spicatum*), Douglas fir–mountain-mahogany (*Cercocarpus ledifolius*), and alpine (subalpine fir and white bark pine–whortleberry [*Vaccinium scoparium*]). We selected these cover types to minimize misclassification due to interspersion of cover types and to decrease numbers of types to minimize the likelihood of a Type II error in Chi-square goodness-of-fit tests (Alldredge and Ratti 1986, White and Garrott 1986).

We compared bobcat use of cover types to availability of types (Neu et al. 1974). A map of available cover types in summer was con-

Table 1. Seasonal use of forest cover types by bobcats in the River of No Return Wilderness, Idaho, 1982–85 (summer = 273, winter = 321).

Season and forest type	Proportion of total area	Proportion of observations	CI on proportion of occurrence (90% family confidence coefficient)
Summer			
Mesic[a]	0.630	0.347	$0.282 \leq P \leq 0.412$
Douglas fir–mountain-mahogany	0.020	0.110	$0.068 \leq P \leq 0.153$[b]
Douglas fir–wheatgrass	0.180	0.433	$0.375 \leq P \leq 0.512$[b]
Alpine[c]	0.170	0.103	$0.062 \leq P \leq 0.144$
Winter			
Mesic[a]	0.373	0.178	$0.136 \leq P \leq 0.220$
Douglas fir–mountain-mahogany	0.126	0.505	$0.450 \leq P \leq 0.562$[b]
Douglas fir–wheatgrass	0.501	0.318	$0.267 \leq P \leq 0.369$

[a] Includes riparian, Douglas fir–ninebark, and Douglas fir–pinegrass.
[b] Use > expected.
[c] Includes subalpine fir and white bark pine–whortleberry.

structed from ground reconnaissance and aerial photographs for the 420-km² core area where most bobcats were instrumented with radio collars. In winter, available types were defined as all forest cover types within an area encompassing all telemetry locations. We found that because snow depth was greater, outlying areas were not available to bobcats. We measured available cover types from maps using a digital planimeter.

We determined the diets of bobcats by analyzing scats and inspecting ungulate carcasses. Bobcat scats were identified on the basis of size and presence of scrapes and tracks. An ungulate was considered killed by a bobcat if sign of hemorrhage and canine or claw wounds were present on the head or neck of the carcass or if snowtracking indicated a bobcat stalked and attacked the ungulate. We considered carcasses fed on by bobcats were scavenged if these signs were not present.

To assess the influences of prey distribution on bobcat use of habitats, we determined habitat requirements of prey by trapping small rodents at 72 sites within the 4 forest cover types during the summers of 1982 and 1983. We trapped each site for 72 hours and checked traps every 24 hours. Each 50- × 20-m plot consisted of 15 stations 10 m apart with 3 snap traps/station. The number and species of rodents captured were recorded. We censused ground squirrels by counting den entrances on each plot.

We used the pitfall trap method to determine small rodent abundance and distribution during winter (Howard and Brock 1961, Williams and Braun 1983). Two mesic and 2 xeric sites were randomly selected for sampling from December 1984 through March 1985. We positioned 4 3.2-L cans as pitfalls, 2 in the middle on each side and 1 at each end of a 15.25-m × 30.5-cm drift fence made of 0.6-cm mesh hardware cloth. We buried pitfalls flush with the ground surface and placed a sheet metal roof 10 cm over each pitfall to exclude snow and debris. One liter of ethanol was added to each pitfall to kill and preserve rodents.

RESULTS

Captures

We captured 35 bobcats (13 ad M, 16 ad F, and 4 M and 2 F kittens). All but 3 male and 2 female kittens were fitted with radio collars. Captured animals were located 1,372 times.

Home-Range Size and Density

Mean home-range size for 2 males and 5 females was 22.7 ± 16.5 (SD) km² during winter and 88.1 ± 60.3 km² during summer. The home-range sizes were 3.9× larger in summer than in winter ($P < 0.05$). Based on our observations of limited intrasexual and complete intersexual home-range overlap of bobcats, the density of adults was 1 bobcat/23.3 km².

