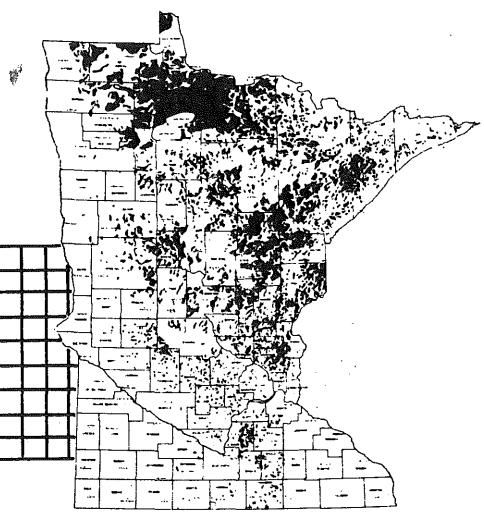
MINNESOTA PEAT PROGRAM

Utilization of Minnesota Peatland Habitats by Snowshoe Hare, White-tailed Deer, Spruce Grouse, and Ruffed Grouse



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UTILIZATION OF MINNESOTA PEATLAND HABITATS BY SNOWSHOE HARE, WHITE-TAILED DEER, SPRUCE GROUSE, AND RUFFED GROUSE

Pamela J. Pietz and John R. Tester

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Department of Ecology and Behavioral Biology

108 Zoology, 318 Church Street S.E.

Minneapolis, Minnesota 55455

ABSTRACT

In a 10-km^2 area of Hubbard County, Minnesota, radio-telemetry was used to study habitat use and selection by snowshoe hare, white-tailed deer, spruce grouse, and ruffed grouse. The study area contained 7 types of lowland habitat interspersed with 4 types of upland habitat. Four deer, 16 hare, 15 spruce grouse, and 7 ruffed grouse were radio-tracked between December 1977 and June 1979. Additional data were collected from snow track surveys, road track surveys, pellet counts, grouse studies, and incidental sightings.

Snowshoe hare varied considerably in patterns of habitat use. The only overall trends were an avoidance of open habitats of all types, and a correlation between intensity of hare use and density of shrubs over 1 m tall. Nine of 16 radio-tagged hares were found most often in lowland habitats; 4 were most frequently in edge habitats. It appears that alder fen, upland-alder edge, and conifer bogs are preferred habitats at high population densities and provide essential refuges for hares during population lows.

All 4 radio-tagged deer used uplands at least 50% of the time, but 3 of these 4 used lowlands more than expected by chance. Preferred habitats included mixed upland, jack pine-alder edge, alder fen, and black spruce bog. There is some indication that pockets of lowlands provide important fawning cover.

Spruce grouse exhibited strong seasonal changes in habitat preferences. In months of snow cover all grouse preferred jack pine upland; from May through September all males and most females selected

for coniferous lowlands. Their strong preferences for display sites in black spruce bogs and for nest sites in mixed bogs suggest that such lowlands may be critical for reproduction.

Radio-tagged ruffed grouse varied considerably in habitat utilization patterns. Selection was shown for mixed upland, mixed upland-mixed lowland, deciduous upland-alder edge, black spruce bog, and alder fen. Drumming logs, nests, and broods were found most frequently in alder or upland-alder edge, suggesting that alder habitat may be important to the reproductive success of ruffed grouse.

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INTRODUCTION

Minnesota contains vast areas of peatlands, yet until recently, little effort had been made to understand certain aspects of their ecology. Virtually nothing was known about the use of these peatlands by terrestrial vertebrates. The primary purpose of this study was to investigate utilization of peatland habitats by 4 game species: snowshoe hare (Lepus americanus), white-tailed deer (Odocoileus virginianus), spruce grouse (Canachites canadensis), and ruffed grouse (Bonasa umbellus).

Despite the volumes of literature available on some of these species, relatively little attention has been given to the role of peatland habitats in their life histories. Habitat selection studies that have been conducted in Minnesota include those of Anderson (1973) and Haas (1974) on spruce grouse; Godfrey (1975) and Maxson (1978) on ruffed grouse; Marshall (1977) on snowshoe hare; and Kohn (1970), Weddell (1973), Pierce (1975), and Rongstad and Tester (1969) on white-tailed deer.

Few of these studies were conducted in areas that contained both upland habitats and a wide variety of lowland habitats. To better evaluate the importance of peatlands to these 4 species, we selected a study site that contained as many habitat "choices" as possible.

Using radio telemetry as the primary tool for collecting data, we wished to determine:

(1) What types of peatlands are used by each of these species, and to what extent;

(2) Which habitats are preferred or avoided (i.e., used disproportionately to their availability);

(3) What changes in use and preference occur in various seasons and in various periods of night and day; and

(4) What activities are carried out by these species in the habitat types they utilize?

STUDY AREA

The study area selected for this project included most of Sections 6 and 7 of Lake George Township (T143N, R34W), and Sections 1 and 12 of Lake Alice Township (T134N, R35W) in Hubbard County, Minnesota (See Appendix A). The area was largely jack pine upland interspersed with several types of lowland, such as tamarack bog, black spruce bog, sedge fen, alder fen, and scrub fen. A complete list of habitat types and their availability can be found in Appendix B.

Throughout this report habitat types are designated by the plant species that dominated them. A short description of vegetational characteristics of these types is given below.

Jack pine upland consisted of variously aged stands of jack pine (Pinus banksiana), 6-18 m tall, having from 50% to 75% cover. They contained some pockets of red pine (Pinus resinosa) and balsam fir (Abies balsamea), and scattered individuals of white spruce (Picea glauca). The shrub layer, varying from 0% to 80% cover, included rose (Rosa spp.), cherry (Prunus spp.), raspberry (Rubus spp.), and hazel (Corylus spp.). Ground cover was dominated by blueberry (Vaccinium angustifolium), bearberry (Arctostaphylos uva-ursi), and grasses.

Deciduous upland generally included mixtures of paper birch (Betula papyrifera) and aspen (Populus spp.), with some balsam poplar (Populus balsamifera) and oak (Quercus spp.). The shrub layer was largely hazel and secondary growth of aspen and birch.

Mixed upland included coniferous and deciduous trees of the species named above. The shrub layer varied from 30% to 90% cover and consisted of a mixture of species. Hazel, speckled alder (Alnus rugosa), cherry, rose, and raspberry occurred most often.

Upland clearings were generally openings in jack pine stands resulting from logging operations. Some shrubs occurred in these openings -- typically raspberry -- and slash piles were common. Ground cover included grasses, bearberry, blueberry, and numerous forbs.

Black spruce bog* included variously aged stands of black spruce (Picea mariana), 10-18 m tall, having from 30% to 90% canopy cover. Understory ranged from 0% cover in the closed canopy stands to 90% in the most open ones. Alder, red osier dogwood (Cornus stolonifera), young black spruce, and bog birch (Betula pumila) were the most common elements of the shrub layer. Ground cover was dominated by Labrador tea (Ledum groenlandicum) and other ericaceous species. Sphagnum mosses (Sphagnum spp.) carpeted the forest floor of hummocks and pools.

Tamarack bog included stands of tamarack, 5-12 m tall, having from 30% to 40% cover. The shrub layer varied from 20% to 80% and contained bog birch, willow (Salix spp.), young black spruce and tamarack, and Labrador tea. Other ericaceous species and numerous herbaceous plants provided ground cover. Sphagnum carpeted much of the forest floor of hummocks and pools. This habitat type intergraded with black spruce bog in some areas.

Muskeg denoted bog areas having from 5% to 25% tree cover. Trees were black spruce or tamarack, typically young or stunted. A hummocky ground surface of sphagnum mosses was characteristic, covered by leatherleaf (Chamaedaphne calyculata), Labrador tea, cranberry (Vaccinium oxycoccus), and other ericaceous species. Pitcher plants (Sarracenia purpurea) and cotton grasses (Eriophorum spp.) were locally common.

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*Bog and fen subdivisions follow those of Heinselman (1970)

Open bog areas appeared much the same as muskeg in all but tree cover. Here the tamarack-black spruce component provided less than 5% ground cover.

Alder fen was characterized by tall, dense stands of alder shrubs. Scattered trees occurred in some stands, as did various shrub species such as willow and bog birch. The ground cover was rich in herbaceous species.

Scrub fen areas were characterized by a low shrub layer (.5-1 m), dominated by bog birch or willow species. Sedges (Carex spp.) and leatherleaf were common in the ground layer. Species of mosses and herbaceous plants differed considerably with location. This habitat type intergraded with sedge fen, alder fen, open bog, and muskeg.

Sedge fen denoted areas generally lacking woody vegetation and dominated by sedge species. A variety of forbs and bryophyte mosses typified the ground flora. These areas were the most flat and wet of all habitat types.

Faunal records for the study area included numerous large mammals and birds, several of which may be considered predators of one or more of our 4 study species. Among the more important mammals were coyote (Canis latrans), red fox (Vulpes fulva), bobcat (Lynx rufus), striped skunk (Mephitis mephitis), shorttail weasel (Mustela erminea), raccoon (Procyon lotor), red squirrel (Tamiasciurus hudsonicus), and black bear (Ursus americanus). Raptorial avifauna included goshawk (Accipiter gentilis), red-tailed hawk (Buteo jamaicensis), broad-winged hawk (Buteo platypterus), sharp-skinned hawk (Accipiter striatus), bald eagle (Haliaeetus leucocephalus), great horned owl (Bubo virginianus), great gray owl (Strix nebulosa), barred owl (Strix varia), and saw-whet owl (Aegolius acadicus).

METHODS

Trapping and Tagging

An attempt was made during this study to maintain a total of 15 to 20 radio-tagged animals at all times. Since radioed animals were frequently lost due to predation, emigration, and transmitter failure, trapping and tagging efforts continued throughout the course of field operations.

Snowshoe hare were trapped during all seasons in national live-traps baited with peanut butter and apples. Trapping efforts covered all available habitat types in the study area, each for a minimum period of 1 week. Radio collars used for hares followed the design described by Mech et al. (1965).

Deer were caught in late winter by using V-shaped wooden traps with a drop-net closure. Several types of bait were tried; of these, corn and commercial deer pellets seemed to be preferred by the deer. Attempts to trap deer in other seasons, with food or salt as bait, were unsuccessful.

The radio collars used for deer were nonexpandable, following the design given by Tester et al. (1964). Since the neck size of males changes during the breeding season, only females could be fitted with radios.

Ruffed grouse males were most easily trapped in spring with mirror traps (Gullion 1964) on drumming logs. Ruffed grouse hens were trapped on nests with either a landing net or a nest trap (Coulter 1958). Unsuccessful attempts were made to catch ruffed grouse in winter by using lily-pad traps (Gullion 1965) baited with red-dyed kernel corn. Radio transmitters were fitted to grouse with a harness design similar to that described by Brander (1968).

Spruce grouse were most successfully trapped during periods of snow cover in lily-pad traps baited with coarse soil. In all seasons attempts were made to "snare" grouse by using the technique of Zwickel and Bendell (1967). This method met with variable success, both in terms of safety to the birds and amount of effort per capture.

Data Collection

Data were collected for this study primarily by the use of a high-frequency radio-tracking system designed and built by personnel of the Cedar Creek Bioelectronics Laboratory, University of Minnesota. Animals were trapped, radio-tagged, and released within the study area and then were relocated at least once in every 48-hour period. The time schedule for relocation was varied as much as possible in an attempt to obtain data from different periods of day and night.

Locations were made most often by triangulating from known positions with hand-held antennas or antennas that were mounted on 7.6 m towers. For each triangulation, bearings were recorded in compass degrees from three or more positions. These bearings were plotted on a gridded vegetation map to find the point of intersection and the corresponding x, y coordinates. Date, time, habitat type, and x, y coordinates were recorded for each location of each animal.

Visual locations were also made since direct observation was often the only means of obtaining data on courtship, reproduction, and other important activities. To make such locations we followed the appropriate radio signal until the animal was in sight. The distance from the point of observation to a known location was paced on a specified compass bearing. This information was then plotted on the vegetation map to determine the x, y coordinates corresponding to the animal's position.

A location was assigned to "edge" habitat types whenever the plotted point fell within 15 m of a vegetational boundary line. If a point fell within 15 m of more than one line, the location assignment was divided among the edge types involved.

Weather data were collected on a daily basis. These included temperature, precipitation, wind direction, and wind speed. Maximum and minimum daily temperatures were available from the Lake Itasca Biology Station, located 15 km west of the study area. During periods of snow cover, snow depth and profile information was gathered weekly in 6 different habitat types.

Additional sources of information on habitat use and selection included snow track surveys in periods of adequate snow cover, a pellet survey in the spring, and road track censuses in the summer and early fall.

Snow track surveys were made after each fresh snowfall from February through April 1978, and from November 1978 through March 1979. In each survey 12 habitats were sampled for tracks, droppings, and other sign of deer, hare, and grouse. Within each habitat type the worker walked a specified number of paces and then stopped, examining a circular area of 3-m radius for the presence or absence of animal signs. This procedure was repeated until a designated number of circular plots had been checked. The number of plots examined in each type was roughly proportional to the amount of that type within the study area.

The pellet survey was conducted in the spring (May 1978) to correspond with Department of Natural Resources' pellet surveys of other areas. For our work 10 habitats were sampled by randomly choosing 30

rectangular plots, 3 m x 2 m , in each type. In each plot the number of deer pellet groups was counted and the presence or absence of hare and grouse droppings was noted. Plot sample sizes were not skewed to habitat availability in this case, because the survey was done in conjunction with a similar survey in the Red Lake peatlands of Beltrami County. An attempt was made to compare the use of comparable habitat types in the two areas.

On an unpaved road bisecting the study site, we undertook a census of deer tracks after each heavy rainfall and after each road grading from 27 June to 3 November 1978 and 2-25 May 1979. Along this 3.2-km stretch of road, we recorded the habitat type from which each set of tracks emerged onto the road and the type it entered upon leaving the road. The total numbers of tracks entering or exiting each habitat type were then compared to the percentages of each type that bordered the road.

Two short-term projects, conducted by individual students, provided additional information about spruce grouse and snowshoe hare habitat relations. From July through August 1978, Cindy Hagley studied 2 radio-tagged spruce grouse hens and their broods, noting the characteristics of habitat they used and recording their feeding habits. One hen, chosen for detailed analysis, was observed for several hours on 10 separate occasions. The vegetation was analyzed at these 10 sites and at an equal number of randomly selected sites within the hen's summer home range. Vegetation was sampled within circles, 6 m in diameter, and percent cover was recorded for all trees, shrubs, and herbaceous vegetation. Basal area and stems per hectare were also determined for trees at each site. Ground cover including mosses, lichens, and stumps was noted.

In February 1979, Peter Harris surveyed snowshoe hare browse in 5 types of vegetation. Adapting techniques developed by Grigal and Moody (in press), he measured available and utilized browse of 3 stem-diameter size classes in 360 sample plots, each with area .6 m^2. "Available" stems included all living stems, browsed or unbrowsed, that were no more than 1 cm in diameter and no more than 50 cm above the snow or ground surface. Numbers of stems in each size class were translated to approximate biomass for each species by using estimates of Grigal and Moody (in press). Plot locations were determined by standardized pacing along parallel transect lines. To avoid possible bias caused by a sampler walking around dense shrubs, plots were arranged in threes to form an isosceles triangle at each stopping point. One plot of the 3 was located on the transect line; the other 2 were located behind it and on either side of the line.

Three additional forms of habitat use information collected during this study are described below. Though less systematically obtained than some of the other types discussed, they were valuable supplements to the data.

In the springs of 1978 and 1979, efforts were made to locate as many ruffed grouse drumming logs as possible. A description of the habitat around each log was recorded. In spring 1979, efforts were also made to locate display sites of male spruce grouse. Again, habitat characteristics were recorded at each site.

Incidental information on all 4 study species was gathered by recording sightings and signs of unmarked animals encountered during routine field work. Data collected during the 18-month field study were tabulated by species, season, and habitat type.

Finally, in late May 1979, a survey of snowshoe hare pellets and shrub cover was conducted in 12 stands of upland and lowland forest. The survey was an attempt to determine the relationship between % shrub cover and intensity of hare utilization without regard to the species of trees forming the forest canopy. Thus, stands were chosen that represented a wide range of shrub cover and canopy type. A total of 85 plots (6 m x 2 m) were examined for number of pellets, total % shrub cover, shrub cover .5 - 1 m tall, shrub cover more than 1 m tall, and species of shrubs present. In addition to number of hare pellets, presence or absence of deer and grouse sign was also recorded.

Data Analysis

When analyzing radio-telemetry data, we assumed that the distribution of radio locations in various habitats reflected the actual distribution of use of those habitats. Thus, if 10 % of an animal's locations were in alder fen, it was assumed that the animal actually used alder fen about 10 % of the time.

Most data were statistically analyzed using Freeman-Tukey and Pearson goodness of fitness tests. We chose the Freeman-Tukey goodness of fitness test for much of our work because its variance-stabilizing properties seemed to yield more reasonable analyses when sample sizes were small (Bishop, Fienberg, and Holland 1975).

Some types of data were analyzed using the nonparametric Friedman test and a multiple range comparisons test (Hollander and Wolfe 1973). These tests were especially useful when looking for trends in habitat use among several individuals or among several time blocks. Use of these techniques generally followed that of Harmoning (1976), who applied them to a habitat utilization study of radio-tagged white-tailed deer.

Another statistical test employed was the correlation coefficient, "r" (Snedecor and Cochran 1967). This was used to check for relationships between parameters such as snow depth and number of tracks, and shrub cover and number of droppings.

When analyzing data to determine presence or absence of habitat selection, we made comparisons between the observed use of each habitat type and the expected use of each type. Expected values were based on the assumption that animals moved at random through the study area, using each habitat type in proportion to its availability (as listed in Appendix B). If observed and expected values were not significantly different, we considered that no habitat selection was exhibited. Figures depicting habitat selection were patterned after those of Berg and Phillips (1973).

In all statistical analyses, test results were considered significant when null hypothesis probabilities were 5% or less.

RESULTS

Snowshoe Hare

Between December 1977 and October 1978, 334 trap nights resulted in 21 captures and 3 recaptures of snowshoe hares. Twenty hares were given radio collars, and 16 of these provided sufficient data for analysis. Figure 1 shows the time period for which each hare carried an effective radio transmitter.

Radio-telemetry data for 16 hares showed that habitat use patterns were highly individualistic. Variation among hares was so great that no overall trends could be found within the species, within sexes, or within seasons. Figure 2 illustrates the proportions of time spent by each hare in upland, lowland, and edge habitats. Nine of the 16 hares were found in lowland more than in any other type, 4 were most often in edge habitats, and 3 were most frequently found in upland.

Eleven hares carried transmitters long enough to allow analysis of seasonal habitat use patterns. Six of these showed no significant changes with time. Four of the 5 that did show seasonal changes had only 1 habitat shift in common; i.e., their relative use of lowlands decreased in spring (March-May) while that of uplands increased.

Six hares had sufficient data to analyze habitat use during day, night, and crepuscular* periods. Four hares showed significant differences between nighttime habitat use and use during the other 2 periods. For these 4, proportions of lowland and edge use were greatest

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*"crepuscular" denotes the periods one hour before sunrise and one hour after sunset.

