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Relationships Between Terrestrial Vertebrate Fauna and Selected Coniferous Forest Habitat Types on the North Slope of the Uinta Mountains

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RELATIONSHIPS BETWEEN TERRESTRIAL VERTEBRATE FAUNA AND

SELECTED CONIFEROUS FOREST HABITAT TYPES ON THE

NORTH SLOPE OF THE UINTA MOUNTAINS

by

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David S. Winn

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ABSTRACT

Relationships Between Terrestrial Vertebrate Fauna and
Selected Coniferous Forest Habitat Types on the
North Slope of the Uinta Mountains

by

David S. Winn, Doctor of Philosophy

Major Professor: Dr. J. Juan Spillett
Department: Wildlife Sciences

The objectives were (1) to relate terrestrial vertebrate responses to the management practices used for lodgepole pine forests within the Barometer Watershed, Mountain View Ranger District, Wasatch National Forest, Utah. (2) To correlate terrestrial vertebrate densities or frequencies with community types, edge, major forest stand structures, and (3) to propose management plans to manipulate densities of major vertebrate species in a predetermined manner.

The study was conducted between 1973-1975 and provides a detailed description of forest vegetation for 53 lodgepole pine *(Pinus contorta)* stands. For each of these stands, a complete summary is provided of tree populations, coverage, and frequency of major vascular undergrowth species. Eight lodgepole pine forest community types are defined. A key is provided for identification of each community type and its anticipated habitat type.

The relationships between densities of major vertebrate species, forest communities, and major forest stand structures are described.

Big game utilization of ecotones created by mountain meadows and the lodgepole pine forest are discussed. In addition, the response of selected small mammal and big game species to clearcut size is provided. Important research findings were: (1) In the lodgepole pine forest most vertebrates exhibit preferences for specific community types. (2) Due to the broad definition of present habitat classifications, limited predictions can be made about the general response of wildlife populations on most sites. (3) The use of park-like openings and associated peripheral timber by big game animals is closely associated with community type, edge configuration, and historical travel lanes. (4) An abundance of downed woody material enhances big game calving and resting areas. (5) The number of bird species is closely associated with understory biomass and diversity. (6) Management schemes that speed up the rotation of lodgepole pine overstories eliminate certain vertebrate communities associated with the final successional stages.

The following specific recommendations for overstory removal are suggested. (1) Timber sales should be developed by drainage, with long-term objectives that insure the distribution of a variety of communities within a drainage. (2) The addition of major stand structure information should be included in habitat classification systems. (3) Timber sales should be designed with irregular edges and buffers of standing timber which provide cover and concealment. (4) Moist sites and relic areas, representing the final stages of succession, should be planned into the overall

drainage sale philosophy. (5) In relatively undisturbed areas, vehicular travel should be prohibited following overstory removal.

(194 pages)

INTRODUCTION

Justification

Within the Intermountain states of Idaho, Nevada, Utah, and Wyoming, lodgepole pine (*Pinus contorta Dougl*) dominates more than 1.6 million hectares of national forest land. The small size of the mature tree protected it from large-scale harvesting prior to the 1950's. Cutting of lodgepole pine was historically aimed at supplying railroad cross ties, fence posts, and mine props. Because the rate and scale of the annual harvest was small, little attention was given to lodgepole pine stand structure, growth patterns, or community dynamics.

With increasing demands for wood products, economic incentives hastened improvements in harvest and milling techniques. Forest managers immediately saw the opportunity to convert mature decadent lodgepole pine stands into younger ones. By the mid-1960's, the impact of clearcutting lodgepole pine forests came to public attention. Public opinion viewed the goals of timber production as completely out of proportion to the scope of the total forest resource value. To the general public, the one-step regeneration system, called "clearcutting", quickly became synonymous with forest devastation.

Prior to 1960, the response of wildlife populations to clearcutting in the lodgepole pine community was virtually unknown. In response to management needs, the development of natural classification systems upon which management decisions could be made was initiated. In the

1970's Smith (1973), Berntsen (1973), Layser (1974), and others reviewed the pertinent information regarding wildlife and classification systems only to conclude that little was known or being done to assess the forest potential for game and non-game species. With the exception of forage production, little factual information existed with regard to cutting and the interspersion of natural openings and stand diversities.

Objectives

This study's primary objective was to relate terrestrial vertebrate responses to the management practices used in lodgepole pine forests within the Barometer Watershed, located in the Mountain View Ranger District, Wasatch National Forest, Utah. Specific objectives were to correlate terrestrial vertebrate densities and frequencies with:

(1) community types

(2) edge

(3) major components of forest stand structure, and

(4) to propose management plans to manipulate densities of major vertebrate species in a predetermined manner.

STUDY AREA

Geographic Location and Physiography

The study area was located within the Mountain View Ranger District of the Wasatch National Forest. The area is about 55 kilometers south and east of Evanston, Wyoming, and nearly centered on the north slopes of the Uinta Mountains.

The Uinta Mountain range, in the northeast corner of Utah and southwestern Wyoming, extends approximately 240 kilometers in an east-west direction. The range is about 56 kilometers wide. Hayward (1945) described this dome-shaped range as a great anticline plateau, characterized by a Pre-Cambrian quartzite substratum, poor drainage, and with generally acid soils and waters.

The study area (41,000 ha) lies between 2500 and 3200 meters in elevation, and is characterized by steep drainages with lodgepole pine dominated vegetation. Meadows comprise most of the level landscape. These meadows are important breeding and rearing areas for major big game species.

Glaciation played a major role in leveling the terrain and creating cirques, high basins, and deep canyons that drain north into the Great Basin and Green River of the Colorado River. The shifting ice gouged lateral moraines, dotted with small meadows and potholes along the northerly oriented ridges. The terrain contributes significantly to the diversity of communities, forest wilderness quality, and corridors that connect major drainages.

The study area is unique in several respects, making a study of this sort possible. The long narrow lodgepole pine forest belt is bisected by a dirt road called the North Slope Highway (Fig. 1). The area south of the road (hereafter called roadless) is classified roadless, and travel is limited to foot or horseback. The higher elevations and south end of the study area are within the High Uinta Primitive Area. Part of the area was selectively logged by "tie hackers" in the late 1880's. However, few remnants of their roads or camps remain. In addition, this portion of the study area contains several large meadows with associated small meadow complexes.

