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Influence of Precommercial Thinning on Snowshoe Hares

Evelyn L. Bull, Thad W. Heater, Abe A. Clark, Jay F. Shepherd, and
Arlene K. Blumton



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Authors

Evelyn L. Bull is a research wildlife biologist, **Thad W. Heater** was a wildlife biologist, and **Abe A. Clark** was a biological technician, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry and Range Sciences Laboratory, La Grande, OR 97850. Heater currently can be reached at P.O. Box 84445, Fairbanks, AK 99708. Clark is currently a graduate student at Oregon State University, Corvallis, OR 97331. **Jay F. Shepherd** is a research assistant, Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83843. **Arlene K. Blumton** is a wildlife biologist, Wallowa-Whitman National Forest, La Grande Ranger District, La Grande, OR 97850.

Abstract

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Relative abundance, survival, home range, and habitat use of snowshoe hares (*Lepus americanus*) were evaluated in five precommercial thinning treatments in lodgepole pine (*Pinus contorta* Dougl. ex Loud.) stands in northeastern Oregon between June 2000 and July 2003. A combination of track surveys, trapping grids, and radiocollared hares was used to evaluate these characteristics. Relative abundance of snowshoe hare tracks was highest in unthinned control stands and lowest in the recently thinned stands. The highest abundance of snowshoe hares in trapping grids occurred in patch cuts (10-m-wide cuts interspersed with unthinned patches 10 to 30 m wide). Hare home ranges were smallest in the patch cuts. Habitat use changed seasonally, with hares using denser stands during summer and more open stands in winter. In the short term, the patch cut appeared to provide the best hare habitat of the treatments investigated.

Keywords: Fuel reduction, *Lepus americanus*, northeastern Oregon, snowshoe hare, thinning.

Summary

The snowshoe hare (*Lepus americanus*) occurs in stands that are frequently thinned, but the effects of thinning on populations of this species are unknown. We evaluated the suitability for snowshoe hares of lodgepole pine stands that had been (1) unthinned, (2) thinned to a 4-m spacing within 10 years, (3) thinned to a 3-m spacing 20 to 25 years ago, (4) thinned in a patch cut within 2 years, and (5) thinned in a corridor cut within 2 years. The unthinned control stands contained the most snowshoe hare tracks and the recently thinned stands contained the fewest. Patch cuts produced the most hares in trapping grids, and hares in this treatment had the smallest home ranges. Hares used denser stands during summer and more open stands in winter. Coarse woody debris provided structure that formed subnivean spaces used by hares in winter for hiding and thermal cover. This study demonstrated that unthinned stands and new thinning regimes with a high proportion of unthinned areas maintained or increased numbers of snowshoe hares for the short term.

Introduction

Little is known of the extent to which wildlife species may be affected by thinning or of thinning treatments that may minimize the effects on wildlife. The snowshoe hare (*Lepus americanus*) occurs in overstocked stands of lodgepole pine (*Pinus contorta* Dougl. ex Loud.) and is important prey for many predators, including the Canada lynx (*Lynx canadensis*) (Aubry et al. 2000, Koehler and Brittell 1990). As such, habitat management activities that influence snowshoe hares likely will influence populations of the predators as well. The historical presence of lynx in north-eastern Oregon (McKelvey et al. 2000) and their recent listing as threatened under the Endangered Species Act have added the responsibility of managing lynx to land management agencies (Ruggerio et al. 2000).

The preference of snowshoe hares for habitat with dense vegetative cover and their avoidance of open habitats has been well documented (Adams 1959, Cox et al. 1997, Hodges 2000a, Orr and Dodds 1982, Sullivan and Moses 1986). In Washington, Koehler (1990) found the highest snowshoe hare use in 20-year-old stands of lodgepole pine (15,840 stems per ha) compared to stands of lodgepole pine older than 43 years, mature stands of spruce (*Picea engelmannii* Parry ex Engelm.) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), mature stands of mixed conifer, and meadows. In British Columbia, overstocked stands of young lodgepole pine covering areas that had burned were optimal habitat for snowshoe hares (Sullivan and Sullivan 1988); snowshoe hare abundance had declined 2 years after lodgepole pine stands were thinned from about 40,000 stems per ha to 2,304 stems per ha at a 2-m-by-2-m spacing. Dense stands of lodgepole pine provided thermal and security cover, in addition to the greatest amount of browse for hares during winter (Koehler 1990).