Seasonal Use of Habitat Variables

From telemetry locations we discovered a significant seasonal difference in bobcat use of elevation ($t = -26.1$, 742 df, $P = 0.0001$), aspect ($\chi^2 = 59.7$, 3 df, $P = 0.0001$), rocky terrain ($\chi^2 = 47.4$, 1 df, $P = 0.0001$), stand density ($\chi^2 = 145.8$, 2 df, $P = 0.0001$), and forest types ($\chi^2 = 120.4$, 3 df, $P = 0.0001$). Mean elevation of locations was 1,852.6 and 1,365.5 m in summer

Table 2. Frequency (%) of prey identified in bobcat scats collected in the River of No Return Wilderness, Idaho, 1982–85.

Prey	Season	
	Summer[a] (n = 25)	Winter[b] (n = 135)
Voles	40.0	65.2
Deer mice		
Peromyscus maniculatus	4.0	3.7
Unknown rodents	12.0	10.4
Pocket gophers		
Thomomys talpoides	4.0	
Woodrats		
Neotoma cinerea	8.0	7.4
Chipmunks		
Eutamias spp.		0.7
Cottontails		
Sylvilagus nuttallii	36.0	1.5
Ground squirrels		
Spermophilus columbianus	32.0	
Tree squirrels		
Tamiasciurus hudsonicus	4.0	2.2
Shrews		
Sorex spp.		0.7
Birds	12.0	3.7
Mule deer		26.7
Bighorn sheep	4.0	15.6
Unknown ungulate		1.5

[a] Apr–Oct.
[b] Nov–Mar.

Table 3. Snap-trap captures (/1,000 trap days) of small mammals and frequency (%) of plots with ground squirrel burrows in the River of No Return Wilderness, Idaho, summer 1982–83.

Mammals	Habitat		
	Mesic[a]	Xeric[b]	Alpine[c]
Voles	6.6	1.7	2.5
Deer mice			
Peromyscus maniculatus	31.0	54.9	7.4
Chipmunks			
Eutamias spp.	5.6	3.4	
Jumping mice and shrews			
Zapus spp. and *Sorex* spp.	4.1		
Ground squirrels			
Spermophilus columbianus	22.7	22.7	

[a] Riparian, Douglas fir–ninebark, Douglas fir–pinegrass.
[b] Douglas fir–curl-leaf mountain-mahogany, Douglas fir–Idaho fescue, Douglas fir–bluebunch wheatgrass.
[c] Subalpine fir and white bark pine–whortleberry.

and winter, respectively. In winter, bobcats used south–southwest aspects 61% of the time (χ^2 = 68.12, 3 df, P = 0.001), whereas in summer, they used all aspects equally (χ^2 = 4.42, 3 df, P = 0.25). During winter, bobcats were located 79% of the time in rocky terrain, whereas in summer only 54% of locations occurred in rocky terrain. Open areas were used 73% of the time during winter, whereas timbered areas were used 78% in summer.

We observed a significant (P = 0.0001) shift in bobcat use of forest cover types between seasons (Table 1). Douglas fir–mountain-mahogany received greater use than expected based on availability in winter (χ^2 = 416.2, 2 df, P = 0.001), whereas Douglas fir–mountain-mahogany and Douglas fir–wheatgrass received greater use than expected in summer (χ^2 = 251.5, 3 df, P = 0.001). Although bobcats used mesic sites and high elevation alpine habitats as melting snow made these areas available, summer use of these sites did not exceed their availability.

Diet

Voles were the most frequent item in bobcat scats and occurred in 65 and 40% of scats in winter and summer, respectively (Table 2). Although 27% of bobcat scats collected during winter contained mule deer (*Odocoileus hemionus*) remains and 16% contained bighorn sheep (*Ovis canadensis*) remains, examination of 117 ungulate carcasses indicated only 9 mule deer and 2 bighorn sheep were killed and only 4 mule deer and 1 bighorn sheep were scavenged by bobcats.