In the northern portion of the study area (hereafter called roaded) road development and use has increased substantially since the early 1960's. This increase is attributed to

(1) oil exploration

(2) larger clearcut-type timber sales

(3) recreational activities, and

(4) suppression of a mountain pine beetle *(Dendroctonus monticolae)* epidemic. From late spring until mid-fall, three well maintained roads provide the travel routes for these activities. With the exception of roads serving active oil wells and winter logging, heavy winter snows close all roads. The division of the study area by the North Slope Highway provided excellent contrasts in noise levels and vehicular traffic.

Overstory Vegetation

In 1959, the U.S. Forest Service completed a comprehensive inventory and classification of the tree stands on the north slope of the

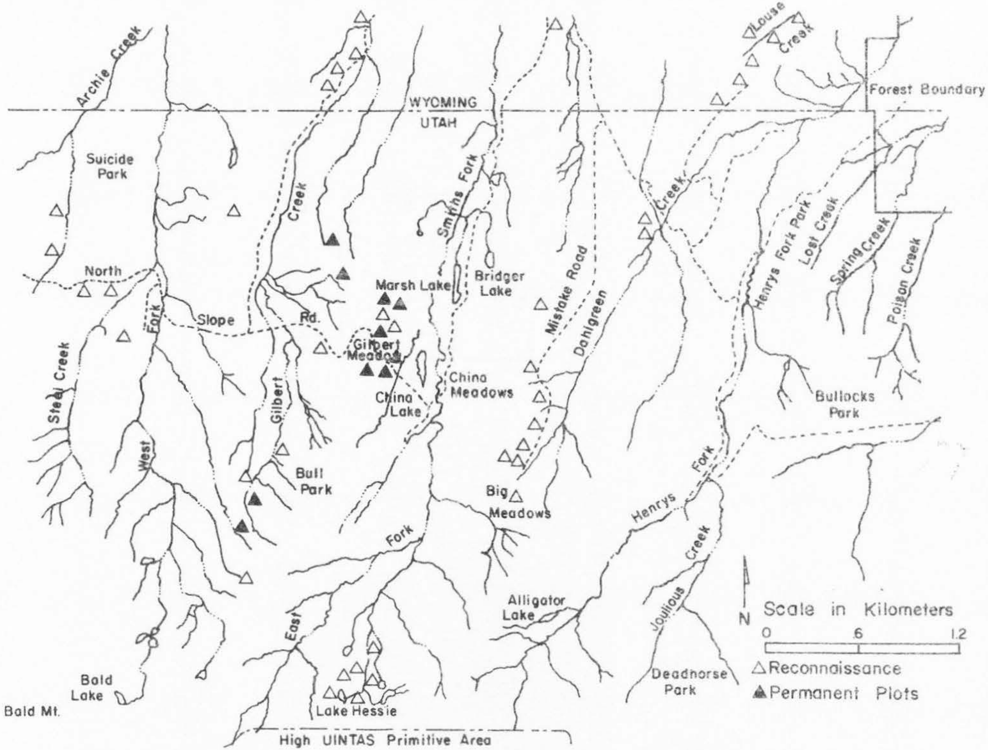


FIGURE 1. Study area, Mountain View Ranger District, Utah.

Uinta Mountains. The study area's forest cover types are summarized in Tables 1 through 5. Seventy-five percent of the study area is classified as commercial forest, 14% wilderness, and 6% non-forested. Most of the non-forested land is grazed by livestock under various allotments. Private enterprise annually harvests designated stands of commercial timber and standing deadwood along the major roadways.

Throughout the study area, coniferous overstories representing North Slope Timber Atlas (1961) site classifications are found in similar proportions. However, the roadless section has five times as much commercial spruce (see Table 2). Tree stands located in the roadless area are older, contain a larger proportion of sawtimber, and have less infestation of dwarf mistletoe *(Arceuthobium americanum)* (see Tables 3, 4, and 5). More than 30% of the trees on 50% of the study area are infected with dwarf mistletoe.

Some adjustments to the general timber inventory are required, since in excess of 900 hectares of standing lodgepole pine were chained, windrowed, and burned in 1961. In this attempt to control epidemic populations of the mountain pine beetle and clear ground for disease-free stands, little consideration was given to wildlife needs. From an aesthetic viewpoint, the results were somewhat awesome, but left an ideal area for studying wildlife-overstory interactions.

Table 1. Summary of the forested, non-forested, and wilderness lands within the study area (North Slope Timber Atlas, 1961).

	Number of Hectares	
	Roadless Area	Roaded Area
Forested		
Lodgepole Pine	10,831	18,431
Engelmann's Spruce	1,163	202
Aspen	13	1,820
Douglas Fir	0	98
Subalpine Fir	0	73
Total	12,007	20,624
Non-forested		
Water	76	103
Meadow Type	1,533	910
Total	1,609	1,013
Wilderness	5,655	0
Subtotal	19,271	21,637

GRAND TOTAL = 40,908

Table 2. Number of hectares in each coniferous forest site class for the roadless and roaded areas of the study area.

Area and Site Classification[1]	Lodgepole Pine ha (%)	Engelmann's Spruce ha (%)	Total ha (%)
Roadless			
Medium	4,148 (38)	71 (6)	4,219 (35)
Poor	6,642 (61)	970 (84)	7,612 (64)
Very Poor	42 (1)	122 (11)	164 (1)
Total	10,832	1,163	11,995
Roaded			
Good	42 (T)[2]	0	42 (T)
Medium	5,573 (30)	0	5,573 (30)
Poor	12,727 (69)	186 (92)	12,913 (69)
Very Poor	90 (1)	17 (8)	107 (1)
Total	18,432	203	18,635
GRAND TOTAL	29,264	1,366	30,630

[1]Classification criteria are described in the North Slope Timber Atlas, 1961.

[2]Trace.

Table 3. Area (ha) and map units (stands) dominated by lodgepole pine categorized by age class in the roadless and roaded areas of the study area.