The *Canada Lynx Conservation Assessment and Strategy* (Ruediger et al. 2000) states that more information is needed on precommercial thinning to determine the potential impacts to snowshoe hare and lynx habitat. Precommercial thinning reduces the density of saplings and understory shrubs and is likely detrimental in the short term to snowshoe hares, but information is lacking on the effect on hare abundance, survival, and home range size. At present, no modifications to traditional thinning techniques (3-m or 4-m tree spacing) have been developed with the objective of addressing this wildlife habitat concern. This study investigates the effects of precommercial thinning treatments in lodgepole pine on snowshoe hares, specifically corridor and patch thinning regimes. Our objectives were to compare relative abundance of snowshoe hares by using winter track surveys and trapping grids in five treatments of precommercial thinning in 25- to 40-year-old lodgepole pine stands. In addition, we compared survival and mortality, home range,

and habitat use of radiocollared snowshoe hares as an indication of habitat quality among the thinning regimes.

Methods

Two study areas (Anthony Burn and Indian Creek) in the Wallowa-Whitman National Forest were selected on the basis of containing (1) snowshoe hare habitat, (2) potential lynx foraging habitat, and (3) stands that could be thinned within a year because the National Environmental Policy Act (NEPA) analysis for precommercial thinning had been completed. Anthony Burn contained stands of 40-year-old lodgepole pine that had regenerated after a stand-replacement fire in 1960. The 2000-ha study area consisted of stands of lodgepole pine, most of which were thinned 25 years ago to promote tree growth. Less than 10 percent of this study area had been recently thinned to a 4-m spacing to promote tree growth, but there had been no other harvesting since the salvage operations following the fire. Lodgepole pine was the predominant tree species with a minority of western larch (*Larix occidentalis* Nutt.) and subalpine fir. Elevation of the Anthony Burn study area is 1710 to 1940 m. Snow was usually present from November through May at depths of 1 to 2 m.

Indian Creek contained 3000 ha of stands that regenerated after extensive harvesting in the 1970s. The harvesting followed an outbreak of the mountain pine beetle (*Dendroctonus ponderosae*) that had killed the lodgepole pine in the overstory. Most of the stands in this study area were now multilayered mixed conifer and had approximately an equal mix of lodgepole pine, western larch, and subalpine fir. There was a greater component of larch and subalpine fir in some of these stands than in the Anthony Burn. More than 75 percent of this study area had been logged or thinned in the last 20 to 25 years for commercial value. Elevation was 1500 to 1680 m with snow present from November through April at depths of 0.5 to 1.5 m.

Stand structures in the two study areas included stem initiation, stem exclusion, young multiage, and old multiage (Oliver and Larson 1990). Approximately 80 to 100 percent of each treatment stand consisted of the stem exclusion structure with trees 8 to 12 m tall with the remainder being young multilayered stands that were taller than 15 m. Stands of stem initiation and old multiage occurred outside the treatment stands.

Treatments

This study included five treatments: (1) stands thinned to a 4.2-m spacing within the last 4 to 10 years (recent thinning), (2) stands thinned in 2000 in corridors

(20 to 200 m wide) that alternated between unthinned trees and trees thinned to a 3-m spacing (corridor cut), (3) stands thinned in 2000 in 10-m circular patches where all the trees were removed and were surrounded by unthinned areas 10 to 50 m wide (patch cut), (4) stands thinned 20 to 25 years ago to a 3-m spacing (old thinning), and (5) stands of unthinned trees (control) (fig. 1). Randomization of the treatments was not possible because there were only three untreated stands larger than 10 ha in Anthony Burn for the control, patch cut, and corridor cut. We selected the only available stands that were adjacent to a groomed snowmobile route for the old and recent thinning treatments in the Anthony Burn. In Indian Creek there was only one old thinning treatment available, and we selected the only available stands that had not been thinned in the past that were more than 10 ha in size for the control, patch cut, and recent thinning. The size of treatment area for the patch and corridor cuts was restricted because of the past thinning that had occurred; other untreated stands were not available within the area approved for thinning by NEPA.