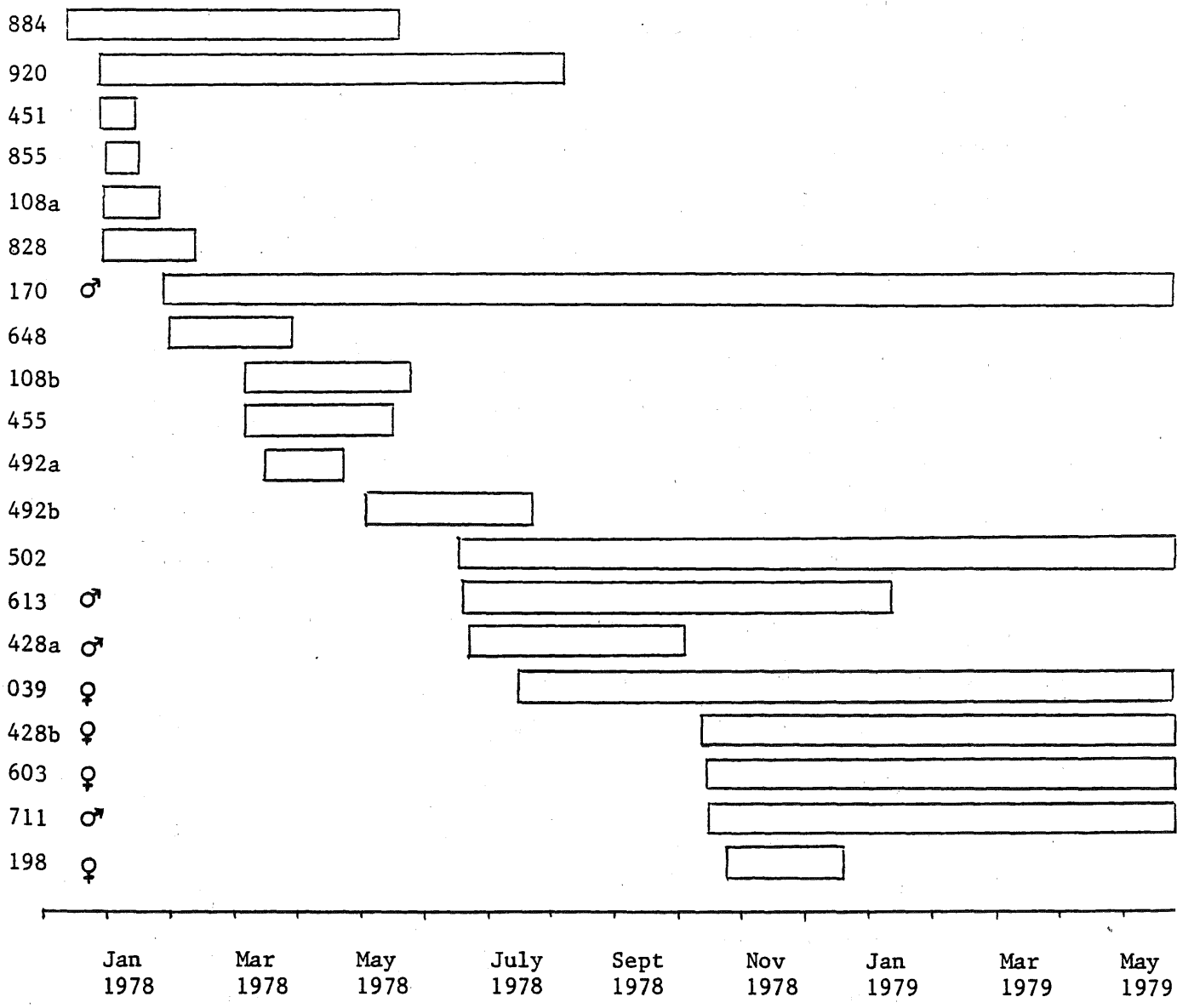

Figure 1. Time periods during which 20 snowshoe hares carried effective radio transmitters on the Lake Alice study site, 1978-1979. Individuals are identified by radio frequency, and sex is indicated where known.

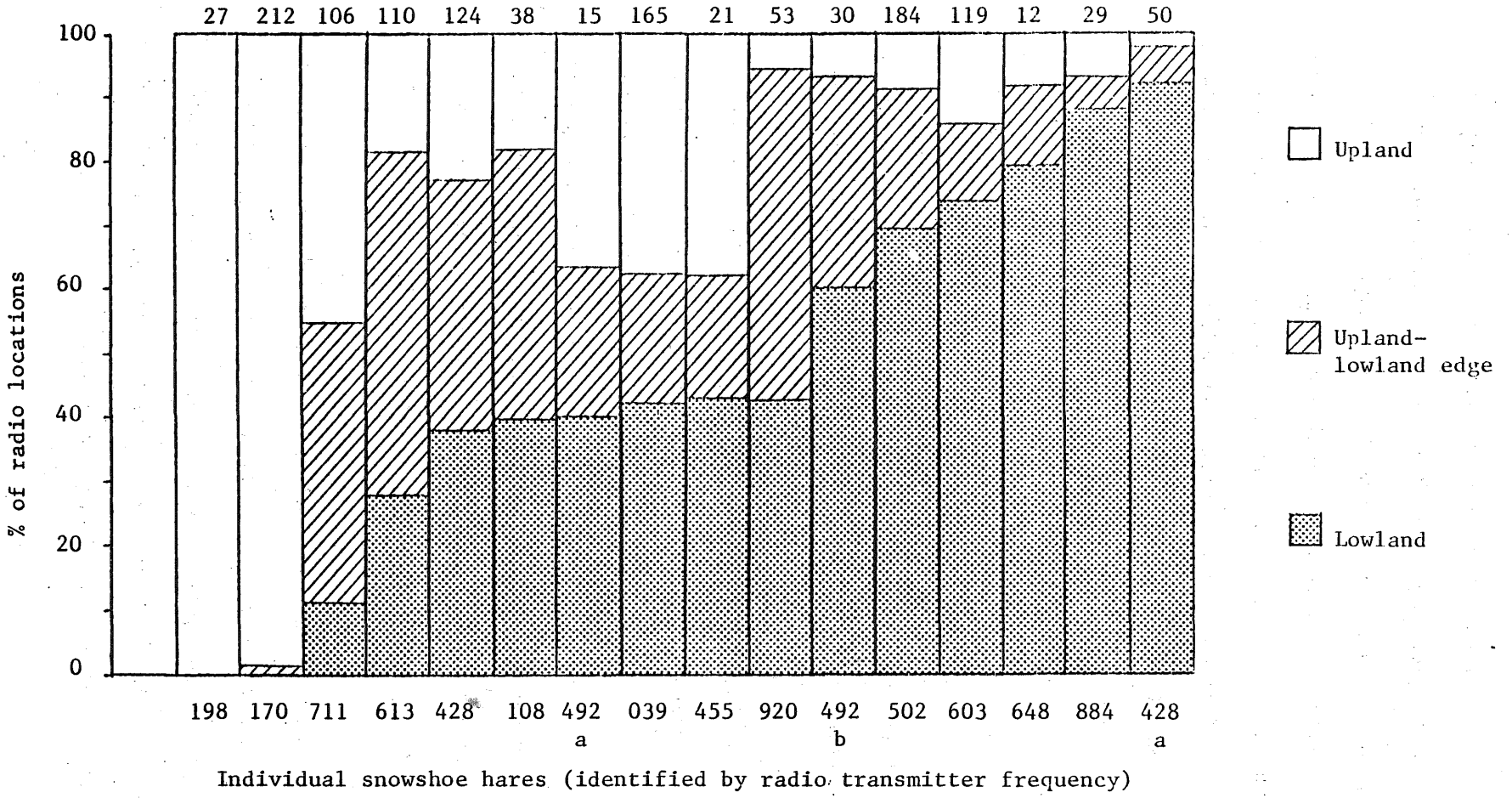

Figure 2. Utilization of upland, lowland, and edge habitats by radio-collared snowshoe hares in the Lake Alice study area, Jan. 1978 - May 1979. Habitat use is expressed as the % of all radio-telemetry locations recorded for each animal. The total number of locations for each hare is indicated above the column.

in the crepuscular and day-time periods; utilization of upland increased significantly at night. For the other 2 hares, differences between periods were no greater than would be expected by chance.

Habitat use is illustrated in more detail in Figures 3 and 4. Figure 3 shows how many hares used each of 21 habitat types. The types used by the greatest number of hares included jack pine upland, alder fen, and jack pine-alder edge. Black spruce bog and mixed upland were the only other types used by at least half of the hares.

In Figure 4, radio-location data for the 16 hares were combined by habitat type to illustrate overall intensity of use. Again jack pine, jack pine-alder edge, and alder fen received the highest rankings. Tamarack bog, black spruce bog, deciduous upland, and mixed upland followed closely, each with about 8%-10% use. No other types were used more than 5% of the time.

Habitat selection is illustrated in Figure 5; again the data were combined for the 16 hares. This figure shows the difference between the % use of a habitat type and the % of that habitat type available on the study site. Given the high availability of jack pine, selection against this type was by far the strongest. Positive selection, or preference, was not overwhelming for any single habitat type: jack pine-alder edge, alder fen, black spruce bog, and deciduous upland were all nearly equal in rank.

When habitat selection was examined on an individual basis, the picture changed somewhat. Four of the 16 hares most strongly preferred black spruce; alder fen and jack pine-alder edge were each the first choice of 3 hares; 2 selected tamarack bog most strongly; and one each selected deciduous upland and deciduous-alder edge.

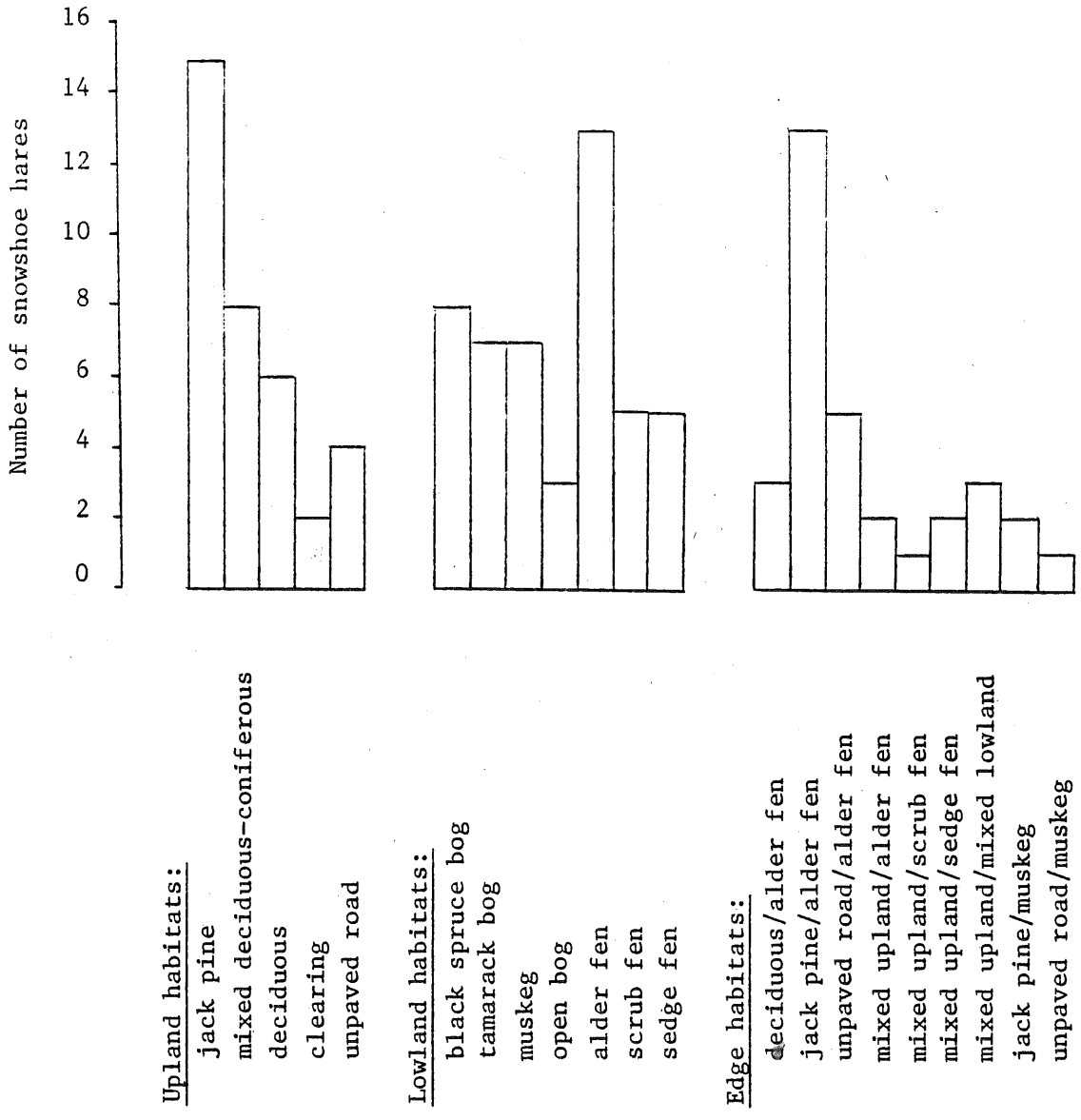

Figure 3. Numbers of radio-tagged snowshoe hares that used each habitat type on the Lake Alice study site, Jan. 1978-May 1979.

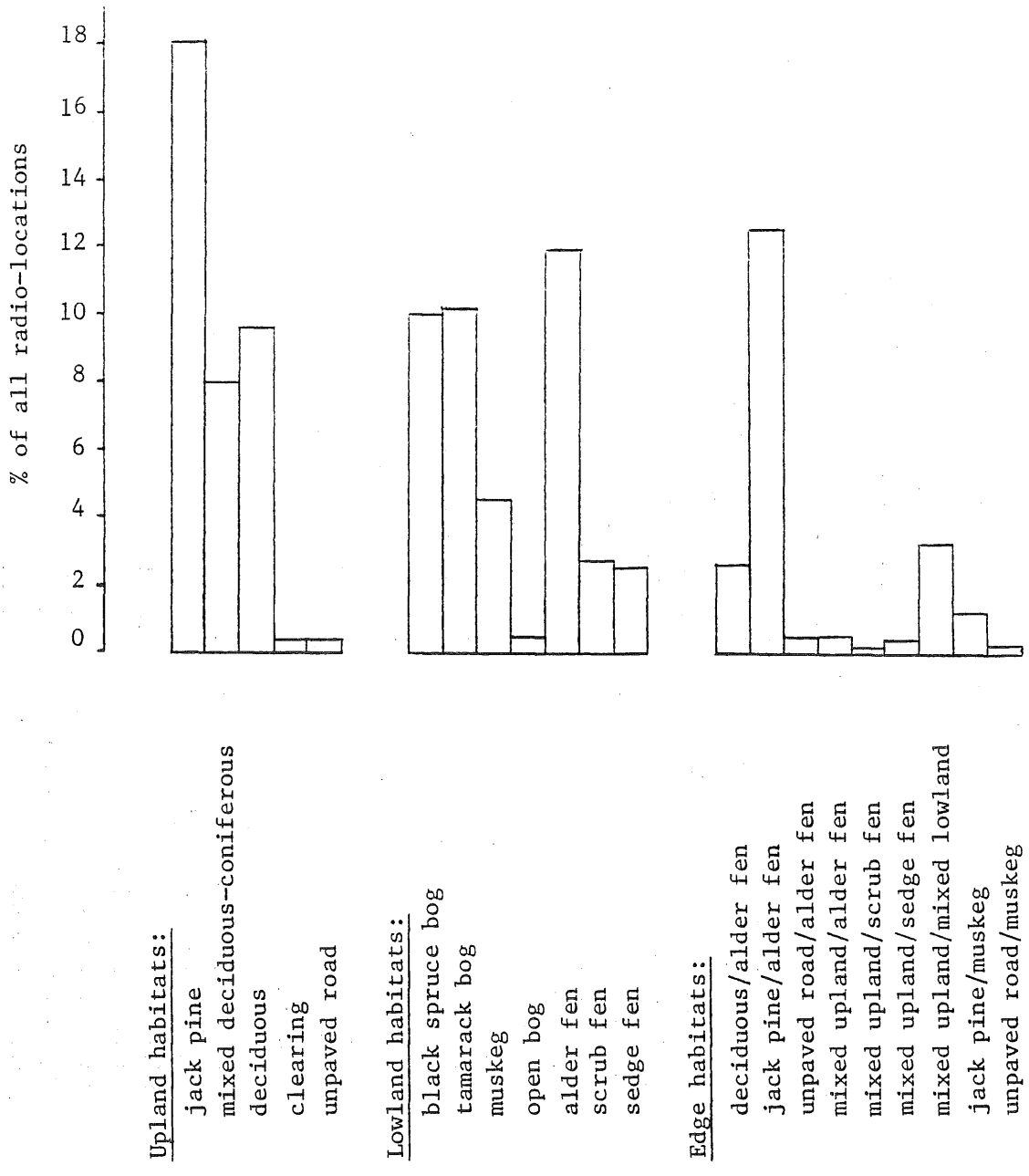

Figure 4. Habitat utilization by 16 radio-tagged snowshoe hares in the Lake Alice study area, Jan. 1978-May 1979. Utilization is expressed as the % of all radio locations of the 16 hares that were ascribed to a given habitat type.

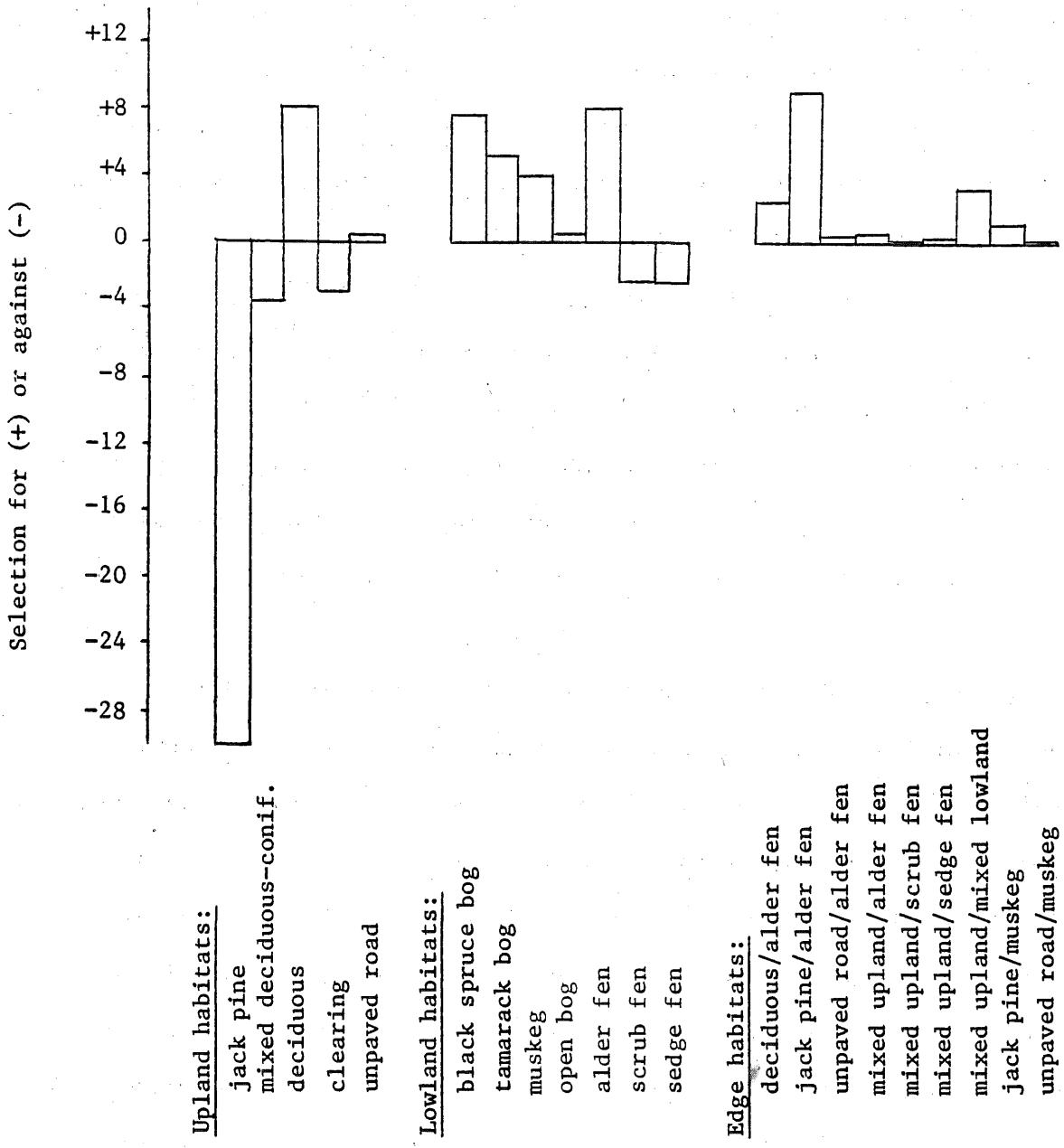

Figure 5. Selection by 16 radio-tagged snowshoe hares for (+) or against (-) habitats in the Lake Alice study area, Jan. 1978-May 1979, expressed as the difference between the % of all radio locations in a given habitat and the % of that habitat available.