	Area		Total
Age Class	Roadless	Roaded	
(years)	ha (stands)	ha (stands)	ha (%)
0-80	2,604 (108)	4,774 (190)	7,378 (25)
81-160	3,025 (72)	8,493 (252)	11,518 (40)
161-240	3,889 (81)	4,976 (110)	8,865 (30)
241-320	1,307 (22)	188 (5)	1,495 (5)
320+	8 (2)	- (0)	8 (T)[1]
Total	10,831 (238)	18,431 (557)	29,264

[1] Trace.

Table 4. Area (ha) and percent of lodgepole pine forest area by tree size class in the roadless and roaded areas of the study area.

Tree Size Class	Area		Total
	Roadless	Roaded	
	ha (%)[1]	ha (%)	ha (%)
Small sawtimber	5,959 (55)	6,539 (35)	12,498 (43)
Pole timber	4,826 (45)	11,371 (62)	16,197 (55)
Seedling-sapling	46 (T)[2]	505 (3)	551 (2)
Non-stocked	-	16 (T)	16 (T)
Total	10,831	18,431	29,262

[1]Percent of the total hectares of lodgepole pine forest in the study area.

[2]Trace.

Table 5. Classification of lodgepole pine forests in the study area by degree of dwarf mistletoe infection.

Percent of Trees Infected	Area: Roadless ha (%)	Roaded ha (%)	Total (%)
0-9	4,528 (42)	3,256 (18)	7,784 (27)
10-29	1,732 (16)	6,226 (34)	7,958 (27)
30-54	3,660 (34)	3,409 (18)	7,069 (24)
55-79	374 (3)	3,224 (17)	3,598 (12)
80-100	539 (5)	2,316 (13)	2,855 (10)
Total	10,833	18,432	29,264

Climate

Elevation, aspect, and local wind patterns within the study area are the major determinants of micro-meterological conditions. In general, as elevation increases, the mean annual temperature decreases about 2.0°C for each 300 m. When the recorded winds from the lower and higher areas are compared, the total recorded wind is nearly double at the higher elevation. Ashcroft and Richardson (1976) class the area's annual growing season as less than 40 days. Based on a critical temperature of 0°C, the long-term freeze-free season of 30 days occurs between July 9 and August 8 (Table 6).

The annual precipitation averages about 36 cm. July is a rainy month. Snows can occur at anytime of the year, but the ground is seldom permanently covered until mid-November. The average maximum snow depth (150 cm) occurs in the late winter and early spring (Jeppson, et al. 1968). By the time heavy snows accumulate, most big game populations have migrated out of the study area onto the winter range.

Vegetation

Lodgepole pine (*Pinus contorta)*, the study area's major pine, is described by Proctor (1971) as a seral, sub-climax species that is intolerant of shade and dependent on natural disturbance. The area's vegetational aspect is a uniform coniferous forest with grass dominated meadows in aspen-conifer mosaics at lower elevations, and spruce-fir overstories invading lodgepole pine communities at upper elevations.

Table 6. Monthly long-term (30-year) normalized temperatures (C°) for the geographic center of the study area (Gilbert Meadows Climatic Station).

Month	Temperature		Month	Temperature		Month	Temperature	
	Max	Min		Max	Min		Max	Min
January	-3	-22	May	7	-4	September	8	-2
February	-4	-21	June	15	-1	October	6	-7
March	-2	-15	July	18	3	November	-1	-14
April	-2	-12	August	17	2	December	-5	-19

Vaccinium spp. dominate understories at higher elevations. Two williow species, Drummond's (*Salix drummondiana)*, and Geyer's (*S. geyeriana)* are common in small meadows and bogs.

METHODS

Field Methods

This three-year study was conducted between 1972 and 1975. To facilitate sampling across a variety of communities and to insure that vertebrate populations were relatively stable, two types of sampling units were used. First, areas marked with "permanent" grids were sampled yearly. Second, "reconnaissance" plots were sampled for only one year. Sampling techniques were similar for both types of plots.

The following data were recorded for each sampling unit:

(1) stand designation

(2) elevation

(3) aspect

(4) slope (%).

Twenty of the largest trees in the stand were measured for height and crown length. However, basal areas for each stand were calculated by summing the basal areas for each stem diameter class. When possible, increment cores were taken from five trees to verify ages of the stands.

Bird censuses were made between 7 am and 10 am by cruising the plot on foot and identifying all birds seen or heard. Five minutes were generally spent standing at a point, recording the numbers and kinds of birds, and then proceeding to another point. This routine was continued for a total of 10 standing points. An attempt was made not to recount birds with loud calls, or wandering birds. Birds flying high overhead were excluded. However, those flying close to or within the canopy were counted. At the end of each census period, data were summarized to include:

(1) the total number of points at which a species was observed (frequency),

(2) the total observations of each species (density).

Bond (1957) and Beals (1960) used a similar approach, and found the counts to be reasonable estimates of the relative densities of bird populations.

Permanent Plots

Twelve permanent plots representing six community types and two clearcuts were established. Six plots were adjacent to meadows. A reconnaissance plot was included within each permanent plots. Permanent plots were marked at 15 m intervals with numbered stakes. Plots associated with meadows were centered on the meadow and consisted of five rows and enough columns to extend 500 m into the adjacent forest. Forest plots had five rows and 12 columns. It is recognized that trapping grids usually result in somewhat less success than setting traps at obvious signs. However, grids approximate random sampling required for statistical analyses and allow for the calculation of sampling areas.

Between 1973 and 1975, small mammals were trapped from mid-July to mid-August. Nine permanent plots, representing four communities and two clearcuts, were trapped for six consecutive nights, twice a year for two years. Trapping stations consisted of one 3" x 3" x 9" and one 5" x 5" x 14" Sherman live traps baited with mixed grains, bacon fat, and peanut butter. Traps were checked and rebaited twice daily.

Only the peripheral forest of meadow areas were trapped (5 x 12 grid). Captured animals were sexed, weighed, ear tagged with serially numbered fingerling tags, and released at the trap site. Comparative small mammal densities were estimated on an animal-per-hectare basis by means of the mark-recapture and the Schnabel Estimator methods (Overton and Davis, 1969). Density estimates based on six trap days were adjusted for trap mortality (Overton, 1965).

