WINTER HABITAT PREFERENCE OF THE BOBCAT (*LYNX RUFUS FASCIATUS*) OF WESTERN WASHINGTON

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ABSTRACT

Crepuscular, day and night time habitat preference of the bobcat (Lynx rufus fasciatus) of western Washington was studied during the winter months from 1978 through 1980. Twenty-seven bobcats were radiotracked and 632 winter locations obtained. Habitat was determined by LANDSAT II Multi-spectral Scanner imagery maps. Regrowth conifer forest and broadleaf forest showed the highest preference during all three time periods. Second growth conifer and mixed forests showed the lowest preference.

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I
INTRODUCTION

In recent years, the bobcat (Lynx rufus) has become an economically important fur-bearer. This is in part due to the availability of the animal throughout the United States and Mexico, and because the animal's becoming a substitute for the large spotted cats where fur is no longer available on the international markets (Hall and Kelson 1959; Toweill 1979; Laycock 1978). This change in the bobcat's status has brought about an urgent need to understand the animal's behavior more thoroughly and, in turn, determine the extent to which bobcats may be trapped without serious reduction in their numbers.

Extensive research has generated much information concerning the bobcat's behavior, including it's habitat preferences and activity patterns. Because the animals are residents in almost all of the 48 contiguous United States, they are obviously adapted to a variety of habitats (Toweill 1979). Most literature indicates bobcats prefer country with dense thickets, scrub, and areas with a considerable edge-environment (Rollings 1945; Dalquest 1948; Hall and Kelson 1959; McCord 1974; Hall and Newsom 1978; Knowles 1981). Areas with rocky outcrops are also preferred (Dalquest 1948; Young 1958). These areas provide high prey densities and cover for the animals (Dalquest 1948; McCord 1974).

Periods of greatest activity are found to be centered around sunrise and sunset, thus making the bobcat a crepuscular animal (Hall and Newsom 1978). Kitchings and Story (1981) came to near identical conclusions, but recorded more activity around sunset. These studies indicate a considerable decrease in activity during the day and night, especially in the day around 1200 hours (Kitchings and Story 1981). These activity periods are reflective of the activity of the bobcat's prey species such as rabbits and rodents (Hall and Newsom 1978).

In Washington, the initiation of a Native Cat Study in 1975 has helped to increase information of the bobcat within the state (Brittell, et al. 1979). Though a variety of studies have been performed, little knowledge has been acquired dealing with habitat preference of the bobcat (Lynx rufus fasciatus) of western Washington. A study of the bobcat from April 1978 to December 1980, using radio telemetry, was conducted. This provided data for determining habitat preference using NASA's LANDSAT II Multi-Spectral Scanner (MSS). This paper reports the findings of day, night, and crepuscular habitat preference of 27 bobcats during winter months.

II
ENVIRONMENTAL SETTING

The study area is located in Pierce County, Washington, 34 miles southeast of Tacoma (Fig. 1). It is a 144 square mile area in the western foothills of the Cascade Range with elevations ranging from 1500 ft. to 3650 ft. The Snoqualmie National Forest and Mt. Rainier National Park border the area's eastern edge. It is commercial forest owned by private timber companies and by the Washington Department of Natural Resources.

A mid-latitude, west coast marine climate is predominant in the area. This consists of a well-defined cool, dry summer season and a mild, wet winter season. Weather data from Electron Headworks weather station on the northern boundary of the area show average annual temperatures of 46.3°F, with extremes of 97°F to -6°F. Precipitation occurring mostly as rain falls mainly during the winter months of November to April. Average annual precipitation is 71.74 inches per year, with extremes of 10.79 inches in December and 1.45 inches in July. The greatest amount of snowfall occurs during January, February, and March, with an annual average of 48.1 inches per year (Phillips 1968).