Winter habitat use patterns, evidenced by 15 snow track surveys, are illustrated in Figure 6. Tracks of snowshoe hares were most frequently found in the sample plots of tamarack bog, black spruce muskeg, alder fen, and jack pine-alder edge. Tracks were least frequent in the 3 most open habitats: upland clearing, sedge fen, and open bog. Hare droppings and forms were found most often in tamarack bog and, to a lesser extent, in muskeg and alder types. In no upland type was the % of plots with sign greater than the average % calculated over all habitat types.

Snow track data were further examined to see if habitat use patterns changed during the period of snow cover. The only clear trend was a decline in use of deciduous upland from mid-November 1978 to early March 1979.

Incidental sightings of unmarked snowshoe hares provided an additional source of information on habitat utilization. As shown in Table 1, there was a clear difference between the pattern of use during snow-free periods and the pattern of use during snow cover. Almost 60% of the 105 sightings in snow-free periods were in upland, while only about 14% were in lowland. The trend reversed during periods of snow cover, with only 24% of the 27 sightings in upland and 52% in lowland. About 1/4 of the sightings were in edge habitats during both periods. As found for radio-tagged hares, jack pine was the most frequently used upland type, alder was the favored lowland type, and jack pine-alder was the most frequently used edge.

Table 2 gives the results of a pellet survey conducted in the Lake Alice study area and in the Red Lake peatlands near Waskish, Beltrami County. Despite the fact that habitat categories were specifically

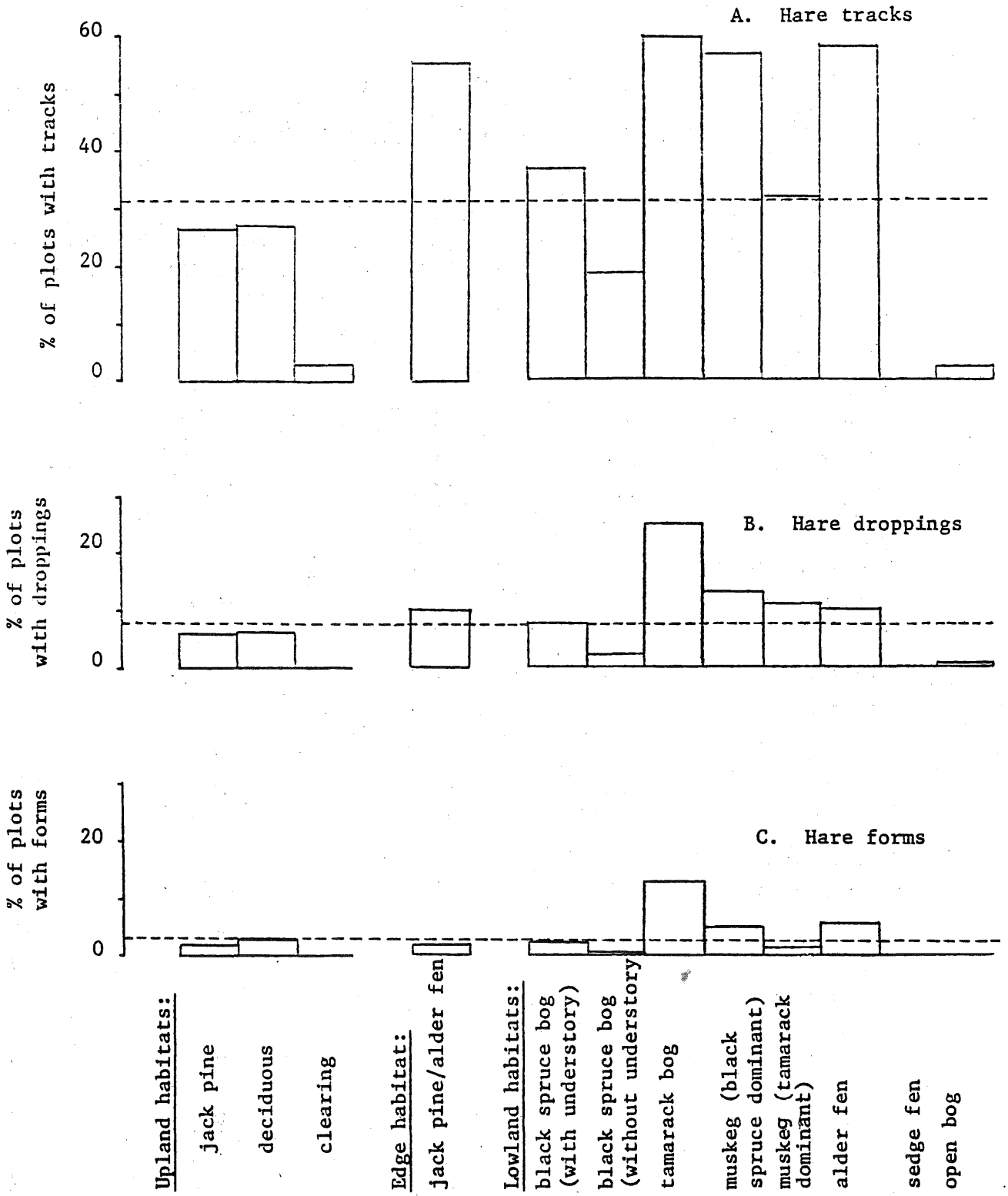

Figure 6. Habitat use by snowshoe hares as evidenced by 15 snow track surveys, Feb. 1978-Mar. 1979, in the Lake Alice study area. Bars represent the % of the sample plots in each habitat in which tracks, droppings, or forms were present. Broken lines indicate the average %s of all sample plots that contained sign.

Table 1. Incidental sightings of unmarked snowshoe hares on the Lake Alice study site. Periods of snow cover included Dec. 1977-Mar. 1978 and Nov. 1978-Mar. 1979. Snow-free periods were Apr.-Oct. 1978 and Mar-May 1979.

Habitat type	Number of sightings during periods of snow cover	Number of sightings during snow-free periods	% of sightings during periods of snow cover	% of sightings during snow-free periods
Jack pine	3.75	23.5	13.9	22.4
Mixed conif-decid.	1	15.5	3.7	14.8
Deciduous	1.5	9.5	5.6	9.0
Clearing	0	1.5	0	1.4
Unpaved road	.25	12	.9	11.4
	6.5*	62.0	24.1	59.0
Lowland:				
Black spruce bog	1	5.25	3.7	3.5
Tamarack bog	4	1	14.8	1.0
Muskeg	.5	0	1.9	0
Alder fen	6.5	7.5	24.1	7.1
Scrub fen	2	.75	7.4	.7
Sedge fen	0	.5	0	.4
Open bog	0	0	0	0
	14.0**	15*	51.9	14.3
Upland-lowland edge:				
Jack pine/Alder	6	12	22.2	11.4
Mixed upland/Alder	0	8	0	7.6
Unpaved road/Alder	.5	3	1.9	2.9
Unpaved road/ Tamarack	0	1	0	1.0
Unpaved road/Sedge	0	3	0	2.9
Mixed upland/ Mixed lowland	0	1	0	1.0
	6.5	28.0**	24.1	26.7
TOTAL	27	105.0	100.0	100.0

*Selection against the habitat type was statistically significant ($p < .05$).

**Selection for the habitat type was statistically significant.

Table 2. Habitat use by snowshoe hares as evidenced by a pellet survey in the Lake Alice study area, Hubbard County, and the Red Lake peatlands, Beltrami County, May 1978. In each of 10 habitats, 30 sample plots (3 m x 2 m) were examined for pellets.

Habitat type	Number of plots (out of 30) in which hare pellets were present		% of all plots in which hare pellets were present	
	Lake Alice	Red Lake	Lake Alice	Red Lake
Jack pine	17	---*	15.2	---
Deciduous upland	8	---*	7.1	---
White cedar	---*	27	---	36.0
Mature black spruce bog	25	8	22.3	10.7
Mature tamarack bog	11	27	9.8	36.0
Intermediate black spruce-tamarack	14	2	12.5	2.7
Small tamarack-muskeg	6	0	5.4	0
Alder fen	29	11	25.9	14.6
Scrub fen	2	0	1.8	0
Sedge fen	0	0	0	0
Open bog	0	0	0	0
TOTAL	112	75	100.0	100.0

* Habitat type not available for survey.

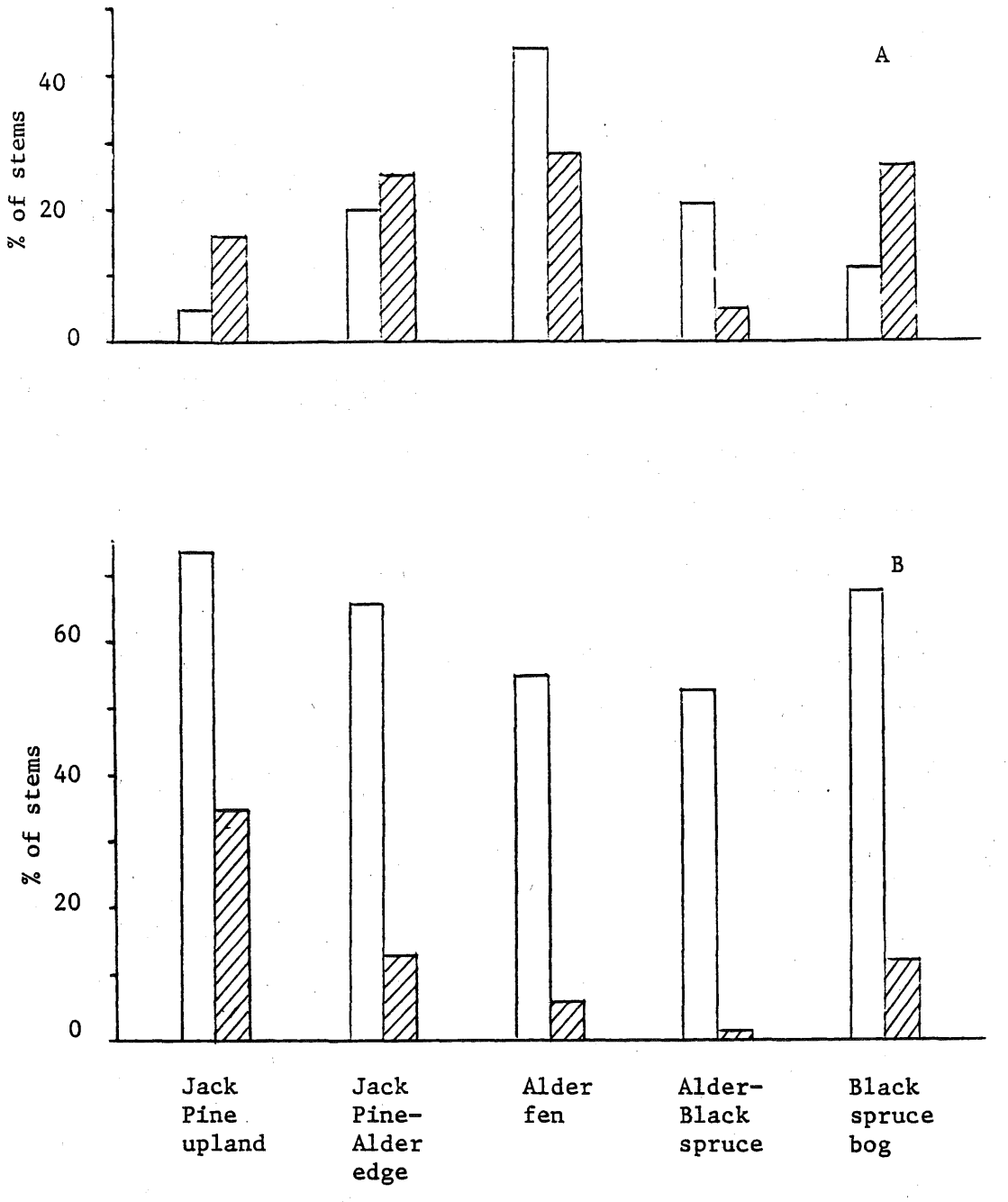

Figure 7. Snowshoe hare browse measured on 360 sample plots in 5 habitats of the Lake Alice study area, February, 1979.

A. Open bars represent the % of the total available stems in all sample plots that were found in each type. Hatched bars represent the % of all browsed stems in all sample plots that were found in each habitat type.

B. Open bars indicate the % of all stems in the sample plots of a habitat type that were $\leq$ 4mm in diameter. Hatched bars indicate the % of available stems in a habitat type that had been browsed by hares.

chosen to facilitate comparisons between these 2 areas, certain important types were not available in both places. At Lake Alice the highest frequency of hare pellets was found in alder fen, closely followed by mature black spruce bog; jack pine upland ranked third. In the Red Lake peatlands the highest frequencies of hare pellets were found in white cedar and mature tamarack bog with white cedar understory; alder fen ranked third. Clearly, the absence of white cedar in the Lake Alice area and the poor representation of upland habitats at Red Lake were reflected in the habitat use patterns of the resident hares.

Results of a browse survey conducted in the Lake Alice study area during February 1979 are shown in Figure 7. Available and utilized browse were compared in jack pine, alder, black spruce, jack pine-alder edge, and black spruce-alder edge habitats. Part A of the figure shows that alder fen had by far the largest density of available stems. However, the % of all browsed stems that were found in alder was not much greater than for black spruce or jack pine-alder edge. There was no significant correlation between % available and % browsed in this case ($r=.62$).

Figure 7, part B shows that the preferred size class of browse (diameter ≤ 4 mm) constituted a greater proportion of the stems in jack pine than it did within other habitat types. Black spruce and jack pine-alder ranked second and third, respectively. Jack pine also showed the highest % utilization of its available browse. Jack pine-alder and black spruce again ranked second and third. The correlation between the % of preferred size class browse in a habitat and the % utilization within that type proved to be statistically significant ($r=.92$).

This survey also revealed which species of woody plants contributed to available browse in each habitat, and which of these species were utilized. Of the species that had at least 20 stems in the survey plots, black spruce showed the highest % utilization (39% browsed), while jack pine, hazel, and red osier dogwood also had more than 20% of their available stems browsed. Of the more rarely occurring species, rose, aspen, and balsam fir showed the highest proportions of utilization.

Given the strong individual variation in habitat use noted earlier and the broad range of forest types utilized, we conducted one final survey in an attempt to find a common element among habitats frequented by hares. Figure 8 shows the results of this survey, in which % shrub cover was measured and the number of hare pellets counted in 85 plots from 12 upland and lowland forest stands. Shrubs from 0.5 m to 1.0 m were recorded separately from those that measured more than 1.0 m in height. The correlation coefficient between number of hare pellets and % cover in the lower shrub layer was not statistically significant ($r=.52$). However, the correlation between hare pellets and the tall shrub layer proved highly signficant ($r=.75$; $p \leq .01$).

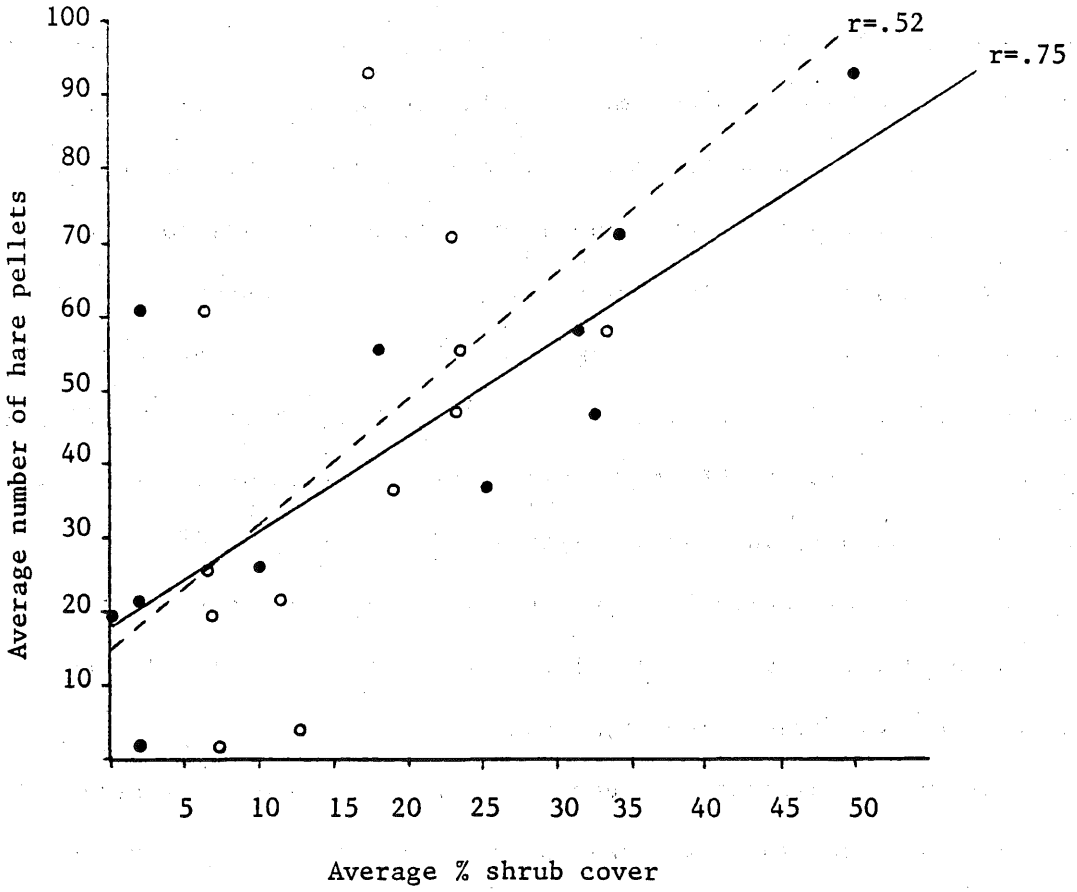

Figure 8. The relationship between forest habitat use by snowshoe hare and density of shrub cover, Lake Alice study site, May 1979. Habitat use is represented by the average number of hare pellets per sample plot in each of twelve upland and lowland forest stands. Average % shrub cover in these types is divided into 2 categories: (1) shrubs 0.5-1.0 m in height (represented by open circles, fitted by the broken line), and (2) shrubs above 1 m in height (represented by filled circles, fitted by the solid line).

White-tailed Deer

Between December 1977 and February 1979 we attempted to attract deer to trap sites by prebaiting. A total of 249 trap nights resulted in 8 captures and 2 recaptures. Since males could not be fitted with collars, only the 4 does that were caught received radio transmitters. Figure 9 shows the time period over which each radio-collared deer was monitored.

Radio-telemetry data for these deer showed that habitat use patterns differed at the individual level. Figure 10 illustrates the proportions of time spent by each deer in upland, lowland, and edge habitats. All 4 used upland types at least 50% of the time. Use of lowlands varied from approximately 2% to 34%, and use of edge ranged from 10% to 20%. Analysis of individual habitat use patterns revealed that deer 914 differed strongly from 729, 308, and 148. The last 3 deer listed were not significantly different from each other.