To establish confidence intervals about the estimated home range areas, trapping stations were numbered with a coordinate system and fed directly into a Fortran IV program for calculating a series of probability ellipses (Keoppl, et al. 1975). While Dolbeer and Clark (1975) indicate the home range of snowshoe hares exceeds the area sampled (1.35 ha), it is felt that a combination of live trapping and pellet densities provide sufficient data for developing indices to community selection by hares. I estimated the area sampled for animals whose home range exceeded the grid area by adding the average adult home range radius to the grid periphery (Dice, 1938). For the small species, *Tamiasiurus hudsonicus* (Wolff and Zasada, 1975) and *Eutamias* (Sheppard, 1972), the grid area appears adequate.

At the conclusion of spring run-off, pellets and middens were counted and removed from a circular plot (1.3 m^2, 100 ft^2) around each grid stake. Plots were counted and cleared again during the last two weeks of September. The fall tally also included the number of stems, saplings, and seedlings.

Four bird censuses for each permanent plot were completed between June 15 and July 15. The census area was expanded to 3.96 ha (9.8 acre), and the boundary marked by color coding tree trunks. Attempts were made to keep the census area in a homogenous community, centered on a permanent plot.

Reconnaissance Plots

Reconnaissance plots (375 square meters, 0.09 acre) were placed in stands to sample homogenous units of tree and understory vegetation. With the exception of sampling associated with permanent plots, selected sites avoided ecotones between obviously different plant community types and areas grazed by domestic livestock.

The procedure associated with site selection, plot size, and orientation are discussed in detail by Daubenmire and Daubenmire (1968). In general, the plots were oriented with the long axis parallel to existing contours. Plot sides were outlined with stretched tapes. Two additional tapes divided the plot into three macroplots (5 x 15 m). Along each boundary tape, 20 microplots (20 x 50 cm) were placed at 1 m intervals. Thus, each reconnaissance plot consisted of 80 microplots and three macroplots. This procedure was replicated three times at each site, once for the months of June, July, and August.

Within each macroplot, tree species were tallied by 5.08 cm (2 inch) breast-height diameter classes. In addition, all trees were tallied by heights as:

(1) stems (greater than 6 m)

(2) saplings (1.37 m to 6 m)

(3) seedlings (less than 1.37 m).

Dead trees were tallied separately.

For each understory plant species canopy coverage was recorded in one of six classes:

(1) 0-1%

(2) 2-5%

(3) 6-25%

(4) 26-50%

(5) 51-75%

(6) 76-100%.

To estimate standing crop, 10 hoops (0.09 m^2, 1 ft^2) were randomly tossed, the herbage clipped, and the wet weight of each plant species recorded. Wet weights of plant species were converted to total herbage (kg/ha), as outlined by the Range Environmental Analysis Handbook (1969). From the three site replications at each location an average standing crop value was calculated.

For each microplot, the following data were recorded:

(1) plant densities by species

(2) number of rabbit pellets

(3) number of deer, elk, and moose pellet groups

(4) number of middens

(5) percent overstory.

Percent overstory was determined by counting the number of times the overstory obscured the sky on a leveled mirror marked with 100 grid intercepts. The mirror was hand held approximately 15 cm above the ground.

Downed woody material on each reconnaissance plot was measured as outlined by Brown (1974). This planar intersect technique inventories naturally fallen woody material and has the same theoretical basis as line intersect methods (Van Wagner, 1968). To facilitate data collection and economize time, the 15 m ends of the stretched boundary tapes defined eight sampling planes for each plot.

The small mammals at each reconnaissance site were inventoried with systematic trapping grids, which consisted of five rows and eight columns. Forty snap traps (Museum Special or standard rat traps) spaced at 15 m intervals were baited with a mixture of grains, bacon fat, and peanut butter. The grid area (0.6 ha, 1.56 acre) was centered on the area sampled by three reconnaissance plots. Each site was trapped twice for four nights each, making a total of 320 trap nights per site.

Bird communities associated with each reconnaissance unit were evaluated with four cruising surveys across a 100 x 200 m area (2 ha, 5 acre). When terrain permitted, the census area was centered on the reconnaissance area.

Track Counts

Immediately following four autumn snows, big game tracks were counted along meadow line transects. Tracks were counted around the entire edge of each meadow and at 50 and 100 m intervals into the meadow. For meadows with widths less than 100 m, a line bisecting the width of the meadow was counted. Counts were made before the general migration toward the winter range commenced.

Scent Posts

The relative abundance of coyotes (*Canis latrans)* and small cats *(Lynx rufus* and *L. canadensis)* was surveyed with scent post stations. This method and its application was reviewed by Linhart and Knowlton (1975). Basically, it consists of track counts at stations spaced at 0.5 km intervals, and baited with a commercial fermented-egg product. Since I was interested only in determining presence or absence of coyotes and small cats, I deviated from the prescribed procedure as follows.

(1) Three scent posts were grouped in the form of an equilateral triangle with 100 m sides. In each phase of each community type, two sites were surveyed during each sample period. Two periods were sampled for four consecutive nights each, giving a total of 16 group nights per community phase.

(2) Two clearcuts were surveyed for five consecutive nights with nine scent posts placed at 0.5 km intervals across a 4.0 km route. The total stations visited each night were summed for a nightly route total.

To reduce bias resulting from weather and recreational activities, all survey stations were read on the same mid-week days.

DATA ANALYSIS

Plant Communities

Following the 1974 field season, first approximations of community types were based on field observations and reviews of previous work by Proctor (1971), Pfister (1972), and Steel et al. (1974). Plant species data were coded and computer programs converted reconnaissance plot data into association tables and species lists. In addition, a two dimensional coefficient of similarity between reconnaissance plots was calculated. This procedure is outlined by Bray and Curtis (1957), wherein $C=\frac{2W}{a+b}$ and:

a = sum of quantitative species values in stand 1

b = sum of quantitative species values in stand 2

W = sum of quantitative values common to both stands.

This index varies from 0.0 to 1.0, with larger values developing from communities which are most alike. From these calculations and association tables, a working key to lodgepole pine-dominated communities was developed for testing during the 1975 field season.