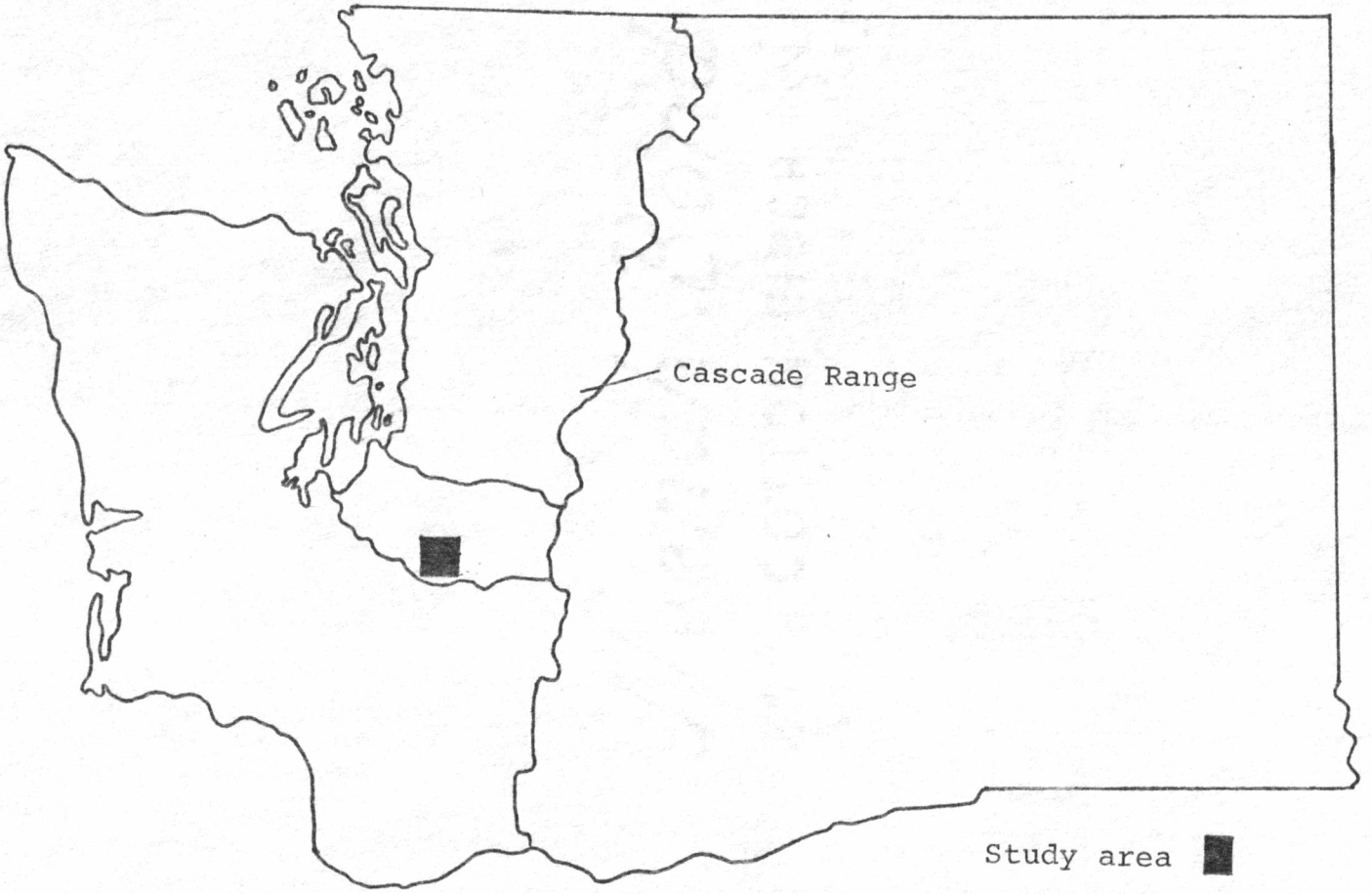

Fig. 1. Map of Washington State showing bobcat study area in Pierce County.