Three deer were monitored long enough to analyze seasonal patterns of habitat use. While 308 and 914 showed no significant changes from month to month, 726 exhibited strong changes. She showed an increase in lowland use during April through September and December through January. Monthly % utilization for lowlands ranged from a low of 4% (Mar. 1979) to a high of 60% (Aug. 1978). Upland use was highest from October through November 1978 with secondary peaks in March of both years. Monthly values for upland use ranged from 29% (June 1978) to 90% (Oct. 1978). Edge utilization peaked from May through July 1978 and from February through April 1979. Monthly edge use varied from 3% (Oct. 1978) to 29% (April 1979).

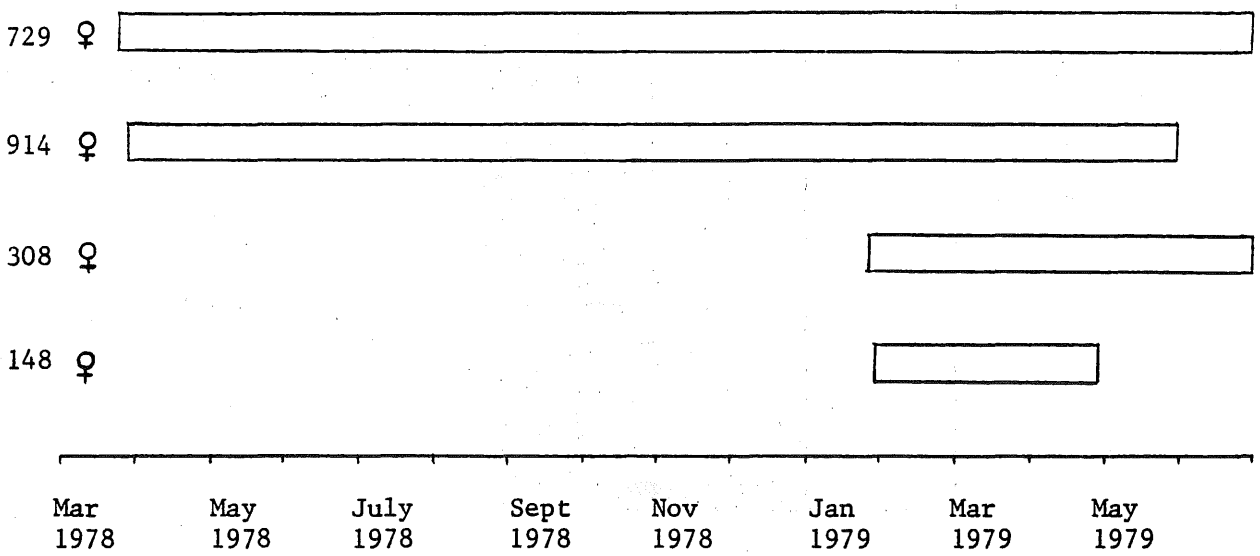

Figure 9. Time periods during which 4 white-tailed deer carried effective radio transmitters on the Lake Alice study site, 1978-1979. Individuals are identified by their radio frequencies.

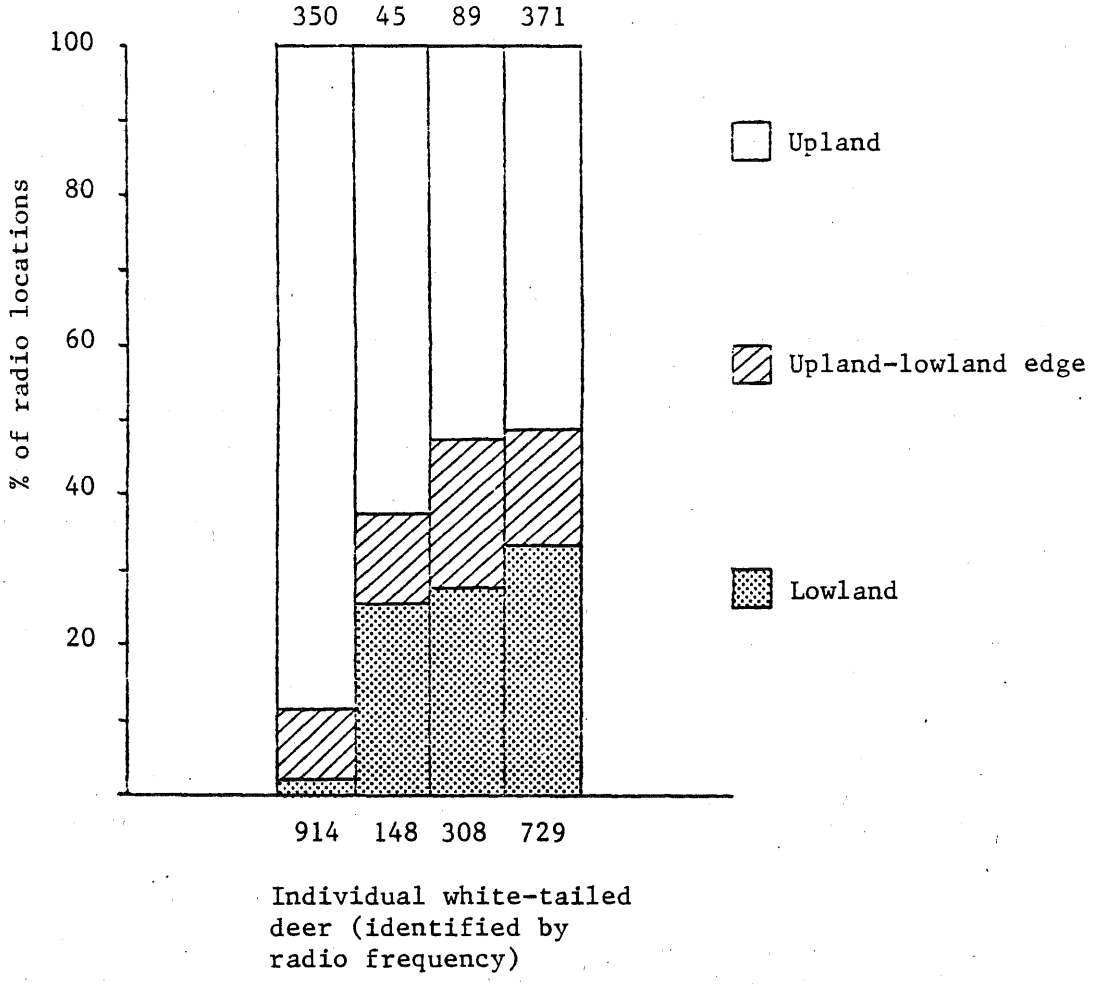

Figure 10. Utilization of upland, lowland, and edge habitats by 4 radio-collared white-tailed deer in the Lake Alice study area, Mar. 1978 - May 1979. Habitat use is expressed as the % of all radio-telemetry locations recorded for each animal. The total number of locations for each deer is indicated above the column.

All 4 deer were analyzed for differences in habitat use during day, night, and crepuscular periods. Although none of the differences among these periods was statistically significant, it is interesting to note that all deer showed some increase (4%-12%) in upland habitat use at night.

Figure 11 illustrates habitat use in more detail. Part A, combining data for deer 729, 308, and 148, shows that jack pine was used more than any other habitat type. Alder fen and jack pine-alder edge each received at least 10% utilization; black spruce bog and tamarack bog were the only other types used at least 5% of the time. Part B, using radio data for 914 alone, indicates highest utilization for mixed deciduous-coniferus forest, followed by jack pine upland. Upland clearing was the only other type used at least 5% of the time.

Figure 12 shows habitat selection patterns for the same 2 groupings of deer. Although both groups showed significant habitat selection overall, only 914 demonstrated a strong preference for any single habitat type. Part A shows that the group of 3 deer mildly favored alder fen, jack pine-alder edge, and black spruce bog while avoiding mixed upland. Part B illustrates 914's strong preference for mixed upland and avoidance of jack pine upland. She used no lowland types more than would be expected by chance.

Winter habitat utilization, as evidenced by 15 snow-track surveys, is illustrated in Figure 13. Deer tracks were found with highest frequency in sample plots of jack pine-alder edge. Jack pine and deciduous upland rated next highest among the types surveyed. Alder fen was the only lowland type having a frequency of use as great as the average calculated

over all habitats. Ten of 4334 plots included in the snowtrack surveys contained deer pellets and 11 contained beds. Upland clearing and alder had the highest % of plots with pellets; jack pine had the highest % of plots with beds.

Road-edge habitat use by deer in snow-free months is illustrated in Figure 14. Data from 25 road track surveys indicated that all road-edge habitats had some use, but only jack pine stands and logging roads were used to a greater extent then expected by chance.

Incidental sightings of unmarked deer supported the results of the road track surveys. Deer were seen in jack pine more than any other single type. In fact, over 90% of the 103 sightings were in upland types, about 8% were in edge habitats, and only 1% were in lowland types (Table 3).

Table 4 gives the results of a pellet survey conducted in the Lake Alice study area and in the Red Lake peatlands of Beltrami County. As explained earlier, habitat categories were chosen specifically to facilitate comparisons between the 2 areas. Unfortunately, the habitats in which deer pellet densities were highest were the ones that were not common to both areas. Jack pine and deciduous upland together accounted for 95% of the 42 pellet groups found in the Lake Alice survey. White cedar and mature tamarack with white cedar understory accounted for almost 87% of the 30 pellet groups found at Red Lake.

Deer pellet groups were also recorded during the shrub cover survey described above. Pellets were found in 50% of the mixed upland plots, 26% of the jack pine plots, 10% of the black spruce plots, and 5% of the tamarack plots. Since a total of 17 pellet groups were found in 85 plots

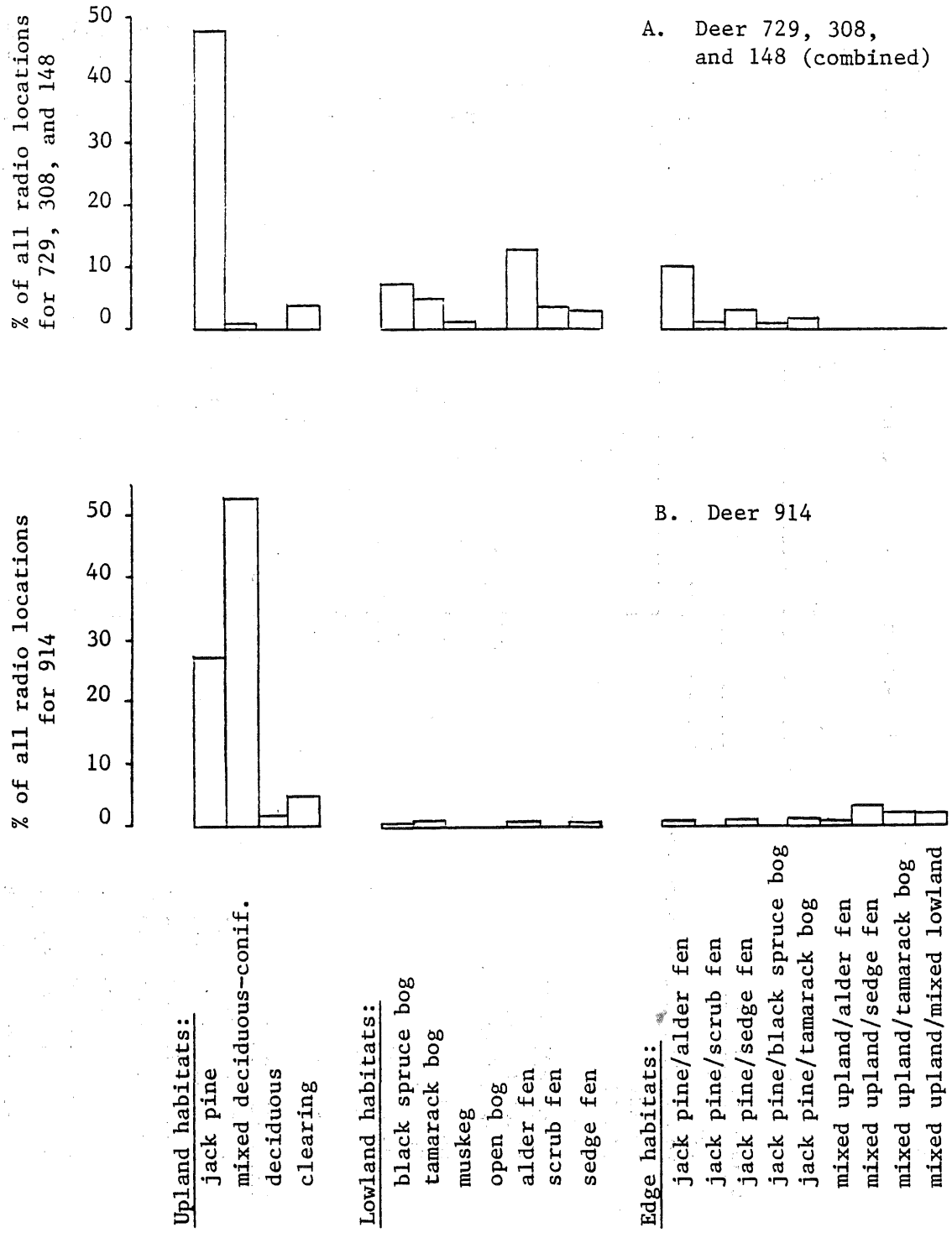

Figure 11. Habitat utilization by 4 radio-tagged white-tailed deer in the Lake Alice study area, Mar. 1978-May 1979. Utilization is expressed as the % of all radio locations that were ascribed to a given habitat type.

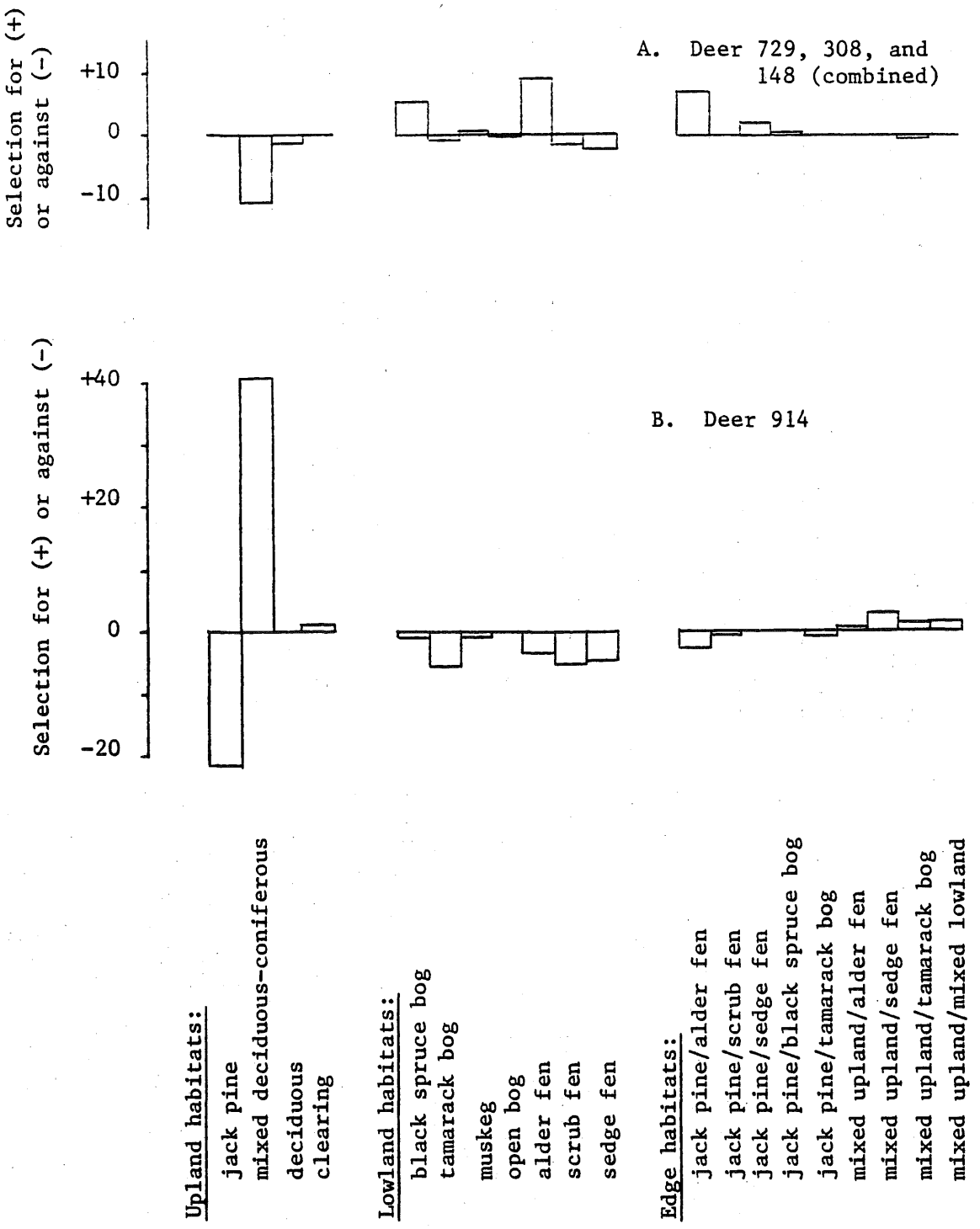

Figure 12. Selection by four radio-tagged white-tailed deer for (+) or against (-) habitats in the Lake Alice study area, Mar. 1978-May 1979, expressed as the difference between the % of all radio locations in a given habitat and the % of that habitat available.

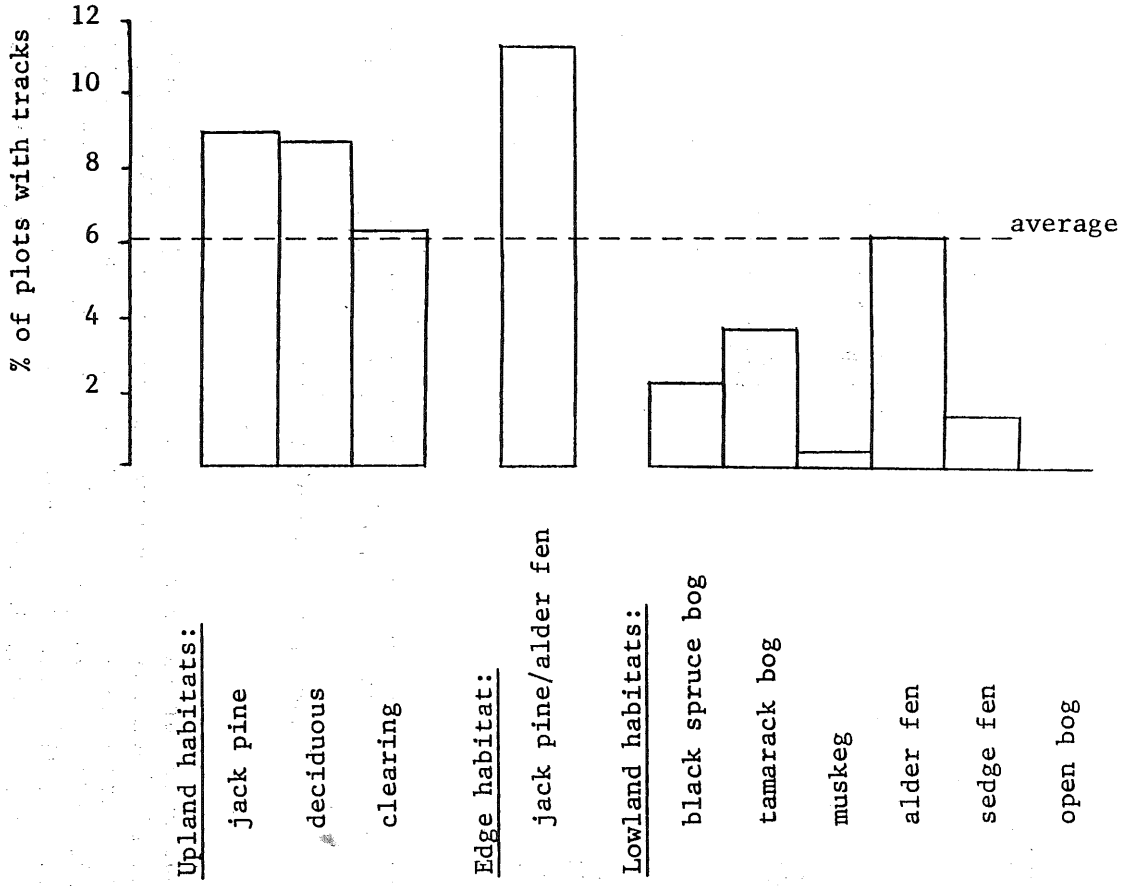

Figure 13. Habitat use by white-tailed deer as evidenced by 15 snow track surveys, Feb. 1978-Mar. 1979, in the Lake Alice study area. Bars represent the % of the sample plots in each habitat in which deer tracks were present. The broken line indicates the average % of all sample plots that contained tracks.