Plant voucher specimens were identified by Arthur Holmgren at Utah State University after the 1975 field season. Since a complete flora for the Uinta range is not available, I compared the field identifications by Tom Phillips (USFS) with the voucher specimens. The final naming of specimens was based on my personal evaluation. Plant nomenclature follows the checklist prepared by Holmgren and Reveal (1966). Standardized computer species codes are presented in Table 48.

To develop the final series of association tables, data from reconnaissance plots were clustered, using a similarity index. Rea (1975) and Tauch (1976) coded sub-routines for the Burroughs 6700 computer, which develop a similarity matrix based on Sorensen's K (Sorensen, 1948). Site clustering begins by joining the two sites with the most similar matrix values. Succeeding clusters are formed by a weighted pair group method (Ward, 1963). In addition to the stem attributes, sites were clustered with an euclidean sub-routine, which calculated euclidean point distance squared from the presence or absence of understory species.

The computer program explanation and theoretical bases were derived from Pyott (1972). However, the general methodology attempts to minimize within group variance and maximize between group variance.

Structural Associations

To test the response of selected vertebrates to the variables associated with basal area, downed woody material, herbage standing crop, canopy components, and the distribution of stem sizes; closely associated attributes were clustered. For example, the basal area associations (Fig. 2) were developed by clustering reconnaissance plots based on the percent basal area of overstory species. Clustered groups were classed as treatments and tested with an analysis of the variance (Snedecor and Cochran, 1973). The means associated with significant F tests were delineated with the Least Significant Difference test (Carmer and Swanson, 1973). The .05 probability level was used to accept or reject the null hypothesis of equal class means.

Figure 2. Typical phenogram from which basal treatments were developed for 21 study area stands.

Regression Analysis

A stepwise multiple linear regression was selected as the most efficient analyses of pellet groups and midden counts. Within the analyses, the coefficient of determination (R^2) represents the percent of variation of the Y variable attributed to the model's X variables. In a stepwise deletion, R^2 represents the percent of variation in the Y distribution that is explained by the remaining X variables. In this analyses, Y represents the occurrence of pellet groups or middens. The null hypothesis that the various coefficients are zero was tested using the F-ratio with model and error degrees freedom (df).

To test the distribution of pellet groups in relation to edge, the following model was used:

$$\hat{Y} = b_o + b_1X_1$$

In this model X_1 represents the distance in 15 m intervals from the meadow's edge. The F-ratio and probability level of .05 was used to determine significance.

Meterological Calculations

Normalized monthly temperatures for the Barometer Watershed's climatic station, located in Gilbert Meadows, were developed from long-term averages recorded in the vicinity of Mountain View Wyoming (Climatological Data, Wyoming, 1944-1975 [see Table 6]).

Both the maximum and minimum temperatures were calculated by:

$$E = \frac{(X)\ (Y)}{Z} \quad \text{(Richardson, 1976)}$$

E = the estimated long-term temperature for Gilbert Meadows

X = the short-term average for Gilbert Meadows

Y = the long-term average for Mountain View, Wyoming

Z = the short-term average for Mountain View, Wyoming.

Average snow depths were calculated from two Colorado River snow courses located in the study area (Jeppson et al. 1968).

Diversity Calculations

The following formula (Shannon and Weaver, 1963) was used to calculate floristic and faunistic diversities.

$$H' = \sum_{i=1}^{s} P_i \log P_i$$

This formula is commonly used by avian ecologists because it accounts for: (1) the presence of each species, often referred to as species richness, wherein s is the total number of species.

(2) the relative abundance of each species (P_i), or the proportionality of each species in the community.

High H' values indicate greater diversity and are obtained in cases where more species are present and/or where the individuals are evenly distributed among the species.

A measure of species eveness (J') was calculated from:

$$J' = \frac{H'}{H'max}$$ (Pielou, 1966).

The value of J' varies from 0 to 1, where all species have equal densities. H'_{max} is the $\log_n$ where N is the number of species in the community. Thus at H'_{max} all species are represented by the same proportion of individuals.

Edge diversity was calculated as outlined by Patton (1975).

$$\text{Diversity Index} = \frac{tp}{2\sqrt{A \cdot \pi}}$$

tp = the total stand perimeter

A = the stand area.

The edge diversity can be converted to percent (Percent = [DI - 1] 100) and used to express the percent of perimeter an area has in excess of a circle with the same area. DI represents the diversity index.

RESULTS

Community Types

Habitat types described for the study area by Proctor (1971) are pending a complete analysis. Therefore, reconnaissance plots were grouped into six community types. In addition, minor floristic variations within three community types have been described as phases. A key (Table 49) is provided for community identification and when applicable, communities are tentatively related to habitat types described by Proctor (1971), Pfister (1972), and Steel et al. (1974). Data supportive of these classifications are presented in Appendix D (Tables 55-63). The tree components are summarized in Appendix C (Tables 50-54). Table 64 presents a summary of the overstory, downed woody material, and forage structures associated with each community type.

Populus tremuloides and *Pinus contorta*-*Populus tremuloides* community types

The *Populus tremuloides* (Potr) and *Pinus contorta-Populus tremuloides* (Pico-Potr) communities common to lower elevations are described as two seral communities (Table 55). In the past, when coniferous species replaced *Populus* dominated overstories, ground fuel accumulated, soils dried, and fire prevented the *Abies* climax. Presently, heavy grazing and abundant understories in the *Populus* communities retard the establishment of conifer seedlings, and fire has been virtually eliminated.