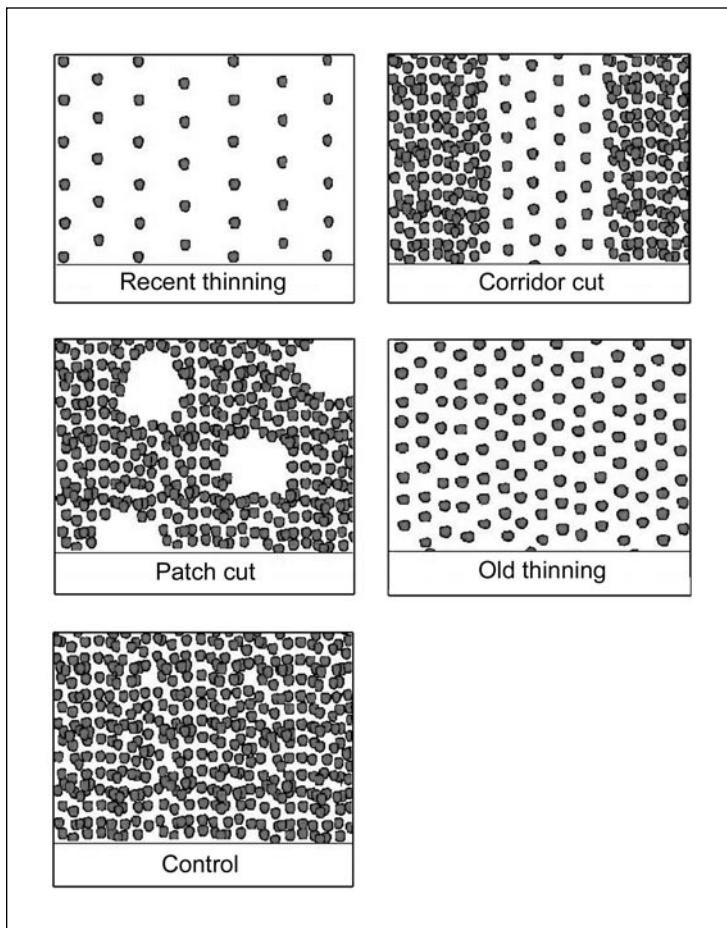


Figure 1—Illustration of relative tree spacing in five thinning treatments in stands of lodgepole pine in northeastern Oregon.

The patch and corridor cuts were designed specifically to improve and prolong the suitability of hare habitat with a secondary objective of promoting tree growth and reducing tree spacing for fire, insect, and disease reduction in the stands. The pretreatment condition of the patch and corridor cuts was similar to the control stands. The patch and corridor cuts were implemented in October 2000, and about 50 percent of the area in each stand was thinned. The leave trees in the portion of the corridors that were thinned were predominantly lodgepole pine in the Anthony Burn and western larch in Indian Creek. Each of the five treatments occurred in single stands in each study area; additional stands for replicates were not available because of past management practices. The stand sizes for Anthony Burn and Indian Creek were 10 and 15 ha in recent thinning, 33 and 17 ha in corridor cuts, 15 and 16 ha in patch cuts, 35 and 54 ha in old thinning, and 12 and 40 ha in controls, respectively.

Track Surveys

We conducted track surveys during two winters (2001–02 and 2002–03) in Anthony Burn and Indian Creek in each of the five treatments. One 100-m transect was established and flagged in the central portion of each stand. Each transect was about half in thinned and half in unthinned portions of the patch cuts and corridor cuts. Track surveys were conducted at least 24 hours but not more than 5 days after a new snow. All individual snowshoe hare tracks that crossed the transect were recorded, and we estimated the number of tracks on runways as 3, 6, 9, or 12, depending on the relative degree of use (Koehler 1990). The number of tracks per 100 m per night without snow was calculated. A successive track survey was conducted only after additional snow fell; four or five surveys were conducted each winter in each area. Track surveys were not conducted if the snow was crusted.

Live Trapping

Relative abundance of hares was determined by live trapping in four treatments in the Anthony Burn and Indian Creek study areas. Hares were trapped in a 4-by-6 grid with traps at 50-m intervals (3.8 ha). Hares were trapped in Tomahawk live traps (model 205, Tomahawk, Wisconsin 54487) during June and July 2000 in Anthony Burn only and in both study areas during August and September 2001 and June and July 2002. Two recently thinned stands were set with traps in Anthony Burn in 2000; the low hare abundance in these stands (based on trapping and track surveys) suggested that further trapping was not cost effective. Traps were set for four nights (96 trap nights for each stand), baited with alfalfa cubes and apples, covered with bark or boughs, and checked each morning. Trapping grids were

0.7 to 4.8 km apart to reduce the probability of hares using more than one grid. Hares were weighed, equipped with a radiocollar (model MI-2, Holohil Systems, 112 John Cavanagh Rd., Carp, Ontario, Canada), and ear-tagged. Hares <425 g were considered juveniles and were not collared because they were too small. To increase the sample size of radiocollared hares, additional trapping occurred in the Anthony Burn in June and September 2000 and October and November 2001 and in Indian Creek in September 2002. Trapping was not limited to grids during these times, so abundance was not compared.

Survival

Survivorship estimates were calculated at 1-month intervals for radiocollared hares in each treatment by using the Kaplan-Meier method (Pollock et al. 1989). Survival was treated separately for the two study areas because the hares were monitored in different years. Hares frequently ventured outside the stand where they were captured, so each hare was assigned to the treatment where it was most frequently found. Each hare was located once each week to verify that it was alive. If the hare was dead, we searched the immediate area for evidence of cause of mortality. Collars found at a pluck site (where the skeleton was intact but the muscle had been removed from the bone) were attributed to a raptor. If a portion of the carcass remained, a necropsy was performed to determine the presence of hemorrhaging (as an indicator of predation) and to measure the spacing of any punctures in the muscle to determine the probable predator. The distance between the tips of two upper canines averages 10 to 12 mm in martens (*Martes americana*), 22 to 27 mm in bobcats (*Lynx rufus*), and 26 to 28 mm in coyotes (*Canis latrans*) (Bull and Heater 2001). Predation by coyotes and by bobcats were combined owing to difficulty in distinguishing them. Collars found on the ground with no accompanying evidence were attributed to an unknown predator, unless bite marks on the collar matched the intercanine spacing listed above.