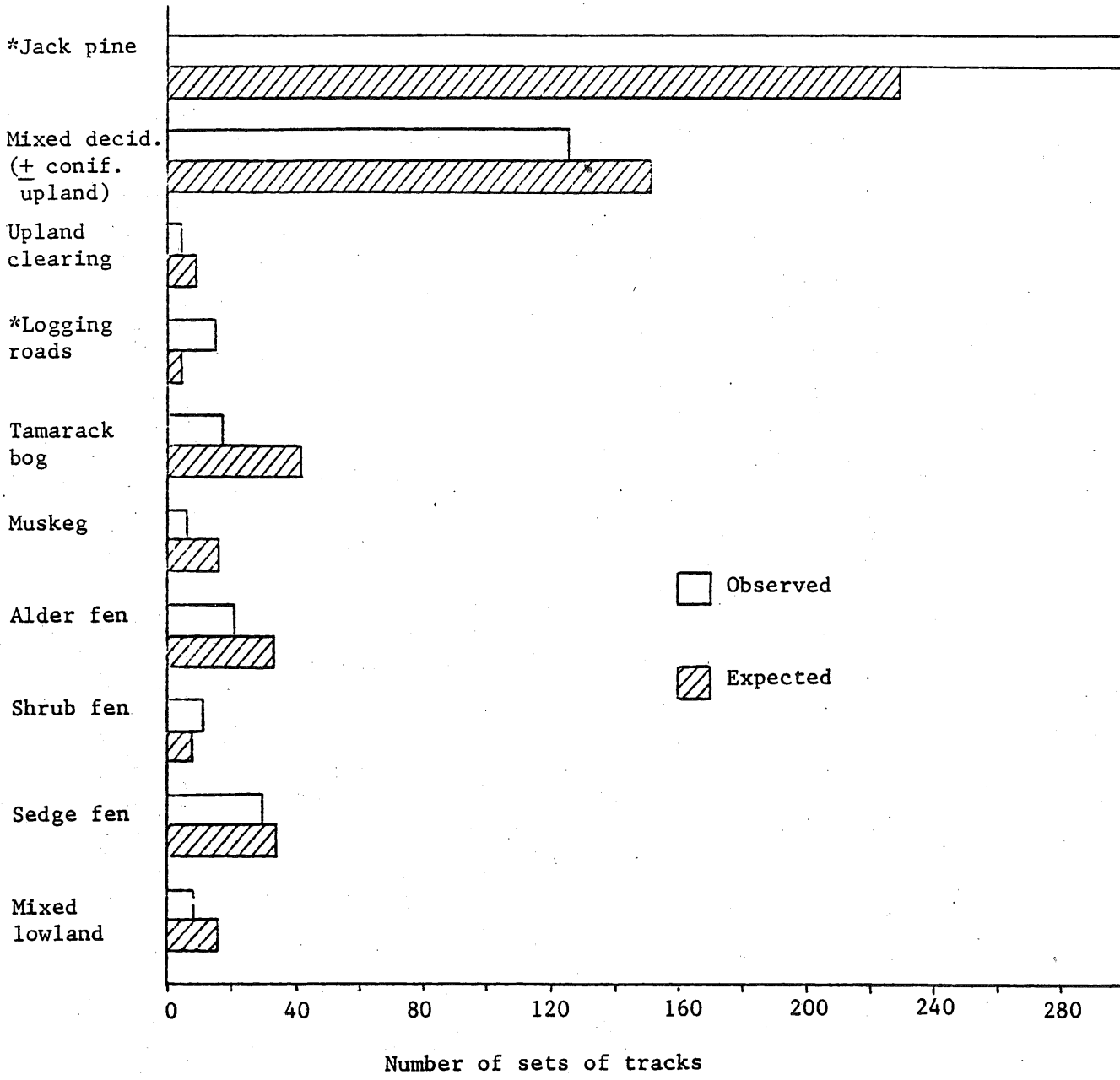

Figure 14. Road-edge habitat use by white-tailed deer, as indicated by deer tracks entering and exiting on unpaved road in the Lake Alice study site. Numbers of track sets were totaled from 25 road track surveys made 27 Jun. - 4 Oct. 1978 and 2-25 May 1979. Expected values represent the number of track sets that would have been found in association with each edge type if tracks were distributed in proportion to the availability of those types.

*Habitat types for which selection was significantly different from expected.

Table 3. Incidental sightings of unmarked white-tailed deer on the Lake Alice study site, Dec. 1977-June 1979.

Habitat type	Number of sightings	% of sightings
Upland:		
Jack pine	36.75	35.6
Mixed conif-decid.	18.75	18.2
Deciduous	5.5	5.3
Clearing	14.25	13.8
Unpaved road	18.25	17.7
	93.5**	90.7
Lowland:		
Black spruce bog	0	0
Tamarack bog	0	0
Muskeg	0	0
Alder fen	.5	.5
Scrub fen	0	0
Sedge fen	.5	.5
Open bog	0	0
	1.0*	1.0
Upland-lowland edge:		
Jack pine/Alder	2.5	2.4
Unpaved road/Alder fen	1	1.0
Unpaved road/Tamarack	1	1.0
Unpaved road/Scrub fen	1	1.0
Unpaved road/Sedge fen	1	1.0
Unpaved road/Mixed lowland	2	1.9
	8.5	8.3
TOTAL	103	100.0

*Selection against the habitat type was statistically significant.

**Selection for the habitat type was statistically significant.

Table 4. Habitat use by white-tailed deer as evidenced by a pellet survey in the Lake Alice study area, Hubbard County, and the Red Lake peatlands, Beltrami County, May 1978. In each of 10 habitats, 30 sample plots (3 m x 2 m) were examined for pellets. The two left columns indicate the total number of pellet groups found in each set of 30 plots.

Habitat type	Number of pellet groups		% of pellet groups	
	Lake Alice	Red Lake	Lake Alice	Red Lake
Jack pine	19	---*	45.2	---
Deciduous upland	21	---*	50.0	---
White cedar	---*	14	---	46.7
Mature black spruce bog	1	1	2.4	3.3
Mature tamarack bog	0	12	0	40.0
Intermediate black spruce-tamarack	0	2	0	6.7
Small tamarack-muskeg	0	0	0	0
Alder fen	1	1	2.4	3.3
Scrub fen	0	0	0	0
Sedge fen	0	0	0	0
Open bog	0	0	0	0
TOTAL	42	30	100.0	100.0

* Habitat type not available for survey.

sampled, one would expect 20% of plots to contain pellets if they were evenly distributed among habitats.

Efforts were made in both years of the study to determine the reproductive success of radio-tagged does and their habitat use patterns during the time of fawning. In 1978, 914 was the only adult female carrying a radio transmitter. Though attempts to visually locate her early in the fawning season failed, she was seen in August with 1 offspring. During the time when fawning probably occurred, she was using primarily mixed upland habitat.

In 1979, 3 adult females were radioed, but the field season ended before any fawns were sighted. Two efforts were made to visually locate 726 and 308 during June and July. In both instances the does were flushed from lowland-upland edges composed of alder and sedge with jack pine or mixed upland. Although no young were seen, the behavior of the does suggested that they may have been attending fawns.

Spruce Grouse

Between January 1978 and April 1979, 121 trap nights and 50 hours of snaring operations led to the capture of 20 spruce grouse. Seventeen of these were released with radio transmitters, and 15 provided sufficient data for analysis. Figure 15 shows the time period for which each radio-tagged grouse was monitored.

Analysis of the radio-telemetry data showed that male and female grouse differed substantially in habitat use patterns. However, individual differences among males were not significantly different, and females fell into 2 groups within which habitat utilization patterns were similar.

Seasonal differences in habitat used were strong within both sexes of grouse. Figure 16 illustrates the monthly patterns of upland, lowland, and edge utilization among males. In winter months, they showed significant preference for upland and avoidance of lowland. In March and April, they used habitats approximately in proportion to their availability. From May through September, males selected for lowlands and selected against upland and edge habitats. In October they showed preference for lowland and edge types and avoidance of upland types. No males were monitored during November and December.

Seasonal habitat use patterns of 8 female spruce grouse are presented in Figure 17. In the winter and prebreeding period all hens used uplands almost exclusively. During the mating and egg-laying period 6 hens (group b) strongly preferred lowlands, and 2 hens (1 in 2 different years; group a) preferred edge habitat. While incubating eggs and attending clutchlings, group b hens favored lowlands and group a hens

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*chicks in their first two weeks of life before they are capable of flight, Leopold 1933

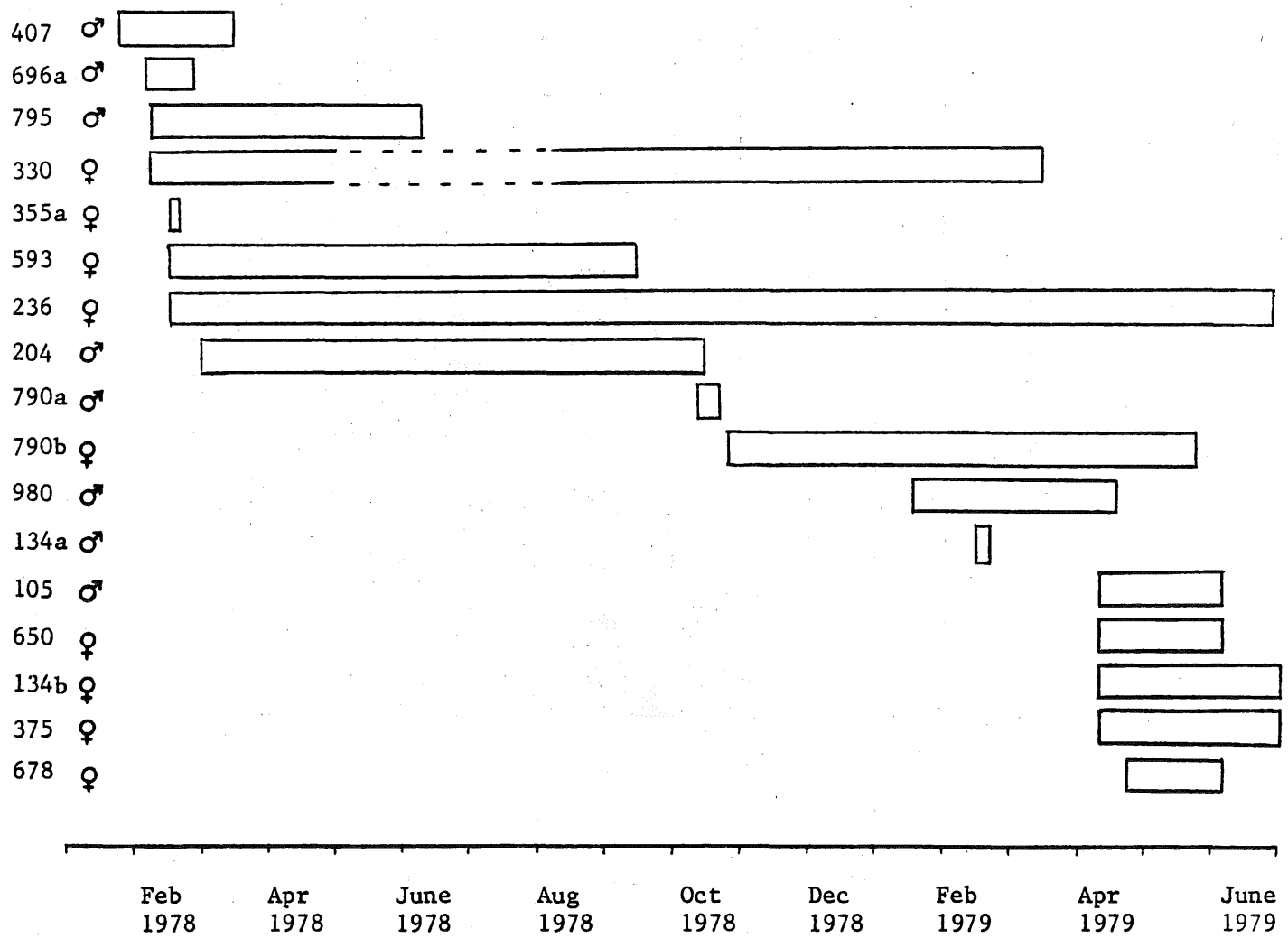

Figure 15. Time periods during which 17 spruce grouse carried effective radio transmitters on the Lake Alice study site, 1978-1979. Individuals are identified by their radio frequencies.

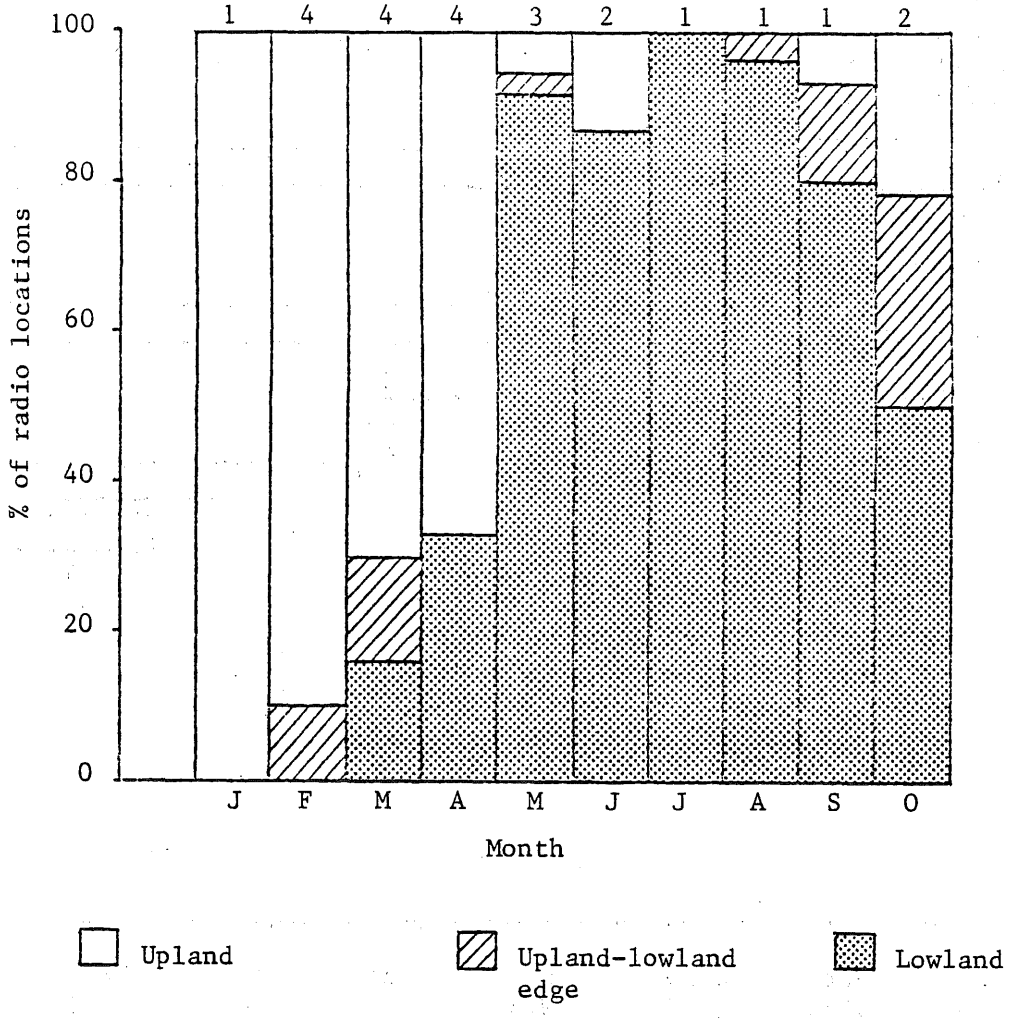

Figure 16. Utilization of upland, lowland, and edge habitats by 7 radio-tagged male spruce grouse in the Lake Alice study area, Feb.-Oct. 1978 and Jan. - June 1979. Habitat use is expressed as the % of all radio-locations recorded for each month. The number of male grouse monitored each month is indicated above the column.

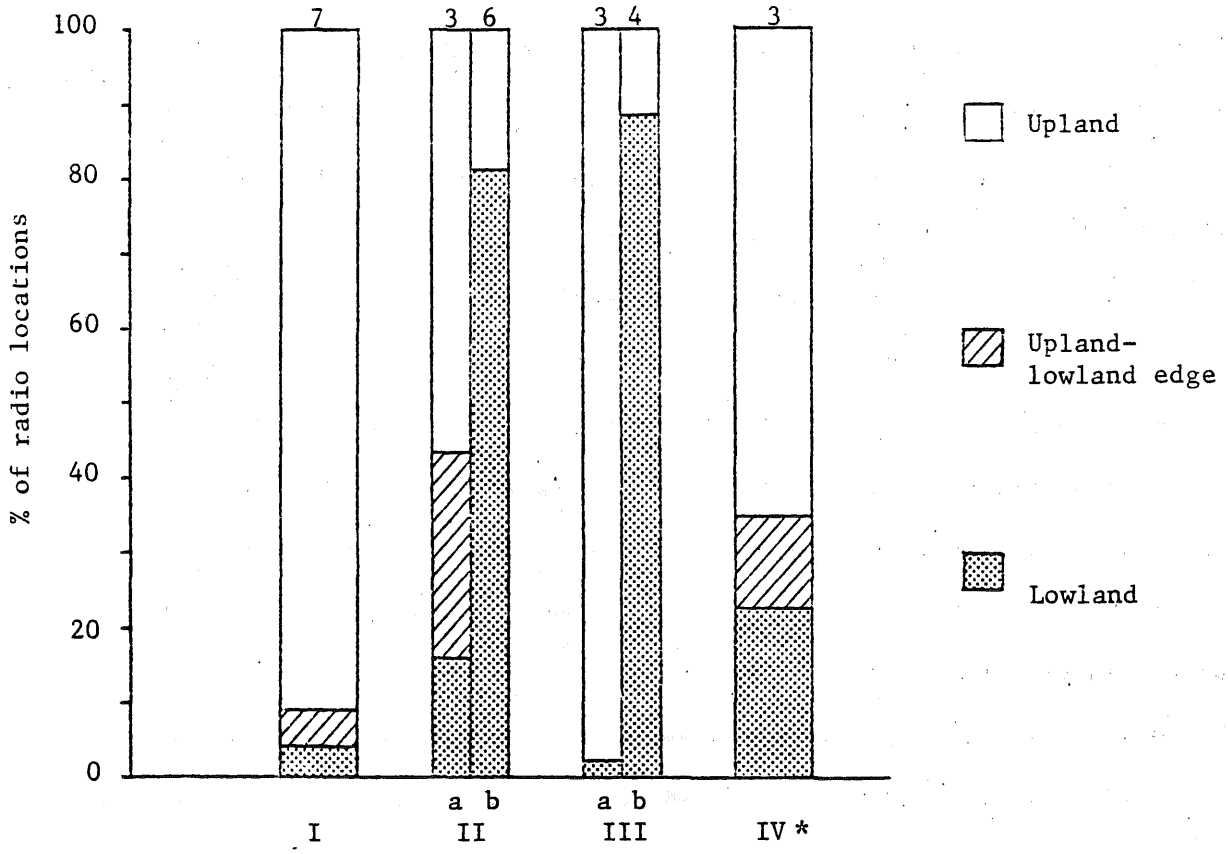

Figure 17. Utilization of upland, lowland, and edge habitats by 8 radio-tagged female spruce grouse in the Lake Alice study area, Jan. 1978 - June 1979. Habitat use is expressed as the % of all radio locations recorded for each period or period subdivision. Periods represent: I. winter and prebreeding, II. mating and egg-laying, III. incubating and attending clutchlings, and IV. attending post-clutchlings and fall dispersal. Subdivisions indicate: (a) hens nesting in upland habitats, and (b) hens nesting in lowland habitats. The number of birds monitored in each group or period is given above the column.