Within these communities, the presence of shrubs and conifers were used to delineate community types. Pico-Potr identifies the successful invasion of lodgepole pine into overstories dominated by *Populus*. As crowns develop in length, competition for light intensifies, understory diversity declines, and the total herbage standing crop drops from 51.4 to 40.9 kg/ha (Table 64). As the site dries, downed woody material accumulates (3113 kg/ha to 9420 kg/ha), the duff layer thins, and grass species give way to the shrubs such as *Berberis repens, Juniperus communis,* and *Rosa nutkana.*

Plants common to both communities are *Juniperus communis, Bromus anomalus, Achillea millefolium, Aquilegia caerulea, Astraglus miser, Galium boreale,* and *Lupinus argenteus.*

Plants found only in Pico-Potr are *Berberis repens, Rosa nutkana, Arnica cordifolia, Ergeron peregrinus, Fragaria virginiana,* and *Thalictrum fendleri.*

Pinus contorta community type

Eleven sampled stands represent a successional gradient among pure *Pinus contorta* stands (Tables 56 and 57). Understory vegetation is sparse with *Carex rossii, Poa nervosa, Sitanion hystrix,* and *Solidago decumbens* being the only species common to all sites. These young, heavily stocked pole stands have the shortest trees (11 m). Competition for light is reflected in low herbage biomass (7.5 to 9.7 kg/ha), and minor amounts of browse in the understory vegetation (9%). The soil is covered with a thin layer of duff (2 cm), and little downed woody material exists (6000 to 7200 kg/ha). The plant communities associated with maturing logdepole pine pole stands are described in two phases.

Pinus contorta/Lupine argenteus (Pico/Luar) have total trunk length to total crown length ratios near 36%, basal areas near 2.3 $m^2/375m^2$, and a herbage biomass of 9.7 kg/ha. In this community, light competition among understory plants is reduced.

Pinus contorta/Berberis repens (Pico/Bere) stands have dense crowns, and basal areas near 3.3 $m^2/375m^2$. Twenty-eight is the average number of plant species per m^2. Understory vegetation within both phases reflects the climate of lower elevations.

Pinus contorta/Vaccinium scoparium
community type

Pinus contorta/Vaccinium scoparium (Pico/Vasc) sites produce the largest basal areas (3.6-3.9 $m^2/375\ m^2$) of the *Pinus contorta* dominated forests. Herbage standing crop is low (11.4 to 22.2 kg/ha), and comprised of approximately 27 species per m^2. Species common to all reconnaissance sites are *Vaccinium scoparium, Carex rossii, Poa nervosa, Trisetum spicatum, Arnica cordifolia, Epilobium angustifolium, Fragaria virginiana,* and *Solidago decumbens.* Two phases appear closely associated with slope (Tables 58 and 59). *Pinus contorta/Vaccinium scoparium-Ribes montigenum* appears on level terrain, has taller trees (16 m), crown ratios of 31%, and high stem class diversities. The duff is thin (1.7 cm), downed woody material sparse (5600 kg/ha), and the understory a mixture of graminoids and forbs. *Pinus* regeneration is good, and some *Picea* and *Abies* regeneration occurs. *Pinus* *contorta/Vaccinium scoparium-Vaccinium caespitosum* (Pico/Vasc-Vaca) is found on steeper slopes (15%), and is characterized by an understory mat of *Vaccinium spp.*, shorter trees (12 m), and *Abies* is absent. Duff layers average 1.9 cm, and decomposing woody materials reach levels of 7300 kg/ha. However the presence or absence of *Ribes montigenum* and *Vaccinium caespitosum* is the best way to delineate the two phases.

Pinus contorta/Calamagrostis canadensis community type

Bogs, seeps, and small meadow complexes are sites in which Pico/Caca communities usually are found. Understories are comprised of numerous species, and shrubby *Picea-Abies* regeneration is an important component of the ground cover (Tables 60 and 61). The community canopy coverage is high (59-65%), and moist soil conditions result in rapid decomposition (78% rotten) of large amounts of downed woody material (11,549 to 12,089 kg/ha). Species common to all reconnaissance plots were *Calamagrostis canadensis, Poa nervosa, Trisetum spicatum,* and *Arnica cordifolia*. In addition, *Ribes montigenum, Carex rossii, Achillea millefolium, Fragaria virginiana,* and *Geranium richardsonii* regularly occur in this community.

The more moist sites of this type are identified by *Pinus contorta/Calamagrostis canadensis-Caltha leptosepala* (Pico/Caca-Cale). The diverse understory (mean number of species = 36.6) produces 72.9 kg/ha of predominately forb forage. Trees are tall (16 m) and have relatively uniform stem diameters and crown lengths. The mean crown ratio is 26%. Common species in this community are *Vaccinium caespitosum, Achillea millefolium, Antennaria rosea, Caltha leptosepala,* *Erigeron peregrinus, Fragaria virginiana, Polygonum bistortides, Potentilla gracilis, Trifolium longipes, Viola orbiculala*, and *Zigadenus elegans*.

Pinus contorta/Calamagrostis canadensis-Vaccinium scoparium (Pico/Caca-Vasc) represents the dry phase of the *Calamagrostis* community. In this phase, trees are shorter (14 m) and have longer crowns (ratio 30% of total tree length). However, the absence of *Caltha leptosepala*, and the frequency of shrubs *(Berberis repens, Arctostaphylos uva-ursi*, and *Shepherdia canadensis)* are the indicators of this phase. The average herbage standing crop declines from 73.4 to 19.3 kg/ha, and its composition changes from grass-forb to forb-shrub. Species common to this phase are *Vaccinium scoparium, Carex rossii, Epilobium angustifolium*, and *Solidago decumbens*.

Picea engelmanii-Pinus contorta/
Vaccinium scoparium community

This community type was classified from eight reconnaissance plots sampled above 3000 meters (Table 62). The average slope is 15%. *Pinus contorta* dominates and *Picea engelmanii* is an important overstory component.

Tall mature trees (16 m) with crown ratios near 29% account for the large volume of commercial timber produced. A canopy coverage of 47% facilitates high herbage biomass (63.9 kg/ha) from a community of few species (mean of 17.4 per plot), and low understory diversity. On these well-drained sites, *Vaccinium scoparium* accounts for 92% of the forage, and downed woody material accumulates (6795 kg/ha). *Vaccinium scoparium, Poa nervosa, Trisetum spicatum*, and *Arnica* *cordifolia* are found on all sites. *Juniperus communis, Antennaria rosea, Ergeron peregrinus, Lewisia pygmaea, Pedicularis racemosa,* and *Solidago decumbens* are common to most sites. Pfister (1972) concluded that natural fire and susceptibility of *Abies* to early mortality prevents communities of this type from reaching the *Abies lasiocarpa* climax forest.