Home Range

Home range sizes were calculated for each hare with more than 25 locations by using the 95-percent minimum convex polygon method (Odum and Kuenzler 1955). Although there are numerous methods of calculating home range (see review in Hodges 2000b of hare home range studies), the primary objective was comparing home ranges among treatments. Home ranges were calculated by using hare locations during daylight hours, which primarily represent the area used for rest sites. These home ranges may not be representative of foraging hares because of the primarily nocturnal behavior of the species.

Habitat Use

Habitat use by hares was determined from June 2000 through October 2002 in Anthony Burn and from June 2002 through July 2003 in Indian Creek. Our objective was to document the range of habitat conditions used by radiocollared hares in the various treatments and compare habitat used at rest sites in summer and winter to determine if structural features were used seasonally. We did not compare used habitat with unused or available habitat; unused habitat could not be defined as all the hares in the study areas were not captured and monitored. It was not feasible to determine the available habitat for each hare because hare home ranges overlap extensively (Hodges 2000b).

Radiocollared hares were located once per week during daylight hours (between 0700 and 1700 hr). The exact spot where the hare was sitting was identified when possible; triangulation was not used. At each hare location, a 5-by-5 m square plot (0.0025 ha) was delineated, and the following habitat characteristics recorded: forest type (lodgepole pine, grand fir, subalpine fir), structural stage, thinning history, canopy closure (percentage), stem density, log density, number of deciduous stems, number of live branches within 0.5 m of the ground (or snow), and ground cover composition (i.e., percentage of grass, forbs, wood debris, and bare ground). The number of live branches was recorded to indicate browse availability and cover within 0.5 m of the ground or snow. During winter, snow depth and the presence of a subnivean site within 3 m of the hare were recorded as well. We recorded each hare location with a global positioning system (GPS) that was accurate to within 15 m.

Analysis

A one-way analysis of variance and post-hoc Tukey's B multiple comparison test were used to determine differences among treatments (both study areas combined) for relative abundance of hare tracks, hares captured, and home range size. As this species may be cyclic in more southern latitudes (Hodges 2000a), we compared hare density among treatments for a time period and not between years. Although most hares in the thinned treatments also used unthinned stands, each hare was assigned to the type of stand where the majority of the locations occurred for comparisons of survival and home range size. For habitat analyses we chose the vegetation plot as the sample unit because individual hares used different treatments. Therefore, we could not analyze by individual hares to test for treatment effects, which introduces the possibility of pseudoreplication. Categorical and continuous habitat

variables were compared between summer and winter with Mann-Whitney U-Wilcoxon Rank tests and t-tests, respectively. The percentages of ground cover and log density were not compared between seasons because they could only be recorded when snow was absent.

Results

Relative abundance of snowshoe hare tracks in winter differed significantly among the five treatments during 2001-03 ($F = 11.97$; 4, 84 df; $P < 0.01$; fig. 2). The Tukey's B multiple comparison test indicated that track abundance was lower in the recent and old thinnings than in other treatments. On the transects in the corridor cut for both winters combined, 72 percent of the tracks were in the unthinned portions of the corridors.