* 1978 data only.

selected for uplands. Data for the last period (attending post-clutchlings and fall dispersal) were available only for 1978, when 2 of 3 radioed hens had nested in upland. For these 3 hens, habitat types were used during this period approximately in proportion to their availability.

Analysis of radio data for day, night, and crepuscular periods indicated that habitat utilization patterns did not change significantly. Radio-tagged spruce grouse generally showed no signs of activity during the night.

Figure 18 presents a more detailed look at the habitats used by radio-tagged spruce grouse. Part A of the figure shows that jack pine upland, black spruce bog, tamarack bog, and alder fen were used most often from May through September. Part B shows that only jack pine had appreciable use from October through April.

Habitat selection by radioed spruce grouse is illustrated in Figure 19. In the May-September period black spruce bog was strongly preferred, while jack pine and mixed upland were avoided. In the October-April period jack pine was strongly preferred and mixed upland again was avoided. There was no strong response either for or against lowland and edge types.

Incidental sightings of unmarked spruce grouse generally supported the results of radio-tracking operations. As indicated in Table 5, grouse were seen primarily in jack pine during periods of snow cover; 96% of 152 sightings were recorded in jack pine stands or on unpaved roads. During snow-free periods only 24% of 79 sightings were in upland habitats, while lowland and edge habitats accounted for 30% and 46% of the sightings, respectively. The most important lowland habitat appeared to be black spruce bog; the highest ranking edge types were black spruce-jack pine, tamarack-jack pine, and tamarack-road.

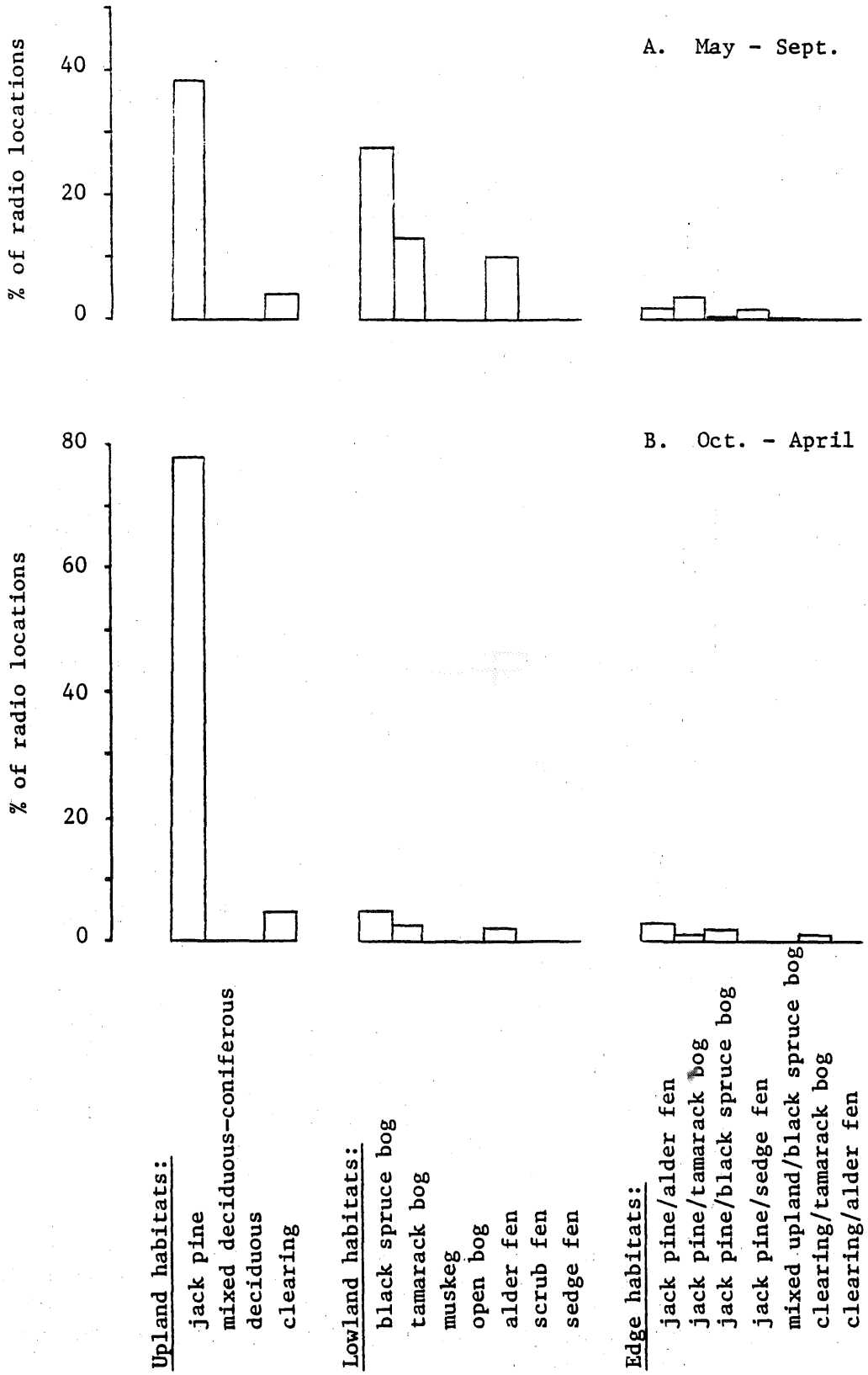

Figure 18. Habitat utilization by 15 radio-tagged spruce grouse in the Lake Alice study area, Jan. 1978-June 1979. Utilization is expressed as the % of all radio locations that were ascribed to a given habitat type.

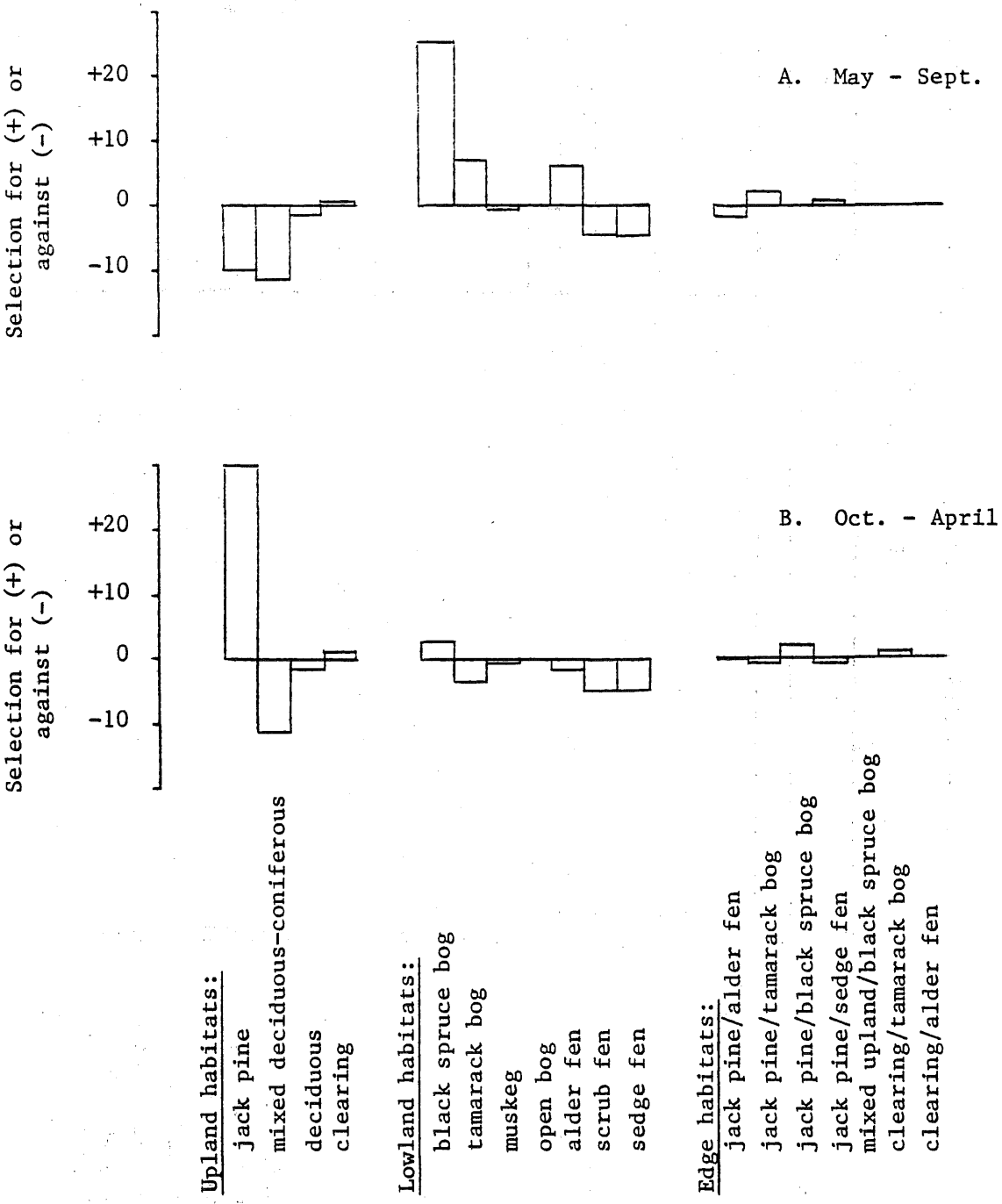

Figure 19. Selection by 15 radio-tagged spruce grouse for (+) or against (-) habitats in the Lake Alice study area, Jan. 1978-June 1979, expressed as the difference between the % of all radio locations in a given habitat and the % of that habitat available.

Table 5. Incidental sightings of unmarked spruce grouse on the Lake Alice study site. Periods of snow cover were Dec. 1977 - Mar. 1978 and Nov. 1978 - Mar. 1979. Snow-free periods were Apr. - Oct. 1978 and Mar. - Jan 1979.

Habitat type	Number of sightings during periods of snow cover	Number of sightings during snow-free periods	% of sightings during periods of snow cover	% of sightings during snow-free periods
Upland:				
Jack pine	118.5	19	78.0	24.1
Mixed conif-decid.	0	0	0	0
Deciduous	0	0	0	0
Clearing	.5	0	.3	0
Unpaved road	27	0	17.8	0
	146**	19*	96.1	24.1
Lowland:				
Black spruce bog	0	15.75	0	19.9
Tamarack bog	0	4	0	5.1
Muskeg	0	0	0	0
Alder fen	0	2.75	0	3.5
Scrub fen	0	1	0	1.3
Sedge fen	0	0	0	0
Open bog	0	0	0	0
	0*	23.5	0	29.7
Upland-lowland edge:				
Jack pine/Alder	6	0	3.9	0
Jack pine/Black spruce	0	14.5	0	18.4
Jack pine/Tamarack	0	11	0	13.9
Unpaved road/ tamarack	0	11	0	13.9
	6	36.5**	3.9	46.2
TOTAL	152	79	100.0	100.0

*Selection against the habitat type was statistically significant ($p < .05$).

**Selection for the habitat type was statistically significant.

In spring 1979, 12 different observations were made of displaying male spruce grouse. Six of these were in black spruce bog, 1 was in jack pine, and 5 were in edges between lowland and upland conifer stands. The edge sites all consisted of black spruce on the lowland side and either jack pine or balsam fir on the upland side.

Since juvenile male spruce grouse may move about extensively during the breeding season -- displaying without establishing a display territory (Ellison 1973; Herzog and Boag 1978) -- it cannot be claimed that all of the 12 males noted above were holding territories at those sites. Several attempts were made to relocate males at the sites where they were first observed. In only 3 instances -- twice in black spruce and once at a black spruce-balsam fir edge -- were male grouse seen a second time at the same location.

Habitat characteristics of spruce grouse nest sites were recorded for two breeding seasons. A total of 7 nests were located, all belonging to radio-tagged hens. Three nests were in jack pine (2 by the same hen), and 4 were in lowlands. In 3 of the lowland sites tamarack dominated the canopy; black spruce and alder shared dominance in the fourth.

Two of the 3 upland nests hatched successfully, the third was destroyed by a predator. Three of the 4 lowland nests were known to hatch successfully; the fate of 1 of the nests in tamarack was uncertain since the radio-tagged hen could not be located after incubation began.

Thirteen different broods were observed in the 2 breeding seasons, some belonging to radioed hens and some to unmarked hens. Four of these broods were in jack pine upland, 4 were in various types of lowland, and 5 were in upland-lowland edge. The lowland sightings were typically in areas of mixed tamarack, black spruce, and alder. Edge types consisted

primarily of jack pine-tamarack and jack pine-black spruce. One brood was seen on 4 occasions at the edge of a road between jack pine and tamarack stands.

Another source of information on habitat utilization was provided by records of spruce grouse droppings. Although no formal survey of grouse droppings was conducted, records were kept of all sign observed during the shrub cover survey described earlier. In the forest stands that were sampled, spruce grouse droppings were found in 37% of the jack pine plots and 25% of the black spruce plots. None were found in mixed upland or tamarack.

Observations on the food habits of spruce grouse were limited to a summer study of a hen and brood living primarily in jack pine upland. Here the observer saw blueberry leaves and fruits eaten most often and noted some utilization of northern bedstraw (Galium boreale), vetch (Vicia spp.), cow-wheat (Melampyrum lineare), raspberry, tamarack, snowberry (Symphoricarpos albus), grass, mushrooms, and insects.

From February to May 1978, most grouse seen in jack pine stands were in trees where they were occasionally observed eating conifer needles. From 1 May through August 1978, they were found more often on the ground feeding on herbs and shrubs.

Ruffed Grouse

Between December 1977 and May 1979, 88 trap nights and approximately 50 hours of baiting operations led to capture and radio tagging of 7 ruffed grouse. Figure 20 shows the time period for which each radioed grouse was monitored.

Invididual differences in habitat utilization patterns were great enough to be statistically significant. No general trends were ascertained among males or among females. Figure 21 illustrates upland, lowland, and edge habitat utilization for 5 individual grouse. Male 304 was the only bird that selected for upland, and male 538 was the only 1 that selected for lowland. Females 395 and 567 and male 355 all showed preference for edge habitats.

Seasonal differences in habitat utilization were analyzed for 5 grouse -- 3 males and 2 females. All but 1 of the 5 (male 355) exhibited significant seasonal changes. Among the males, the only trend held in common was an increase in the use of upland in autumn (September-November).

Hen 567 shifted from upland to edge and lowland after her nest was destroyed by a predator and then moved back into upland habitats for fall and winter. Hen 395 nested in edge but used both edge and upland after her eggs hatched.

Analysis of radio-telemetry data for day, night, and crepuscular periods indicated that habitat utilization patterns did not change significantly. Like spruce grouse, ruffed grouse exhibited a general lack of nighttime activity.

A more detailed picture of habitat utilization is given in Figure 22. Compiled data for the 7 ruffed grouse indicated that mixed upland and jack pine upland had the greatest amount of use, followed by jack pine-alder

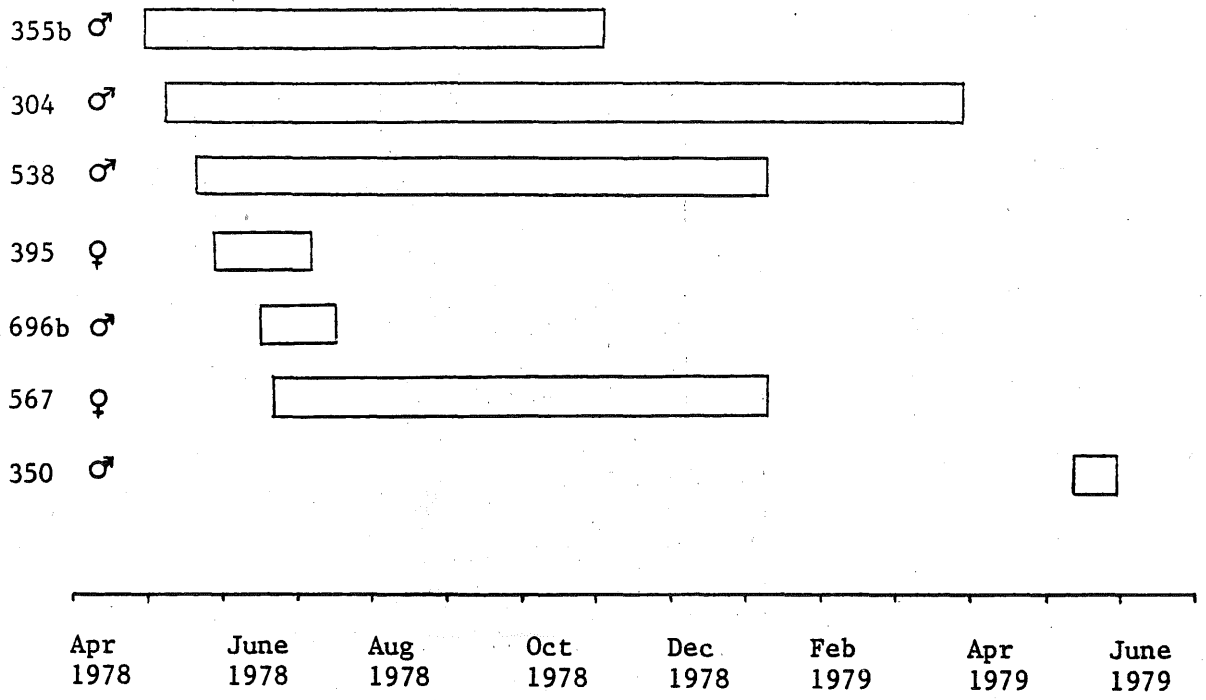

Figure 20. Time periods during which 7 ruffed grouse carried effective radio transmitters on the Lake Alice study site, 1978-1979.