Vertebrate Response to Community Types

Mammals

Permanent plot densities. Pellet and midden counts indicate that relatively stable snowshoe hare and red squirrel densities occurred through the study period (Table 7).

Population estimates derived from trapping small mammals did not differ appreciably between years (Table 8). In general, the mammal densities in permanent plots which had not been logged were stable, and significant yearly changes were not observed. Throughout the study, chipmunk densities were significantly higher at the MRI stand that other permanent plots. A general reduction in *P. maniculatus* densities was observed on both clearcut areas. Also apparent is the selection of cutover areas by *E. minimus*.

The seasonal big game densities did not change significantly throughout the study period. It was obvious the importance of these animals in the area occurs during the summer, fall, and early winter (Table 9).

Table 7. Mean densities of small mammals as determined by grid counts for permanent plots (1.1 ha) during the years 1973, 1974, and 1975.

Treatment	Hare Pellets		Red Squirrel Middens	
Year	Spring	Fall	Spring	Fall
1973	2.6	11.9	.07	.36
1974	2.0	8.4	.06	.21
1975	2.1	8.6	.06	.21
Standard Error (s.e.)	.90	4.9	.018	.14

degrees of freedom (treatment/error) 2/30

Table 8. Annual estimate for summer small mammal densities as derived from live trapping on the 1.35 ha control sites between 1972 through 1975 (adjusted for mortality with 95% confidence limits adapted from Chapman, 1948).

Species & Site[1]	Year 1972	1973	1974	1975
E. umbrinus				
GRW	6.1<11.9<20.0	7.5<13.8<24.9	7.3<17.4<19.8	6.9<11.5<17.7
GRE	3.5<8.1<9.5	2.9<6.8<10.9	5.0<6.3<16.6	4.2<7.5<12.2
MRI	21.0<28.1<38.2	23.5<32.4<42.9	25.4<29.2<36.2	23.2<29.8<35.4
BRD[2]		3.2<5.1<12.5		3.2<6.2<15.6
E. minimus				
BRD[2]	31.5<55.2<88.6	25.5<41.8<48.6	28.2<43.8<64.1	
PUS[2]	27.3<49.6<82.2	35.8<50.2<87.9		32.9<52.4<79.6
L. americanus				
GRW		2.4<4.5<7.9	3.1<4.2<7.1	1.6<3.1<5.4
MRI		5.2<10.8<19.3	6.4<9.6<18.3	4.0<8.2<14.7
P. maniculatus				
BRD[2]	11.4<23.2<27.9	11.3<18.2<27.4		5.2<14.6<22.9
PUS[2]	9.8<18.4<26.2	14.2<21.2<30.1		4.1<13.2<24.4

1 Site code found in Appendix G.

2 clearcuts

Table 9. Mean big game pellet groups (groups/ha/day) on the permanent plots for the years 1973, 1974, and 1975.

Treatment	Deer		Elk		Moose	
Year	Spring	Fall	Spring	Fall	Spring	Fall
1973	.036	.142	.011	.130	.013	.058
1974	.030	.091	.020	.093	.015	.037
1975	.014	.133	.019	.095	.015	.038
s.e.	.032	.050	.009	.058	.009	.024

degrees of freedom (treatment/error) 2/30

Small mammal numbers

Table 10 and 11 present summaries of the number of small mammal species trapped within each community and phase. In addition to the standard F test, these data were analyzed with the Kruskal-Wallis Test (Hollander and Wolf, 1973). In both tests, the significant relationships remained the same, and only the calculated F value is reported. Using Kimbal's (1972) frequency of observation classification, three species trapped are listed as occasional, five as uncommon, five as common, and four as abundant.

Of the occasional species (badger, flying squirrel, and pine martin), only the flying squirrel was trapped. Badgers were observed in two stands of the Pico/Caca and Pico/Vasc communities. Pine martin were observed in 16% of the stands representing every community, except those characterized by homogeneous stands of aspen or lodgepole pine. The mean number of flying squirrels trapped in the combined *Pinus contorta/Lupinus argentenus* and *P. contorta/Berberis repens* (chart symbol Pico/) communities was significantly lower than in all other community types (see Table 10). Flying squirrels were trapped in 33 stands, the highest frequency occurring in stands with taller trees, open crowns (percent overstory) and high stem class diversity (Table 64).

Within the study area, the boreal redback vole, porcupine, long-tailed weasel, vagrant shrew, and western jumping mouse are considered uncommon residents. The porcupine was not trapped. However, it was observed in 12 stands representing three community types and four phases.

Table 10. Summary of mean number of small mammals snap-trapped in each community type in the study area.

Species	Potr	Pico-Potr	Pico/Caca	Pico/Vasc	Pico/*	Pien-Pico	F Cal***
	Community Type (Treatment)						
Golden mantled squirrel	1.0	0.0 (.15)**	0.1 (.08)	0.2 (.09)	0.2 (.09)	0.0 (.11)	.641
Boreal redback vole	.	1.3[a](.50)	1.7[a](.20)	1.2[a](.28)	0.6[b](.30)	0.1[b](.35)	3.843***
Least chipmunk	1.0	0.0 (.24)	0.0 (.16)	0.3 (.16)	0.5 (.18)	0.0 (.21)	1.367
Uinta chipmunk	3.0	2.3 (1.5)	5.0 (.85)	5.1 (.88)	1.9 (.96)	3.8 (1.12)	2.219
Northern flying squirrel	2.0	2.3[a](.60)	1.8[a](.37)	2.2[a](.38)	0.3[b](.42)	1.8[a](.49)	3.343***
Snowshoe hare	.	0.3 (.45)	1.3 (.24)	1.3 (.25)	1.2 (.27)	0.8 (.32)	1.354
Long-tailed weasel	.	0.0 (.22)	0.1 (.11)	0.5 (.12)	0.2 (.13)	0.0 (.15)	1.859
Deer mouse	4.0	5.8[a](.88)	1.1[c](.46)	3.0[a](.49)	4.2[a](.53)	1.1[c](.62)	9.714***
Vagrant shrew	.	0.0 (.11)	0.2 (.06)	0.0 (.06)	0.0 (.07)	0.0 (.08)	2.209
Red squirrel	.	0.5 (.55)	1.8 (.29)	1.2 (.30)	1.5 (.33)	0.6 (.39)	2.121
Northern pocket gopher	3.0	1.3[a](.12)	0.0[b](.07)	0.0[b](.07)	0.0[b](.07)	0.0[b](.09)	23.523***
Western jumping mouse	3.0	0.5[a](.08)	0.0[b](.04)	0.0[b](.04)	0.0[b](.05)	0.0[b](.05)	10.350***

* Combined Pico/Luar and Pico/Bere phases.