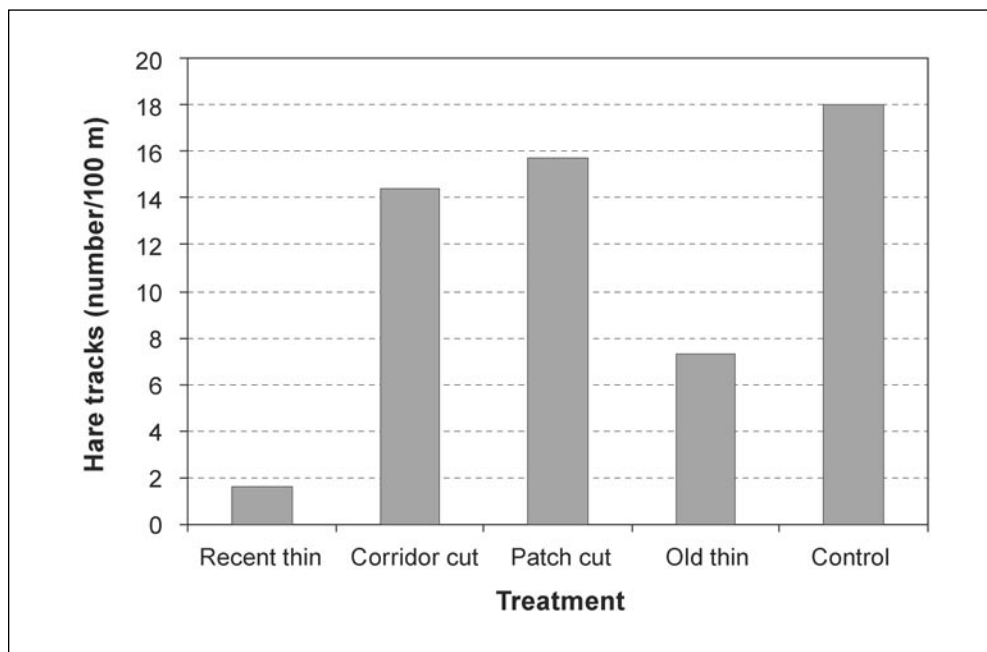


Figure 2—Mean number of snowshoe hare tracks per 100 m of transect per night without snow in lodgepole pine stands for five treatments in northeastern Oregon during nine surveys between December 2001 and March 2003.

In all, 31 and 42 hares were captured on the trapping grids in Anthony Burn and Indian Creek, respectively. Snowshoe hare abundance was significantly higher in the patch cuts for both study areas in 2001–02 (1 year posttreatment) ($F = 9.79$; 4, 13 df; $P < 0.01$) than the other treatments (figs. 3 and 4). Hare abundance in the Anthony Burn was lower in the corridor cut after treatment than before but was higher in the patch cut after treatment than before (fig. 3).

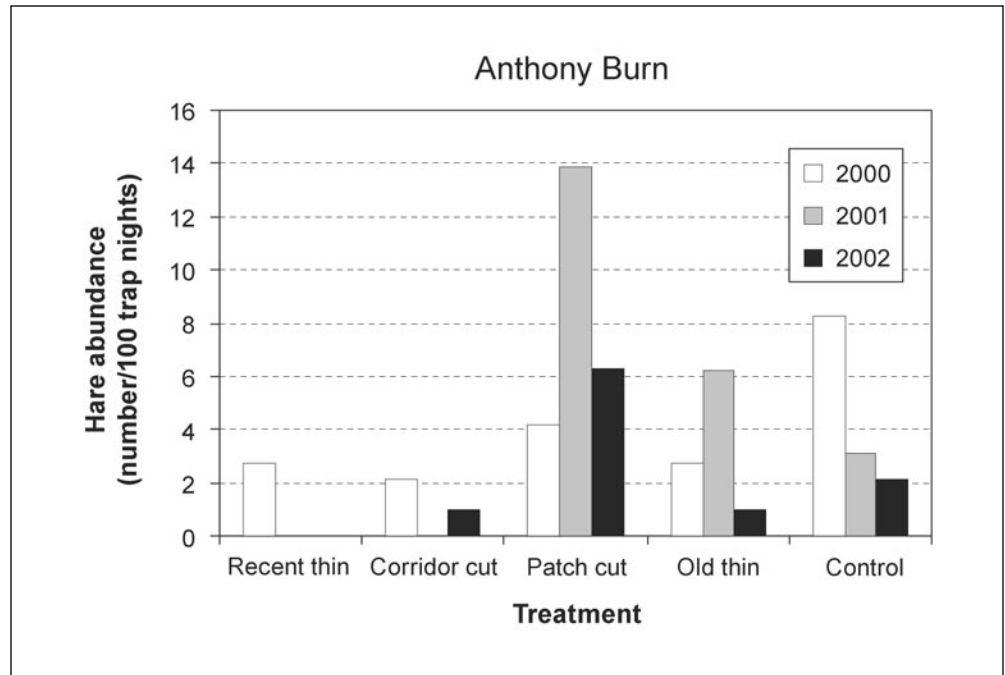


Figure 3—Number of snowshoe hares captured during 96 trap nights in the Anthony Burn between June and September 2000–2002 in five thinning treatments. Pretreatment trapping occurred in 2000 and posttreatment trapping in 2001–02. Two stands with recent thinning were trapped only in 2000.