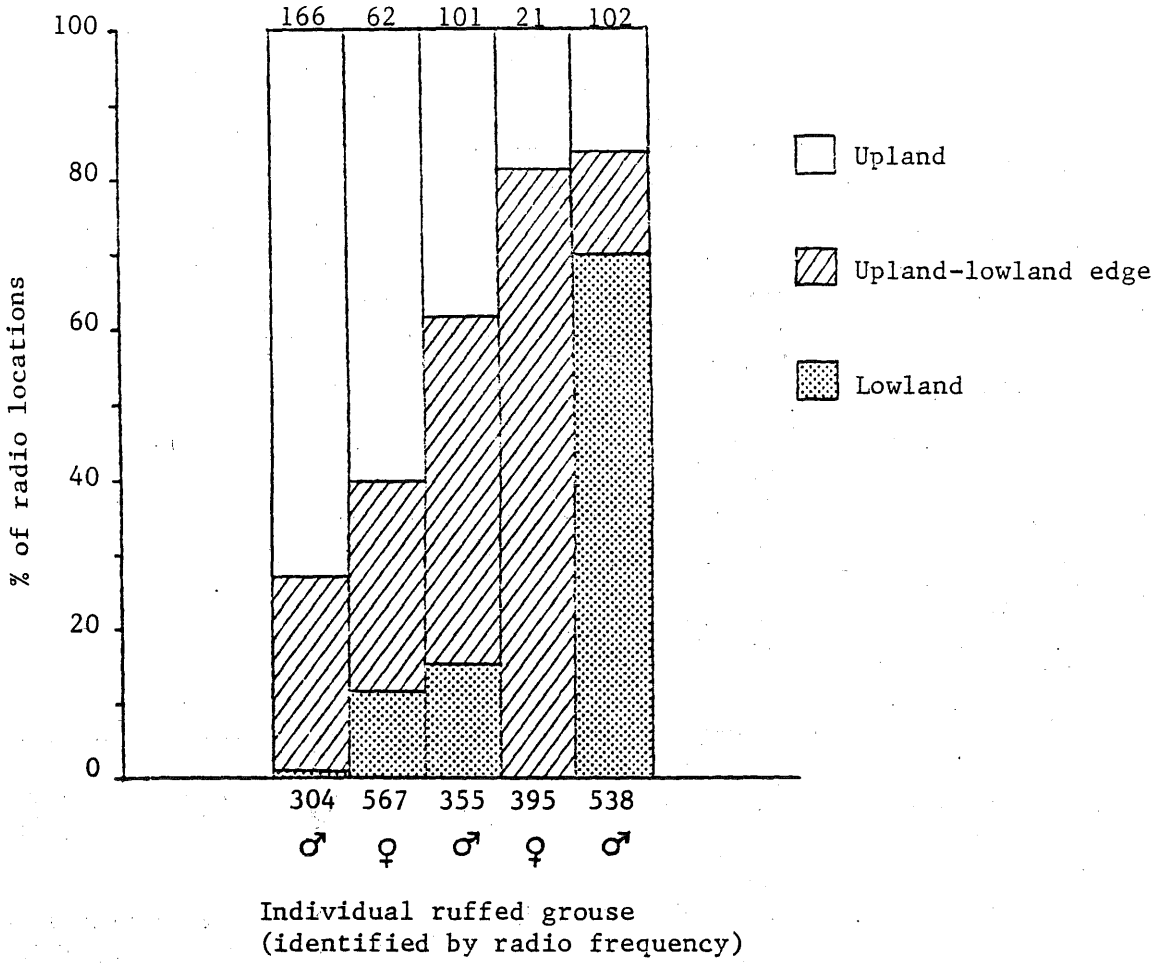

Figure 21. Utilization of upland, lowland, and edge habitats by 5 radio-tagged ruffed grouse in the Lake Alice study area, May 1978 - May 1979. Habitat use is expressed as the % of all radio-telemetry locations recorded for each animal. The total number of locations for each grouse is indicated above the column.

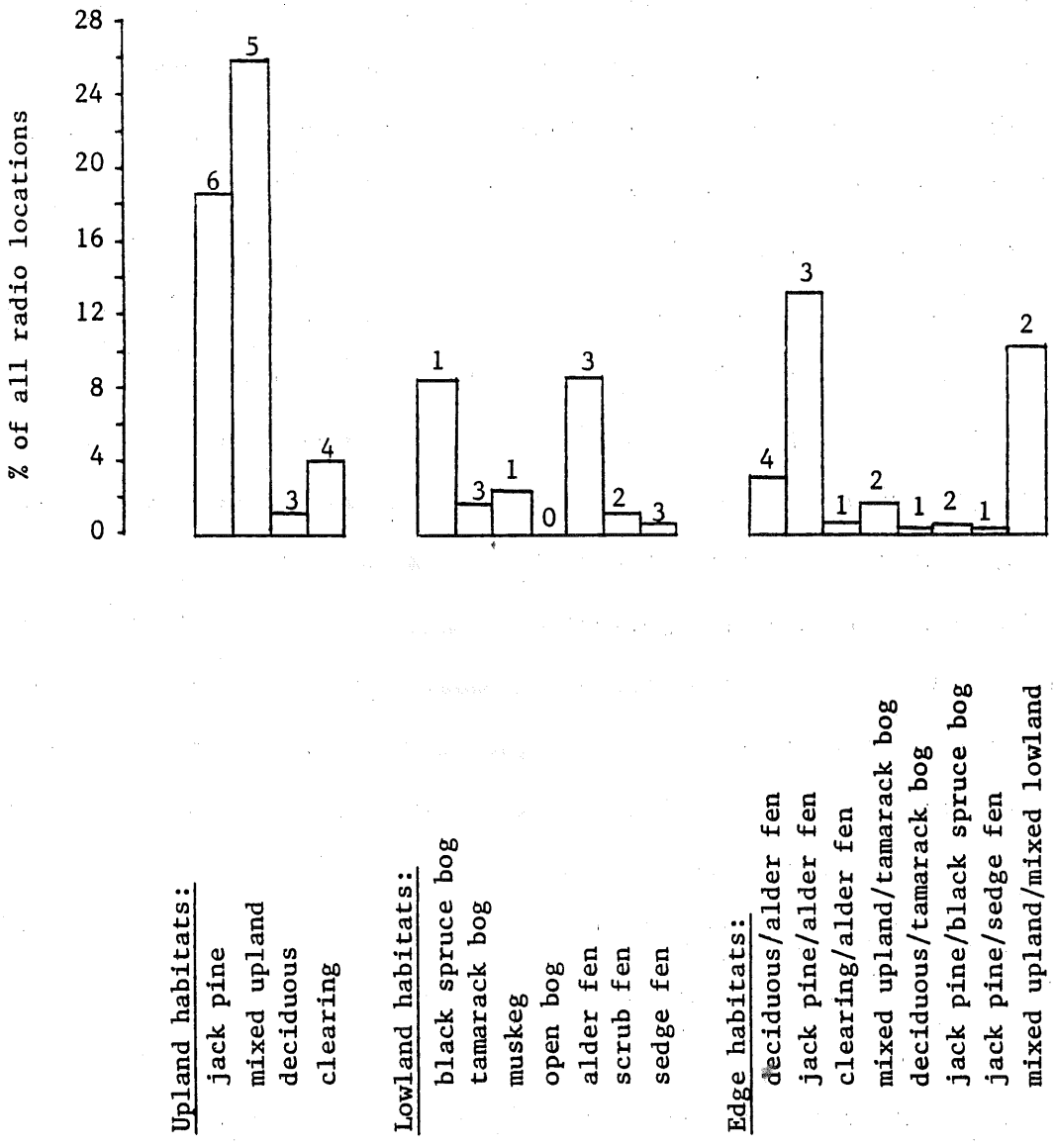

Figure 22. Habitat utilization by 7 radio-tagged ruffed grouse in the Lake Alice study area, Jan. 1978-June 1979. Utilization is expressed as the % of all radio locations that were ascribed to a given habitat type. The number of grouse using each type is indicated above the column.

edge and mixed upland-mixed lowland. Alder fen and black spruce bog were the only other types utilized more than 5% of the time.

Figure 23 presents the habitat selection picture for radioed ruffed grouse. Preference was strongest for mixed upland, followed by deciduous-alder edge and mixed upland-mixed lowland. Strong avoidance was demonstrated for only 1 habitat type -- jack pine upland.

Incidental sightings of unmarked ruffed grouse differed significantly between snow-free periods and periods of snow cover. As shown in Table 6, during snow cover over 70% of 41 sightings were in upland, while in snow-free periods upland accounted for 42% of 69 sightings. Lowland sightings increased from approximately 10% to 20% between the 2 periods, and edge sightings increased from almost 20% to over 38%.

In both periods edge sightings were most common in jack pine-alder, and lowland sightings were most often made in alder fen and black spruce bog. The largest share of upland sightings were in jack pine; however, this may be, in part, a reflection of the disproportionate amount of time observers spent in that type.

In the spring of 1978 and 1979, attempts were made to locate as many ruffed grouse drumming logs as possible. A total of 15 logs were found, with 3 in lowland, 2 in upland, and 10 in edge or mixed upland-lowland habitats. Alder was the dominant shrub species at 7 drumming log sites; hazel was prevalent at 3. Aspen was recorded at or near 6 of the drumming logs, black spruce at 4, and birch and balsam fir at 3 logs each.

Six ruffed grouse broods were observed in summer 1978. Three of these were found in jack pine-alder edge, and 1 each was found in black spruce-tamarack bog, jack pine upland, and mixed upland-lowland.

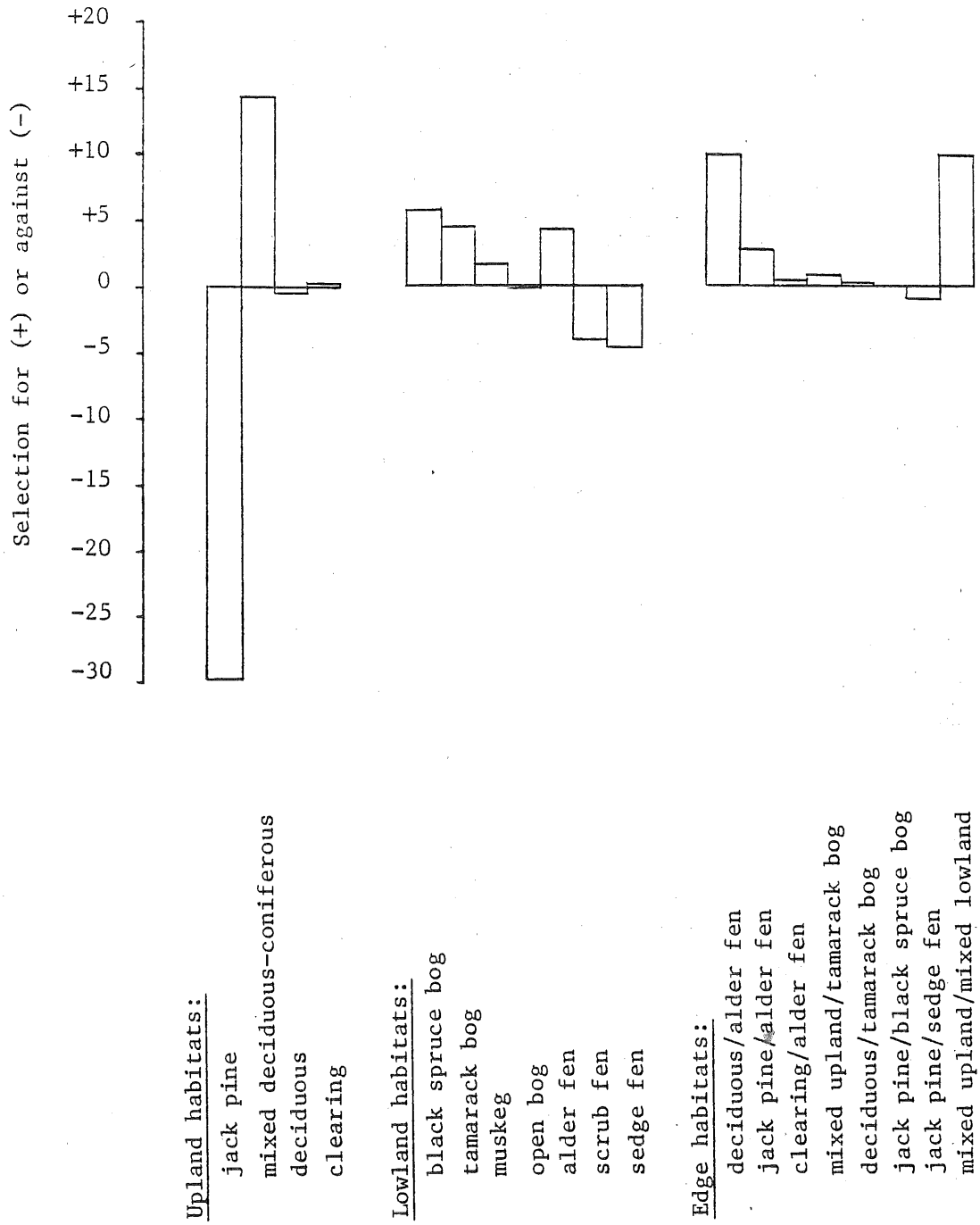

Figure 23. Selection by 7 radio-tagged ruffed grouse for (+) or against (-) habitats in the Lake Alice study area, Jan. 1978-June 1979, expressed as the difference between the % of all radio locations in a given habitat and the % of that habitat available.

Table 6. Incidental sightings of unmarked ruffed grouse on the Lake Alice study site. Periods of snow cover were Dec. 1977-Mar. 1978 and Nov. 1978-Mar. 1979. Snow-free periods were Apr.-Oct. 1978 and Mar.-June 1979.

Habitat type	Number of sightings during periods of snow cover	Number of sightings during snow-free periods	% of sightings during periods of snow cover	% of sightings during snow-free periods
Upland:				
Jack pine	14.0	13.5	34.1	19.6
Mixed conif.-decid.	6.0	11.5	14.6	16.7
Deciduous	6.5	1.5	15.9	2.2
Clearing	0	.25	0	.4
Unpaved road	2.5	2.25	6.1	3.3
	29.0**	29.0*	70.7	42.0
Lowland:				
Black spruce bog	1.5	5.0	3.7	7.2
Tamarack bog	0	2.5	0	3.6
Muskeg	0	.25	0	.4
Alder fen	2.5	5.5	6.1	8.0
Scrub fen	0	0	0	0
Sedge fen	0	.25	0	.4
Open bog	0	0	0	0
	4*	13.5	9.8	19.6
Upland-lowland edge:				
Jack pine/Alder	4.5	16.5	11.0	23.9
Mixed upland/Alder	2	1	4.9	1.4
Deciduous/Alder	1.5	1.0	3.7	1.4
Decid./Black spruce	0	.5	0	.7
Deciduous/Sedge	0	1.5	0	2.2
Mixed upland/ Mixed lowland	0	6	0	8.7
	8.0**	26.5**	19.5	38.4
TOTAL	41	69	100.0	100.0

*Selection against the habitat type was statistically significant.

**Selection for the habitat type was statistically significant.

Only 3 ruffed grouse nests were located during both years. Two nests were situated beneath alder shrubs at the border of alder fen and jack pine upland; both hatched successfully. The third nest, thought to be a "renest", was at the base of a large jack pine in an area of sparse shrub cover. It was destroyed by a predator, immediately after which the hen moved into a pocket of alder shrubs nearby.

DISCUSSION

Snowshoe Hares

The results detailed above suggest that snowshoe hares used many habitat types in the Lake Alice area but that most individuals preferred either conifer bogs, alder fen, or jack pine-alder edge. This conclusion corresponds well to conclusions reached by Marshall and Miquelle (1978) in their literature search on terrestrial wildlife in Minnesota peatlands. They stated that snowshoe hares may be found in all forested or bushy habitat types when they are abundant, but that they are restricted mostly to "swamp conifers", "swamp thickets", and fen habitats during years of scarcity.

In Alberta after a population decline, Keith (1966) found that the remaining hares were in thickets of small black spruce and alder at the edges of bogs and in patches of hazel. Hares also inhabited an area covered by dense regrowth of aspen and willow. Similarly, hares in the Lake Alice study area that used mixed upland habitat were found in stands with dense hazel or with thick second-growth aspen and birch. The only hare located predominately in jack pine was usually found in a small shrub-filled depression within the jack pine stand.

In northern Wisconsin, Grange (1932) noted that the amount of shrub cover largely determines the desirability of any particular range, mature stands being less frequented than younger, bushier stands, which provide both cover and food. This corresponds well with findings of the shrub cover survey conducted at Lake Alice. The correlation found between % tall shrub cover (> 1 m) and density of hare pellets suggests that this layer was important to hares no matter what the canopy type. Lack of

significant correlation between pellets and the % low shrub cover (.5-1 m) suggests that this layer was less important, possibly because it was largely buried under snow during much of the year.

Grange (1932) included among favorite hare habitats aspen-mixed conifer woods, coniferous "swamps", and the fringes of alder and other deciduous species common along coniferous swamps. He believed that alder "swamps" constitute a favorite resort for hares and that willow stands are also used by hares. He further noted that young jack pine areas are apparently used by hares, but that mature stands have little if any utilization.

Both Grange (1932) in Wisconsin and O'Farrell (1965) in Alaska mentioned the high incidence of hare runways through areas of sphagnum moss. O'Farrell found networks of runways, especially in the muskegs, where heavy utilization had packed the sphagnum mosses to 2-5 cm below the ground level. Such runways were common in the black spruce muskeg of the Lake Alice study area as well. The high incidence of tracks found in this habitat type during snow track surveys further emphasized its importance in the Lake Alice area.

O'Farrell (1965) noted that during the summer all forms found in his Alaskan study area were in the midst of dense clumps of small spruce or willow. In winter, most forms were located under spruce, willow, or alder branches that were bowed over by the weight of snow. This created a canopy under which a hare was sheltered from the elements and concealed from predators. Similar winter forms occurred in the Lake Alice area; in fact, there were some alder stands that contained subnivean runways amid buried branches. Snow track survey results given above indicate that

forms were found in vegetation much like that described by O'Farrell. Although he made no mention of tamarack bog, the type with the highest incidence of forms at Lake Alice, it is interesting that the species he listed were all common in the understory of the tamarack stands.

The importance of alder as a winter habitat was evidenced not only by the number of forms found there but also by the number of incidental sightings. During periods of snow cover in the Lake Alice area, more hares were seen in alder and alder edges than in any other types.

In accordance with findings at the Cloquet Forest Center (Marshall 1977), hares avoided open areas in all seasons. Radio-telemetry, snow track survey, and pellet survey results indicated that neither open lowland nor open upland habitats were used. When snows were deep enough to cover low shrubs, much of the scrub fen was avoided as well.

Although hares undoubtedly need habitats that afford protection from predators and severe weather, they also must utilize habitats that provide food. In Alaska, Wolff (1978) found that hare diet changed from hardwood browse and spruce bark and needles in winter to leaves and other herbaceous plant material in summer. Blueberry and cranberry leaves became important when April snow melt exposed them. In summer, their diet included willow leaves (24.5%), spruce needles (12.3%), Labrador tea (7.6%), Vaccinium species (6.6%), and alder (6%).

A dietary shift to deciduous leaves and herbaceous plants might explain the increase in utilization of certain habitats during the snow-free periods at Lake Alice. The percent of incidental sightings increased in deciduous and mixed uplands and along road edges, all habitats that provide an abundance of forbs and grasses. The increase

in jack pine sightings during snow-free periods may reflect the abundance of blueberry plants in that habitat type.

Winter browse has been the focal point of numerous hare studies. Marshall and Miquelle (1978) reviewed the findings of 2 Minnesota studies (1 near Cushing and another near Grand Rapids) that found pines and black spruce to be preferred winter foods. Results of the Lake Alice browse survey also indicated high browsing intensity on black spruce and jack pine.

On Manitoulin Island, Ontario, DeVos (1964) calculated the intensity of hare browse on numerous species, including 4 plants that were common in the Lake Alice area. He found that hares had browsed 39% of the available black spruce, 50% of the tamarack, 20% of the willow shrubs, and 6% of the alder. These values correspond closely to those calculated in the Lake Alice survey for all species except tamarack. Unfortunately, owing to lack of time and manpower, only a few habitats at Lake Alice were surveyed for browse, and tamarack was not present in most of them. However, incidental records indicate that tamarack was utilized by hares where it occurred in the understory of black spruce and tamarack stands.

DeVos (1964) reviewed 7 other browse studies and concluded that food preferences are highly variable; hares selected a wide variety of upland and lowland species. Telfer (1972) drew similar conclusions from work in 2 forests in Nova Scotia and New Brunswick. He found that hares were highly opportunistic feeders, using whatever browse species were available. In each area surveyed, hares had browsed on all but one minor species.

As noted above, the jack pine stands surveyed at Lake Alice had the highest % utilization of available browse. Since few of the many browsed species found in jack pine stands were abundant, it appeared that hares had a strong preference for some of these species. This might explain the increased use of jack pine at night by some radio-tagged hares. Perhaps the wide spacing of preferred browse plants and the generally poor cover available in jack pine stands limited browsing in these areas to hours of darkness.