The study area lies within the western hemlock (Tsuga heterophylla) zone. Because of logging and burning in and around the area, temporate coniferous forest in various stages of succession dominate the landscape. Characteristic forest tree species include western hemlock, Douglas fir (Pseudotsuga menziessi), and western red cedar (Thuja plicata). Recently disturbed sites contain an abundance of red alder (Alnus rubra)(Franklin and Dyrness 1973; Sweeney 1978).

Successional growth of harvested areas typically consist of herbaceous species which include fireweed (Epilobium augustifolium), bull thistle (Cirsium vulgare), and bracken fern (Pteridium aquilinium). The shrub stage is dominated by vine maple (Acer circinatum), salmonberry (Rubus spectabilis), sword-fern (Polystichum munitum), huckleberry (Vaccinium spp.) and salal (Gaultheria shallon). Douglas fir and western hemlock saplings planted after logging generally succeed the shrub stage (Franklin & Dyrness 1973; Sweeney 1978).

III
METHODS AND MATERIALS

Animal Capture and Monitoring

The field study was done by Washington Game Department biologists from April 1978 to December 1980. Capture of the bobcats was done by hunters with trained "cat" hounds accompanied by the biologists. When hounds came across fresh tracks (≤ few hours old), they would follow the tracks until they caught up with the bobcat. The hounds would pursue the animal until it was treed, or isolated in some other stationary hiding place. An intramuscular anesthetizing dart would be shot into the animals hindquarters. The drug used was Ketamine hydrochloride at a dosage of 20 mg/ pound of body weight. Within five to ten minutes the bobcat would become immobile and slip from the tree into a catch net, or be pulled from the tree or hiding place (Sweeney, personal communication). Field data forms containing cat number, sex, date, time of capture, capture method, capture locality, and biologist name were filled out for each animal. After approximately one hour, the bobcats would regain mobility and be released.

Telonics (Mesa, Arizona) radiotransmitters attached to collars were strapped around the necks of the captured animals. Each transmitter had a frequency range of 148 to 148 MHz; therefore, each bobcat had a different frequency allowing

individual indentification (Sweeney, pers. comm.).

The bobcats were monitored with hand held TR-1 20 channel receivers with RA-2A directional H-antennas (Telonics, Mesa, Arizona) over the 33 month period. Each location was recorded when three or more different compass bearings were taken from an identified signal. Also recorded were the date and time of location. The animal locations were estimated as the point of smallest triangle formed by the intersection of three bearings, then plotted on study area base maps (scale 1:24,000)(Sweeney, pers. comm.). Although not randomized, data were collected during all months and hours of the study. A total of 2,282 locations were collected from 27 bobcats. The number of locations per animal ranged from 3 to 303.

Habitat Classification

Classification of the bobcat study area into eleven generalized land cover types was determined by LANDSAT II MSS. This experimental satellite developed by NASA is part of a program designed for earth observation remote sensing; thus, it has a wide variety of potential uses including management applications (Kroeck 1976).

The primary sensing unit onboard LANDSAT is the MSS. Briefly, this system collects radiometric data in four spectral bands - two in the visible spectrum (500-600 nm and 600-700 nm) and two in the near infrared (700-800 nm and 800-1100 nm). The data are telemetered to ground receiving stations, then sent to the NASA-Goddard Space Flight Center.

There the signals are converted into an image format, or "scene," containing various reflective patterns are classified into independent land cover classes. Resolution of the MSS is one pixel which is equivalent to approximately 1.1 acres (Kroeck 1976; Neal 1984).

In this study, an image map of the study area was generated on July 20, 1979. The land cover was classified according to successional stage and dominant tree type as viewed from LANDSAT. No species composition nor understory growth is obtained. The classification of land cover is presented in Table 1.

Preparation for Data Analysis

Prior to data analysis, it was necessary to record the field data onto format sheets for data entry. This was done by myself, from June 21, 1983 to July 8, 1983, in the Remote Sensing Application Laboratory, University of Washington. The information was organized into species, cat number, sex, age class, tooth age, location number, date of location, military time of location (Pacific Standard), and remarks (i.e. den location, capture location, intensive monitor). Once these data were recorded, the base maps with bobcat locations were overlayed by a LANDSAT imagery map of the study area (scale 1:24,000). This provided a line and sample for each bobcat location represented by a single pixel. The land cover of this pixel and its eight adjacent pixels were recorded.