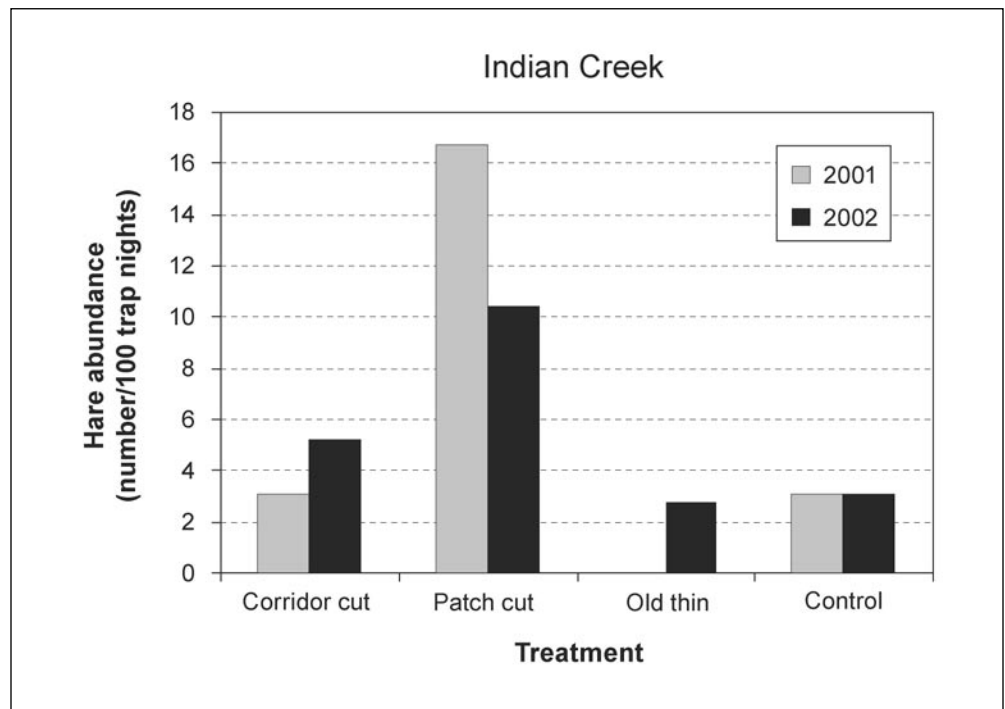


Figure 4—Number of snowshoe hares captured during 96 trap nights in Indian Creek between June and September 2001–02 in four thinning treatments. Trapping occurred only during posttreatment.

Home ranges (95-percent minimum convex polygon) of the 51 hares with more than 25 locations averaged 10.0 ha (range = 0.4 to 49.6 ha). Average home range size in patch cuts was the smallest (mean = 5.6 ha, SE = 1.48) when compared with corridor cuts (mean = 10.1 ha, SE = 2.78), controls (mean = 12.5 ha, SE = 2.65), and old thinning (mean = 15.6 ha, SE = 4.42). Given the high variability, there was no statistical significance ($F = 2.15$; 3, 47 df; $P = 0.11$), but there is some suggestion that home range size differs by treatment.

Survival may reflect quality of habitat of the treatments investigated. In the Anthony Burn, 64 hares (43 adults, 21 juveniles) were radiocollared in the summers of 2000 and 2001. Only four of these hares were known to be alive at the end of the monitoring in October 2002; 52 had died, 6 had radios that failed, and 2 had chewed the collar off. Of those hares that died, 24 were killed by mammals (bobcats, coyotes, martens), 5 by raptors (accipiters and owls), 22 by unknown predators, and 1 had abscesses on the liver. Although sample sizes were limited for all treatments except the control stands, the Kaplan-Meier survivorship estimates were highest in the control stands after 12 months but were the same in the control and corridor cut after 24 months (table 1).

Table 1—Average Kaplan-Meier survivorship estimates (variance) for snowshoe hares in four thinning treatments in two study areas in northeastern Oregon, 2000–2003

Study area/time interval	Corridor cut	Patch cut	Old thinning	Control
Anthony Burn				
6 months	0.50 (0.06)	0.58 (0.03)	0.33 (0.04)	0.64 (0.01)
12 months	.25 (0.02)	.23 (0.04)	.17 (0.02)	.59 (0.01)
24 months	.12 (0.1)	—	0	.13 (0)
Number of hares	5	11	4	41
Indian Creek				
6 months	.75 (0.05)	.48 (0.02)	—	.33 (0.07)
12 months	.50 (0.12)	.2 (0.01)	—	—
Number of hares	6	14	1	3

— = Not enough hares to calculate survival.

Note: Hares were monitored for 13 months in all stands in Indian Creek, for 14 months in the patch cut in Anthony Burn, and for 27 months in the other stands in Anthony Burn.

In Indian Creek, 25 hares (21 adults, 4 juveniles) were radiocollared in the summer of 2002. Four were known to be alive at the end of monitoring in July 2003, 18 had died, and 3 were missing. Of the hares that died, 9 were killed by mammals, 1 by a raptor, 6 by unknown predators, and 2 from handling. Kaplan-Meier survivorship estimates were higher in the corridor cut than in the patch cut (table 1).

Mortality was low during winter months with snow and was high during the snow-free months. Of the 52 hares that died at Anthony Burn, 50 percent died from April through July, 46 percent from August through November, and 4 percent from December through March. Of the 18 hares that died at Indian Creek, 33 percent died from April through July, 50 percent died from August through November, and 17 percent from December through March.