White-tailed Deer

Several radio-telemetry studies of deer habitat use have been conducted in Minnesota. Kohn (1970), Waddell (1973), and Pierce (1975) all conducted studies in northern Itasca County in an area that had approximately 5% lowland (combining 4 types). Unfortunately, the differences in habitat types available in each study area make comparisons difficult.

Pierce (1975) monitored 14 deer during 2 springs and reported that the animals were individualistic in their use of various habitats. Although upland types received the majority of use, lowland forest accounted for as much as 17% of the radio-locations for some individuals.

Kohn (1970) radio-tracked 3 deer and conducted track counts along roads during 1 summer. His data indicated that upland habitats were used extensively while fields and lowland areas were avoided.

Waddell (1973) monitored 7 radio-tagged deer during the fall of 2 years and found considerable individual variation in habitat selection patterns. The only discernible trend was a preference for upland conifers and an avoidance of young forest types in October following leaf-fall.

Radio-tracking data for 4 deer in the Lake Alice study support the conclusion that habitat selection patterns can be highly individualistic. While deer 148 used habitats in proportion to availability, 729 selected for lowland, 308 selected for edge, and 914 selected for upland.

As noted above, 729 was the only deer exhibiting seasonal changes in habitat use. In contrast to the findings of Kohn (1970), she showed strong preference, rather than avoidance, for lowlands in summer. In keeping with the findings of Waddell (1973), she exhibited a strong shift to upland conifer stands in October.

Many authors have noted the importance of cedar swamps to deer that are yarding in winter (e.g., Rongstad and Tester 1969) but have concluded that other types of lowland conifers are of little, if any, importance. Marshall and Miquelle (1978) stated that lowland conifer stands do not provide adequate food for over-wintering deer and thus are used only if there is adjacent upland where food can be obtained. The Lake Alice area contained none of the favored white cedar but did provide considerable lowland conifer-upland edge. Radio-telemetry data for 729 and snow tracking data from winter 1978-1979 indicate that upland-lowland edge received heavy use in this season.

During snow-free seasons, deer may have been attracted to jack pine upland to browse on blueberry shrubs. In Nova Scotia and New Brunswick, Telfer (1972) observed heavy browsing on blueberries and other shrubs of the heath family.

During the fawning season, Harmoning (1976) found that radio-tagged does with fawns exhibited a preference for wetlands associated with woody species. As a result of his investigation in central North Dakota, he concluded that small, well-spaced wetlands should be conserved because of

their importance as fawning cover. Sightings of does 308 and 729 in the Lake Alice area indicated that they, too, were utilizing such habitat during June and July.

Furthermore, Harmoning (1976) noted that large complexes of wetlands may be less valuable for fawning cover than scattered small ones. Apparently, does spatially isolate themselves even where good fawning cover is continuous.

As noted above, radio-tagged deer in the Lake Alice area exhibited an increase in use of upland habitat at night. Similarly, Rongstad and Tester (1969) found that radioed deer near Bethel, Minnesota spent more time in upland communities at night than in the day. They believed this to be a result of nightly feeding trips to oak woods and open fields. It is possible that deer in the Lake Alice area utilize jack pine stands and upland openings in much the same way.

Spruce Grouse

Spruce grouse in the Lake Alice study area differed in habitat use patterns from those studied by Haas (1974) and Anderson (1973) in northern Minnesota. In their study area upland conifers were apparently unavailable, and all phases of male and female activity were restricted to various types of lowlands. At Lake Alice, upland conifer was the preferred winter habitat for all radio-tagged grouse and the preferred nesting habitat for 2 of 6 radioed females.

It is interesting to note that, in terms of physiognomy and ground vegetation, sites selected in jack pine by hens in the Lake Alice area showed striking similarities to those selected in bog habitats described by Haas (1974). Apparently, the degree of canopy cover and the types of

shrub and herbaceous vegetation available for food are more important than the actual species of trees present in the area.

The seasonal shift from jack pine upland to lowland conifer made by most grouse in the Lake Alice area was also documented for grouse in 5 other counties of northern Minnesota. Stenlund and Magnus (1951) reported that use of black spruce increased in the summer, almost equaling jack pine use.

Utilization of jack pine forest by spruce grouse has been documented by 2 studies in northern Michigan. Ammann (1963) claimed that spruce grouse in that area were associated more often with jack pine than with spruces. After 3 summer surveys, Robinson (1969) concluded that spruce grouse on the Yellow Dog Plains chose areas where jack pine was mixed with black spruce and white spruce. Blueberry was cited as an important component of the ground vegetation.

Traditionally, spring displays of male spruce grouse have been associated with black spruce bogs (Robinson 1969). Such views have gained support from studies by Anderson (1973) in northern Minnesota and Ellison (1971) in Alaska. In Ellison's study area, cocks established territories in moderately dense stands of mixed black spruce and white spruce, the understories of which included sphagnum mosses, blueberry, and lingenberry. Anderson described display sites in black spruce bogs near Big Falls, Minnesota that were very similar to sites used in the Lake Alice study area.

As noted above, jack pine forests and spruce forests used by grouse in different areas have some striking similarities. Tree and shrub densities appear to be similar, and both have ground vegetation dominated by ericaceous species. In the Lake Alice area, where jack pine stands and

spruce stands are plentiful, it is interesting that nesting hens and displaying males have been observed in both.

Results of several studies of spruce grouse food habits agreed closely with what we observed. Marshall and Miquelle (1978) reviewed several of these studies and concluded that conifer needles were the major winter food, leaves and berries of ericaceous plants were among the most important summer foods, and conifer needles gradually became important again through the fall.

Two studies of grouse food habits note the importance of tamarack needles during autumn. In northwest Montana, Jonkel and Greer (1963) found that western larch (Larix occidentalis) needles were the principal food during this period, but that consumption of this item declined in October. In central Ontario, Crichton (1963) observed that tamarack (Larix laricina) needles were heavily used by spruce grouse while they were available in early fall. After the tamaracks shed their needles, jack pine became the most important food and remained so through winter.

Seasonal movements of radioed grouse at Lake Alice might readily be explained by such dietary changes. Tamarack stands were used in late summer and early fall, even by hens that had nested in jack pine. The nearly exclusive use of jack pine stands in late fall and winter has already been noted above.

Ruffed Grouse

The ruffed grouse is not commonly regarded as a member of the peatland fauna; Marshall and Miquelle (1978) did not even mention this species in their review of terrestrial birds of Minnesota peatlands. However, our data showing the importance of alder lowlands to ruffed grouse are not unprecedented. In northern Michigan, Palmer (1963) studied 40 drumming

logs, all of which were located in lowland vegetation. Over 73% of the tall shrub stems around logs were speckled alder. He emphasized that this size class of vegetation furnished the most important cover for male ruffed grouse.

Palmer (1963) also noted that a combination of factors, such as juxtaposition of cover types and proximity of the log to edge, apparently governs selection of drumming sites. Eng (1959), studying male grouse in northeastern Minnesota, found the majority of drumming logs to be associated with upland-lowland edge. These findings concur with records from the Lake Alice study, where 10 of 15 logs were in edge habitat.

In Minnesota and Wisconsin, 6 studies have been conducted on habitat use by female grouse with broods. Six years of observations in northern Wisconsin led Dorney (1959) to conclude that alder "swamps" and to a lesser extent swamp hardwoods are used by broods almost exclusively during the hot summer months. For this reason he contended that alder lowlands were vital to grouse production in that area.

Near Cloquet, Minnesota, Eng (1959) found that 38 of 40 nests were located in upland but that broods increasingly were found in adjacent lowlands as the summer progressed. Most brood sign was observed in alder zones on the periphery of lowland swamps or bogs.

In the same area used by Eng, Kupa (1966) found 108 of 113 nests in upland habitats, primarily jack pine. Yet he, too, located most broods in lowlands from mid-July through August. Alder and black spruce were the lowland types most commonly utilized.

Godfrey (1975) conducted a radio-telemetry study in the same area and formed the same conclusions. Almost 64% of his brood locations were in

lowlands dominated by homogeneous stands of mature speckled alder. Brood locations were in upland-lowland edge 23% of the time. He defined edge as a 9-m strip along either side of an upland-lowland boundary.

Godfrey (1975) suggested that alder was used because of the great diversity of ground vegetation in this community and because of the protection it offered from avian predators. Kubisiak (1978) drew similar conclusions about the role of alder as brood cover. His central Wisconsin study area contained stands of alder-aspen, sapling aspen, pole-sized aspen, and pole-sized oak. Flushing surveys revealed that broods and adults used alder-aspen more than any other type. Kubisiak contended that the alder-aspen stands provide a variety of good grouse foods as well as protective overhead cover.

Near Bethel, Minnesota, Maxson (1978) studied spring habitat use by 15 radio-tagged female grouse. He concluded that habitat use varied considerably with individuals and with stage of the breeding season. After 3 seasons of observations, he found that major use was confined to alder, mixed hardwoods, tamarack, paper birch, and oak. Alder and mixed hardwoods were the types used most consistently.

Maxson (1978) located 22 grouse nests, 7 of which were in wet habitats. He postulated that:

> Nests in wet areas may be more common than generally believed. Since lowlands are usually more difficult for humans to traverse, activities which lead to chance finding of nests probably occur in uplands. The high success rate of lowland nests suggests a selection pressure for hens to utilize these areas as nest sites.

Maxson (1978) also cited preferential use of alder by hens prior to incubation and by broodless hens after the incubation period. He suggested that a small, dense alder stand can provide ample food and adequate cover for broodless hens.

Godfrey (1967) radio-tracked 1 broodless hen during his study at Cloquet. She occupied alder lowland until the end of July and then moved to the edge of an upland pine stand for the rest of the summer. The broodless hen monitored at Lake Alice exhibited a similar pattern of habitat use.

Only 1 hen with brood was monitored during our study, but numerous incidental sightings of adults and broods were made during the summer. Together, these data strongly support the contention of the authors cited above that alder and alder-upland edge are important summer habitats for ruffed grouse.

MANAGEMENT IMPLICATIONS

While all 4 species studied in the Lake Alice area used peatlands to some extent, none of them appeared to be completely dependent on these habitats at all times. However, it is possible that such lowlands are vital to these species in certain seasons or in certain years.

Alder fen, upland-alder edge, and conifer bogs provided important snowshoe hare habitat at Lake Alice. As reported in the literature, availability of these types apparently becomes critical in years when hare numbers are low. Removal of these plant communities not only would eliminate vital habitat but also would create openings that are avoided by hares at any population density.

Although some white-tailed deer showed preferences for lowlands during our study, these preferences did not appear to be a general trend. However, we lack adequate data to evaluate the importance of lowlands for fawning cover. Other workers have cited the importance of small wetlands associated with woody plants as cover for does and their young fawns. This suggests that vast expanses of lowlands may be of little value to deer, but that pockets of lowlands or upland-lowland edge probably should be conserved.

Spruce grouse at Lake Alice demonstrated that lowland bogs are unimportant in winter if upland conifers are available. However, their strong preferences for display sites in black spruce bogs and for nest sites in mixed bogs suggest that lowlands may be critical for reproduction. It is unclear whether these grouse can survive and reproduce as successfully in areas that completely lack conifer bog. Because they adhere to traditional nesting areas and display sites, clear cutting of lowlands inhabited by spruce grouse would probably eliminate local populations.

Ruffed grouse at Lake Alice demonstrated a preference for upland-alder edge for drumming and nesting activities. Whether these edges are critical for survival and reproduction has not been determined. Several other studies suggest that alder provides essential brood cover. In light of these findings, alder stands and upland-alder edge should be preserved.

SUMMARY

In a 10-km^2 area of Hubbard County, Minnesota, radio telemetry was used to study habitat use and selection by snowshoe hare, white-tailed deer, spruce grouse, and ruffed grouse. The study area contained 7 types of lowland habitat interspersed with 4 types of upland habitat. Four deer, 16 hare, 15 spruce grouse, and 7 ruffed grouse were radio-tracked between December 1977 and June 1979. Additional data were collected from snow track surveys, road track surveys, pellet counts, browse studies, and incidental sightings.

Snowshoe hare varied considerably in patterns of habitat use; the only overall trend was an avoidance of open habitats of all types. Nine of 16 radio-tagged hares were found most often in lowland habitats, 4 were most often in edge habitats, and 3 were most frequently in uplands. Most hares used jack pine, alder fen, and jack pine-alder edge to some extent. Selection was shown for jack pine-alder edge, alder fen, black spruce bog, tamarack bog, and deciduous upland. In lowland and upland forests there was a significant correlation ($p < .01$) between intensity of hare use and density of shrubs over 1 m tall.

All 4 radio-tagged white-tailed deer used upland at least 50% of the time, but only 1 deer exhibited a preference for upland in all seasons. Three deer used lowlands more than expected by chance, and 1 deer showed a preference for edge habitats. Preferred types included mixed upland, jack pine-alder edge, alder fen, and black spruce bog. Pellet surveys, track surveys, and incidental sightings re-emphasized that upland habitats had the highest utilization.

Spruce grouse exhibited strong seasonal changes in habitat preferences. In months of snow cover all grouse preferred jack pine upland and avoided lowlands. From May through September male grouse strongly selected for black spruce lowlands. During mating and egg-laying, 6 females showed preference for lowlands, and 3 selected for edge. Two of 6 nesting hens used jack pine upland, and 4 nesting hens used bogs. In fall, habitats were used in proportion to their availability.

Radio-tagged ruffed grouse varied considerably in habitat utilization patterns: 1 used lowland most of the time, 2 used edge most frequently, and 2 were most often in uplands. Selection was shown for mixed upland, mixed upland-mixed lowland, deciduous upland-alder edge, black spruce bog, and alder fen. Four of 5 radio-tagged grouse exhibited significant seasonal changes, but the only trend held in common was an increase in the use of uplands during autumn. Most drumming logs were located in upland-lowland edge, and alder was most often the dominant shrub species at the log site. Of 3 nests found, 2 were in alder near jack pine. Broods were observed in a variety of edge, upland, and lowland habitats.

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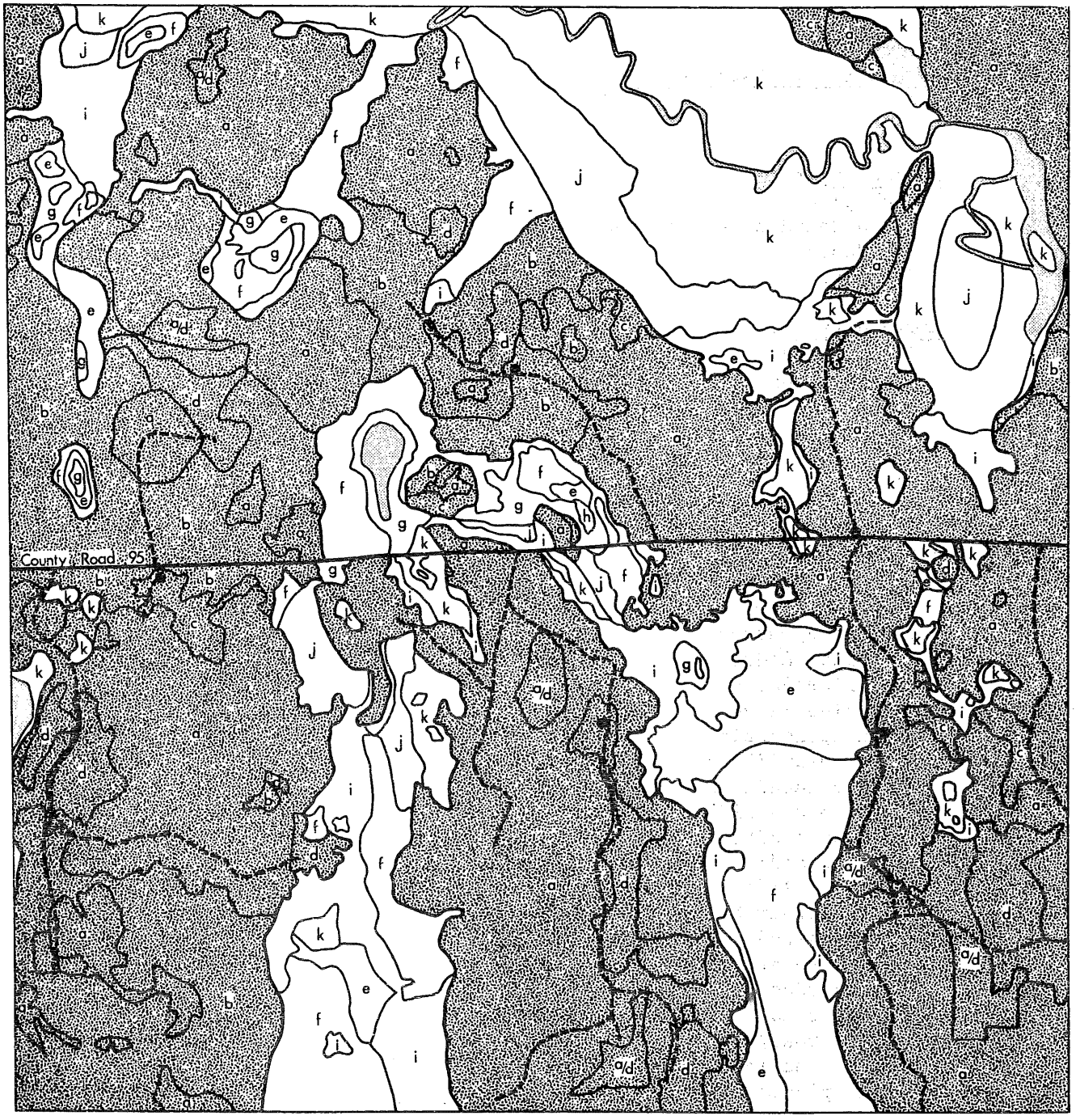
Appendix A. Vegetation of the Lake Alice Study Area, Hubbard County, Minnesota



UPLANDS

a Coniferous upland forest
b Mixed deciduous-coniferous forest
c Deciduous forest
d Clearing

LOWLANDS

e Black spruce bog
f Tamarack bog
g Muskeg
h Open bog
i Alder fen
j Scrub fen
k Sedge fen

WATER

RADIO TOWER

ROAD

LOGGING ROAD

0 ½ 1 Kilometer

N

Appendix B. Habitat types available in the Lake Alice study area.

	Hectares	Percent
Upland types:		
Jack pine	479.2	48.1
Mixed deciduous-coniferous	114.7	11.5
Deciduous	16.3	1.6
Clearing	37.6	3.8
	647.8	65.0
Lowland types:		
Black spruce bog	23.5	2.4
Tamarack bog	60.3	6.1
Muskeg	6.9	0.7
Open bog	1.0	0.1
Alder fen	39.7	4.0
Scrub fen	52.0	5.2
Sedge fen	51.6	5.2
	235.0	23.6
Upland-lowland edge types:		
Jack pine/Black spruce bog	2.0	0.2
Jack pine/Tamarack bog	14.8	1.5
Jack pine/Muskeg	1.5	.2
Jack pine/Alder fen	33.0	3.3
Jack pine/Scrub fen	4.1	.4
Jack pine/Sedge fen	11.3	1.1
Mixed upland/Black spruce bog	1.7	0.2
Mixed upland/Tamarack bog	7.3	0.7
Mixed upland/Muskeg	2.8	0.3
Mixed upland/Alder fen	1.2	0.1
Mixed upland/Scrub fen	0.8	0.1
Mixed upland/Sedge fen	2.5	0.3
Deciduous/Alder fen	2.9	0.3
Deciduous/Scrub fen	0.8	0.1
Deciduous/Sedge fen	2.4	0.2
Unpaved road/Tamarack bog	0.8	0.1
Unpaved road/Muskeg	0.8	0.1
Unpaved road/Alder fen	1.7	0.2
Unpaved road/Sedge fen	1.3	0.1
Upland clearing/Alder fen	1.4	0.1
Mixed upland/Mixed lowland	1.6	0.2
	96.7	9.7
Total land area	979.5	98.3
Open water	17.0	1.7
TOTAL AREA	996.5	100.0