Table 1. LANDSAT II land cover classification, age structure and percent composition for bobcat study area in western Washington, July 20, 1979.

Land Cover Class	Age Structure (years)	% Composition
Old growth coniferous forest	> 70	2.2
Second growth coniferous forest	20 - 70	38.0
Regrowth coniferous forest	10 - 20	6.7
Mixed conifer/broadleaf forest	20 - 70	17.4
Broadleaf forest	all ages	16.3
Shrub/seedling	5 - 10	11.5
Grass/forb	< 5	2.5
Bare ground/rock	*	2.9
Water/wetland	*	0.8
Developed	*	0.0
Unclassified	*	1.4
Other	*	0.3
		100.0

Data Analysis

Although some of the bobcats were located more than once per day, data analysis was limited to only one observation per day per animal. The data were then entered on a computer at the Washington Department of Game. This produced 632 winter locations distributed over day (one hour after sunrise to one hour before sunset), night (one hour after sunset to one hour before sunrise), and crepuscular (sunrise ± one hour and sunset ± one hour) hours. Each bobcat location was represented by nine pixels. A chi-square test was used to compare bobcat locations with the percent availability of five LANDSAT habitats (considered to be 100% of the total area) during each period. The test was also used to determine any significance among cover types in each period.

IV
RESULTS

Results of the statistical test comparing observed and expected winter bobcat locations within available habitats for crepuscular, day and night hours are shown in Tables 2, 3, and 4. A significant difference ($df = 4$; $p < 0.005$) is seen for each time period.

Results of the chi-square test comparing observed and expected winter bobcat locations among each habitat during the three periods are below. During crepuscular hours, the bobcats showed a significant preference for regrowth coniferous and broadleaf forests than for second growth coniferous and mixed forests ($df = 1$; $p < 0.05$). No significant differences existed between the two habitats preferred, nor between the two not preferred ($df = 1$; $p > 0.05$). No significance resulted when the shrub/seedling environment was compared to each of the other four cover types ($p > 0.05$).

In the daylight hours, the regrowth coniferous forest was highly preferred ($p < 0.05$) compared to each habitat, whereas the second growth coniferous forest was least preferred ($p < 0.05$). The shrub/seedling habitat and broadleaf forest show no difference in bobcat preference between them ($p > 0.05$); however, they were more apt to be found in those two environments than in mixed forest ($p < 0.05$).

Table 2. Chi square analysis comparing observed and expected winter bobcat locations within available habitats during crepuscular hours.

Habitat	Percent Availability	Observed	Expected	Chi-square value
Second growth conifer forest	42	29	37.38	1.879
Regrowth conifer forest	8	15	7.12	8.721
Mixed conifer/ broadleaf forest	19	9	16.91	3.700
Broadleaf forest	18	22	16.02	2.232
Shrub/seedling	13	14	11.57	0.510
		89		$\chi^2 = 17.042$

Table 3. Chi-square analysis comparing observed and expected winter bobcat locations within available habitats during daytime hours.

Habitat	Percent Availability	Observed	Expected	Chi-square value
Second growth conifer forest	42	111	191.94	34.132
Regrowth conifer forest	8	82	36.56	56.477
Mixed conifer/ broadleaf forest	19	77	86.83	1.113
Broadleaf forest	18	110	82.26	9.355
Shrub/seedling	13	77	59.41	5.208
		457		X^2= 106.285

Table 4. Chi-square analysis comparing observed and expected winter bobcat locations within available habitats during nighttime hours.