Habitat Use

We obtained 2,565 locations of 87 hares from June 2000 through July 2003. The different thinning treatments resulted in obvious differences in the density of live stems, live branches within 0.5 m of the ground, canopy closure, and logs available within the stands. The patch and corridor cuts had both unthinned portions and small areas with no trees or trees thinned to a 3-m spacing, respectively. Stands with old thinning had a more open canopy, which resulted in more ground vegetation than occurred in the unthinned stands. These treatments provided various options of habitat conditions, which are reflected in the habitat used; significant differences were detected in all but two of the continuous variables when hare use was compared among treatments (table 2). About half (57 percent) of the hares in the corridor cut were located in the unthinned portions, whereas two-thirds of the hares in the patch cuts were found in the unthinned portions. Both of these treatments contained a high density of logs from the thinning slash.

Table 2—Mean (standard error) measurements of habitat characteristics at snowshoe hare rest sites in four treatments in northeastern Oregon, 2000–2003

Characteristic	Corridor cut	Patch cut	Old thinning	Control	F value	P value
Stem density (number/plot)	17 (1.1) ^{ab}	40 (1.4) ^{abc}	11 (0.6) ^a	32 (1.0) ^{abc}	71.60	<0.01
Live branches (number/plot)	46 (2.8) ^b	55 (2.8) ^{ac}	35 (2.5) ^a	62 (1.9) ^{abc}	15.22	<0.01
Deciduous stems (number/plot)	12 (2.5) ^c	19 (1.9) ^{abc}	4 (1.4) ^a	7 (1.0) ^b	16.33	<0.01
Canopy closure (percent)	73 (1.6) ^{ab}	87 (0.7) ^{abc}	68 (1.3) ^a	84 (0.6) ^{ac}	71.50	<0.01
Ground cover (percent).						
Bare ground	32 (2.0) ^{ab}	35 (1.3) ^a	19 (3.4) ^a	39 (1.1) ^{ab}	7.95	<0.01
Forbs	25 (1.8) ^a	25 (1.1) ^b	52 (5.2) ^{abc}	34 (0.6) ^{abc}	19.11	<0.01
Woody debris	29 (2.2) ^{abc}	24 (1.2) ^{abc}	12 (1.4) ^a	18 (0.5) ^b	22.18	<0.01
Grass	4 (0.7)	6 (0.5)	11 (4.4)	6 (0.6)	2.35	0.07
Other	10 (1.8) ^a	10 (1.0) ^a	6 (2.4)	4 (0.5) ^a	15.07	<0.01
Woody debris (number/plot)						
Logs 5–20 cm diameter	9 (1.1) ^{ab}	10 (0.7) ^{ab}	3 (0.3) ^a	4 (0.2) ^b	38.68	<0.01
Logs 21–50 cm diameter	1 (0.1)	2 (0.2)	1 (0.2)	2 (0.1)	2.06	0.10
Logs >50 cm diameter	<1 (0.3) ^a	<1 (0) ^a	<1 (0)	<1 (0)	4.31	<0.01
Number of plots	289	558	242	1,123		

Note: Habitat plots were 25 m². Same superscripts indicate significant differences among treatments from a posthoc Tukey's B analysis.

Habitat use by season was significantly different for forest type ($Z = -3.70$, $P < 0.01$), structural stage ($Z = -7.73$, $P < 0.01$), and harvest activity ($Z = -3.83$, $P < 0.01$) with a tendency for hares to use more open stands in winter and denser stands in summer. Hare use of more open sites in winter is also reflected in the lower density of live stems, deciduous stems, and canopy closure at hare locations compared to use in summer (table 3). Use of lodgepole pine stands increased from 49 percent in summer to 62 percent in winter, while use of subalpine fir stands decreased from 38 percent in summer to 28 percent in winter. Lodgepole pine stands were typically less dense than subalpine fir.

Table 3—Mean (standard error) measurements of habitat characteristics at snowshoe hare rest sites in summer and winter in northeastern Oregon, 2000–2003

Characteristic	Summer	Winter	t value	df	P value
Stem density (number/plot)	34 (1.0)	25 (0.07)	7.54	2,123	< 0.01
Live branches (number/plot)	56 (2.0)	53 (1.6)	1.26	2,309	< 0.01
Deciduous stems (number/plot)	18 (1.4)	3 (0.05)	9.75	1,475	< 0.01
Canopy closure (percent)	84 (0.06)	78 (0.6)	6.37	2,400	< 0.01

Note: Habitat plots were 25 m². Logs and ground cover could not be measured in winter when snow was present. df = degrees of freedom.

Use of the control stands (unthinned) decreased from 90 percent in summer to 56 percent in winter. The use of stands with old thinning, which were more open than control stands, increased to 24 percent in winter compared to only 3 percent in summer. Only 6 percent of the locations occurred in patch and corridor cut in summer, but these increased to 15 percent in winter.

The majority (64 percent) of summer locations were in stem exclusion stands, with 24 percent in young multistory stands, and 10 percent in old multistory stands. Use of structural stages in winter was 72 percent in stem exclusion, 23 percent in young multistory stands, and 5 percent in old multistory stands. Seventy-five percent of winter locations had a subnivean site within 10 m; 61 percent of the subnivean sites were formed by branches in snow and 39 percent by coarse woody debris.