Rodent Distribution and Abundance

During summer, we found voles to be most abundant on mesic sites (χ^2 = 3.8, 2 df, P < 0.10) (Table 3), but during winter we did not capture voles on mesic sites but captured 3.8 voles/1,000 trap days on xeric sites.

DISCUSSION

Winters were severe in the study area with snow depths >100 cm at elevations >1,545 m. This had an influence on bobcat use of space, habitat, and prey.

Snow influenced bobcat use of space by restricting bobcats to home-range areas that were almost 4× smaller during winter than during summer. During winter bobcats were forced to use relatively snow-free south–southwest aspects at lower elevations (1,365.5 m in winter vs. 1,852.6 m in summer) where less energy would be required for travel and thermoregulation. Bailey (1974), McCord (1974), Fuller et al. (1985), and Litvaitis et al. (1986*b*) also found that snow restricted bobcat movements.

Besides selecting areas where snow depth was less, bobcats used habitats where escape cover and prey were available. During winter, bobcats selected Douglas fir–mountain-mahogany habitats but avoided Douglas fir–wheatgrass habitats. Although both types occurred on snow-free south–southwest aspects, Douglas fir–wheatgrass habitats lacked rocky terrain and an overstory as cover for bobcats. Rocky terrain was considered an important habitat component in Massachusetts (McCord 1974), Missouri (Hamilton 1982), and southeastern Idaho (Bailey 1974).

Snow-free habitats provided opportunities to capture prey. During winter, ungulates congregated on snow-free sites (Seidensticker et al. 1973) and voles were restricted to these habitats. Although voles were more widely distributed during summer, the occurrence of voles on xeric sites during winter may be attributed to increased cover on these opposed to mesic sites. Cranford (1984) found similar seasonal differences in vole distributions. Voles occurred in 65% of the winter diet of bobcats, perhaps because they were vulnerable in xeric habitats where ground cover averaged <30% (Steele et al. 1981).

Although showshoe hares (*Lepus americanus*) represented a potential source of prey during winter (Parker and Smith 1983, Mills 1984, Litvaitis et al. 1986*a*), bobcats in the RNRW avoided high elevations where snowshoe hares were more abundant. Bobcats can be effective predators on large ungulates (McCord and Cordoza 1982, Litvaitis et al. 1986*b*). The rugged terrain in the RNRW provided stalking cover for bobcats, but mule deer may have been able to elude bobcats on the steep snow-free slopes.

Limited prey and severe winters may contribute to the low density of bobcats (1/23.3 km²) in the RNRW. Although similar to densities in Minnesota (Berg 1979), the density was less than reported elsewhere (McCord and Cordoza 1982, Lawhead 1984, Knick et al. 1985, Rolley 1985). Large home-range areas and lower densities appear to be typical of northern latitudes where winters are severe and food less abundant (Bailey 1974, Harestad and Bunnell 1979, Fuller et al. 1985, Litvaitis et al. 1986*b*).

MANAGEMENT IMPLICATIONS

Bobcat populations may be vulnerable to overharvesting in areas where their density is low and winters restrict their use of space, habitat, and prey. This is shown by comparing capture successes during winters of varying harshness. During winter when snow depth averaged <5 cm, we captured only 6 animals, and 401 trap days were required/capture. In contrast, during the 3 winters when snow depth in the valley exceeded 20 cm, we captured 12, 16, and 17 bobcats and 157, 212, and 121 trap days were required/capture, respectively. As found in Minnesota (Petraborg and Gunvalson 1962), our data indicate that bobcats were more vulnerable to trapping during severe winters. For these reasons harvest should be controlled and populations closely monitored in the mountainous regions of the western United States where bobcat behavior is influenced by winter conditions.

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