Habitat	Percent Availability	Observed	Expected	Chi-square value
Second growth conifer forest	42	25	36.12	3.423
Regrowth conifer forest	8	21	6.88	28.979
Mixed conifer/ broadleaf forest	19	7	16.34	5.339
Broadleaf forest	18	17	15.48	.149
Shrub/seedling	13	16	11.18	2.078
		86		$X^2 = 39.968$

Distribution of bobcats locations among the cover types at night show the animal had a preference for the regrowth conifer forest ($p < 0.05$), especially over the second growth forest (chi-square = 30.093; df = 1; $p < 0.001$) and the mixed forest (chi-square = 27; df = 1; $p < 0.001$). The shrub/seedling environment was selected over second growth conifer and mixed forests ($p < 0.05$), though no significance was recorded between this shrub/seedling habitat and broadleaf forest ($p > 0.05$). Also, no significant difference was seen comparing second growth conifer forest with mixed or broadleaf forests ($p > 0.05$).

V
DISCUSSION

A consistant relationship of winter habitat selection by the bobcat is evident from my results. Regrowth conifer forest, though it makes up only 8% of the total area, was the most highly used cover type throughout all three time periods. This habitat is probably significant to the bobcat by providing dense cover for hunting activities, rest areas during the day and night, and a maximum of small prey species (McCord 1974; Hall and Newsom 1978). Sweeney (1978) noted that the bobcat of western Washington preys mainly on mountain beaver (Aplondontia rufa) which are probably abundant in lush understory vegetation of previously logged areas. McCord also concluded that areas of high cover density, characteristic of cut-over areas, were selected by Maine bobcats in winter to reduce effects of environmental conditions (i.e. snow depth, radiation loss and wind) and; therefore, to conserve energy.

Broadleaf forest composing 18% of the study area was also a highly preferred habitat of the bobcat throughout crepuscular, day and night hours. In contrast to my results, McCord's (1974) study concluded that hardwood habitats (broadleaf forests) were the least selected cover type due to a low density cover. But, he noted that prey densities were high in those areas which, in turn, may be important to the bobcat of western Washington.

Though second growth coniferous forests comprised 42% of available habitat in the study area, this was overall the least used by the bobcats during the winter. Likewise, the mixed conifer/broadleaf forest (19% of available habitat used) was not highly selected. These areas are probably regions within the animals home ranges which were less used due to a low prey base or cover density.

The shrub/seedling habitat (13% of available habitat used) was consistantly preferred over the second growth and mixed forests during the day and night periods. This habitat was probably not used for its density of cover because of its young vegetative growth (5-10 years after logging), yet may be reflective of hunting areas which provide a variety of small prey species.

Management Importance

The significance of this study lies in its potential management applications. In Washington State, where forest activities are a major economic industry, it is important to understand and predict how land use changes will affect not only the bobcat behavior, but the behavior of other animals as well. According to Sweeney (1978), reforestation of logging areas are subject to an increase in population of, and consequent destruction by, the mountain beaver and snowshoe hare (Lepus americanus). Both animals are a

favorite prey for the bobcat which, in turn, provides potential benefit for the timber industry.

As these results suggest, the bobcat depends heavily throughout the winter months on the availability of a re-growth conifer forest. This conclusion can be used to predict the effects of land management on bobcat populations and, thus, facilitate the development of desired populations through proper management of the land.

The adoption of LANDSAT II MSS in this study has some important applications in wildlife management. Because LANDSAT's computational ability is extremely fast, cost and time spent in the field to determine habitat are substantially lowered. Also apparent is the rapid accessibility of the data generated for a particular area. The accuracy of the data is 90.5% within ten independent LANDSAT classification strata; however, more accuracy could be obtained if more classes were used (Shinn 1982).

Though LANDSAT has great potential, it still has problems which need to be resolved. The major problem related to this study was the satellite's ability to only generate gross cover types, not species composition nor understory density. This latter point affects the ability to do detailed analysis of habitat preference for any animal species.

Future Studies

The preliminary organization of the data onto computer sheets involved much more information than what has been used in this report. Comparisons of male and female bobcats, age classes, seasons, home ranges, etc. could easily be done using LANDSAT land cover data. The knowledge obtained as a result of these studies will help increase the information needed to properly manage the bobcat of western Washington.

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