Discussion

Although this study had limitations of stand size and the number of replicates, our findings suggest that the patch cut is a promising silvicultural treatment for snowshoe hares, at least in the short term. The patch cut appears to provide foraging and hiding cover for hares, and we know of no other study that has evaluated this kind

of modification to stand structure. It is unknown if the patch cut will continue to provide suitable habitat in the long term; follow-up studies would be required to determine suitability over time.

Of the thinning treatments, the highest numbers of trapped hares and the smallest home ranges occurred in the patch cuts, whereas traditional methods of thinning stands of precommercial lodgepole pine (recent thinning and old thinning) resulted in lowest numbers of snowshoe hares. In the short term, the patch cut appeared to provide the best habitat of those treatments investigated. The hare numbers that we found in patch cuts are characteristic of peak densities found in southern montane forests (1 to 2 hares/ha; Hodges 2000a), and hare densities found in the other treatments were lower than these (figs. 3 and 4). Home ranges reported in this study were similar to the 5-to-10-ha home range size reported by numerous studies reviewed by Hodges (2000b).

The two new thinning regimes (patch and corridor cuts) were developed specifically to improve habitat for hares as compared to traditional thinning treatments, and we are not aware of these treatments being used elsewhere. Because of the low hare abundance in the corridor cuts and the lack of hare use of the thinned portions of this treatment during winter, we did not find that the corridor treatments with the widths used in this study improved hare habitat or survival over untreated stands. Interpretation of the corridor cut is difficult owing to the lack of consistency in the width of the thinned corridors. The corridor-cut stands with wide strips (200 m) of thinning probably functioned as separate stands and mimicked the low hare use we observed in the recent thinning. In the 200-m wide corridors, hares seldom ventured into the thinned portions during winter, but hares regularly crossed a thinner corridor (20 m wide) in winter in Anthony Burn. The tree growth benefit in the corridor cut would probably exceed that of the patch cut. If the thinning were done when the trees were young and a low crown base were retained, it would likely provide better habitat for hares than what we observed because it would retain cover from the branches low to the ground.

Cover provided by vegetation and coarse woody debris within 1 m of the ground appeared to be important for hares, particularly in summer. Slash from the patch and corridor cuts provided both forage and dense hiding cover for a year after treatment. Coarse woody debris provided hiding cover at more than half the rest sites in summer, and created subnivean habitat at many of the rest sites in winter. Subnivean sites occurred at 75 percent of the rest sites, and either coarse woody debris or branches at or below the snow level provided suitable subnivean habitat. The low vegetative cover and coarse woody debris provided hiding cover from both

mammalian and avian predators. In Utah, Wolfe et al. (1982) found a strong association between hare use and the density of horizontal cover of understory vegetation at heights of 1 to 2.5 m owing to the protection it provided from terrestrial and avian predators. They suggested that less than 40 percent vegetation cover above the snow precluded use by snowshoe hares.

The high rate and type of predation we observed are consistent with the literature (Hodges 2000a, Keith et al. 1993). Our semiannual and annual survivorship estimates (table 1) were higher than those reported in Wisconsin (semiannual survival 0.29 to 0.59; annual survival 0.015 to 0.179; Keith et al. 1993). In our study, the majority of predation was from bobcats and coyotes from spring through fall; little predation occurred in winter. Lynx are not present in our study area, and deep powder snow kept bobcats, mountain lions (*Puma concolor*), and coyotes out of the study area during most of the winter. If lynx had been present in our study area, we would have expected greater predation during winter owing to their ability to move through deep powder snow. The absence of lynx and the low predation in winter may explain our observations of hares moving into more open habitat in winter, which differs from Litvaitis et al. (1985), Parker et al. (1983), and Shaw (2002) who reported that denser cover was used by hares in winter.

Our data from northeastern Oregon suggest that precommercial thinning of lodgepole pine in 10-m-wide patch cuts dispersed across less than 50 percent of a stand increased the abundance of snowshoe hares compared to the other thinning treatments in northeastern Oregon in the short term. This treatment provides dense hiding cover in proximity to small patches of more open foraging habitat. Precommercial thinning in patch cuts may be a useful tool in treating stands to improve snowshoe hare habitat and may provide management with options in treating stands within lynx habitat that could otherwise not be altered. These treatments could represent a compromise that could allow some thinning to help reduce the fuel loading and fire risk but minimize the detrimental effects to snowshoe hares and other wildlife dependent on overstocked, dense stands.

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English Equivalents

When you know:	Multiply by:	To find:
Millimeters (mm)	0.039	Inches
Meters (m)	3.28	Feet
Kilometers (km)	0.62	Miles
Hectares (ha)	2.47	Acres

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