** Standard Error (s.e.) is found in parenthesis.

*** Significant $P \leq .05$, degrees of freedom (treatment/error) = 4.45.

[a,b,c] denote groups of means which are significantly different.

Table 11. Summary of mean number of small mammals snap-trapped in each community phase in the study area.

Type	Potr	Pico-Potr/	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/	
Phase		Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc	
Species										F Cal*
Citellus lateralis	1.00	.	.	.13	.13	.20	.14	.25	.	.495
(Golden mantled squirrel)	.	.	.	(.11)*	(.11)	(.14)	(.12)	(.16)	.	
Clethrionomys gapperi	.	1.25	1.83[a]	1.63[a]	1.25	1.20	.86	.25[b]	.13[b]	2.26*
(Boreal redback vole)	.	(.51)	(.21)	(.36)	(.36)	(.46)	(.39)	(.51)	(.36)	
Erethizon dorsatum	.	.	T	T	T	.	.	.	T	
(Porcupine)	.	.	.	.	.	.	.	.	.	
Eutamias minimus	1.00	.	.	.	.	.80[a]	.14[b]	1.00[a]	.	2.95*
(Least chipmunk)	1	1	1	1	1	(.24)	(.20)	(.26)	.	
Eutamias umbrinus	3.00	2.25	4.50	5.38	6.63	2.60	1.57	2.50	3.75	2.17
(Uinta chipmunk)	.	(1.54)	(1.26)	(1.09)	(1.09)	(1.38)	(1.17)	(1.54)	(1.09)	
Glaucomys sabrinus	2.00	2.25[a]	1.00[b]	2.38[a]	3.13[a]	.60[b]	.14[b]	.50[b]	1.75	5.21*
(Northern flying squirrel)	.	(.60)	(.48)	(.42)	(.42)	(.53)	(.45)	(.60)	(.42)	
Lepus americanus	.	.25	.83	1.63	1.13	1.20	1.43	.75	.75	1.40
(Snowshoe hare)	.	(.44)	(.36)	(.31)	(.31)	(.40)	(.34)	(.44)	(.31)	
Martes american	.	T	T	T	T	.	.	.	T	
(Pine martin)	.	.	.	.	.	.	.	.	.	
Marmota flaviventris	.	.	.	.	.	T		T	T	
(Yellowbelly marmot)	.	.	.	.	.	.	.	.	.	
Mephitis mephistis	T	T	.	.	.	.	.	.	.	
(Striped skunk)	.	.	.	.	.	.	.	.	.	
Mustela frenata			.17	.13	.50	.40	.14	.25	.	1.05
(Longtailed weasel)	.	.	(.18)	(.15)	(.15)	(.20)	(.17)	(.23)	.	
Peromyscus maniculatus	4.00	5.75[b]	.67[a]	1.38[a]	3.00[b]	3.00[b]	3.86[b]	4.75[b]	1.13[a]	5.49*
(Deer mouse)	.	(.89)	(.73)	(.63)	(.63)	(.80)	(.68)	(.89)	(.63)	
Sorex vagrant	.	.	.	.38	.	.	.	.	.	3.02*
(Vagrant shrew)	.	.	.	(.07)	.	.	.	.	.	
Tamiasciurus hudsonicus	.	.50	1.83	1.75	1.13	1.40	1.43	1.75	.63	1.20
(Red squirrel)	.	(.57)	(.46)	(.40)	(.40)	(.51)	(.43)	(.57)	(.39)	
Taxidea taxus	.	.	.	.	T	.	T	.	.	
(Badger)	.	.	.	.	.	.	.	.	.	

Table 11. Continued

Type	Potr	Pico-Potr/	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/	
Phase		Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc	
Species										F Cal*
Thomomys talpoides	.	1.25	.	.	.	.	.	.	.	12.54*
(Northern pocket gopher)	.	(.13)	.	.	.	.	.	.	.	
Zapus princeps	3.00	.50	.	.	.	.	.	.	.	5.52*
(Western jumping mouse)	.	(.08)	.	.	.	.	.	.	.	
Total species	8	10	9	11	11	10	10	10	9	
Trap nights ***	320	1280	1920	2560	2560	1600	2240	1280	2560	

Community (Treatment)

T only observed on the reconnaissance plots.

* Standard Error (s.e.).

** Significant P $\leq .05$, degrees of freedom (treatment/error) 7/42.

*** Total trap nights = 16,320.

a,b denote groups of means which are significantly different.

The boreal redback vole was trapped in every phase except those associated with homogeneous aspen stands. Considerably more boreal redback voles were trapped in the Pico-Potr, Pico/Caca, and Pico/Vasc community types (see Table 10). With the exception of the Caca-Vasc phase, the number of voles trapped in the Caca-Cale phase was significantly higher than in the other phases. Boreal redback voles occurred in 30 stands.

Long-tailed weasels were trapped in nine stands. With the exception of the aspen communities and stands at higher elevations, this species' abundance appeared to be constant throughout the community types and phases.

The vagrant shrew was trapped in three stands and was restricted to the Pico/Caca-Vasc community phase.

The western jumping mouse occurred in three stands associated with aspen communities.

Kimbal (1972) lists the golden-mantled squirrel, yellowbelly marmot, striped skunk, snowshoe hare, and red squirrel as common species. Of these species, the striped skunk was observed in two stands associated with aspen communities. The yellowbelly marmot was observed on three of the drier sites which were in close proximity to rock outcroppings or ridge tops. The golden-mantled squirrel was trapped in five stands, representing five lodgepole pine phases found at intermediate elevations.

Comparisons between the number of snowshoe hares and red squirrels trapped in each community were not statistically different; however, distinct differences in community densities were indicated by pellet and midden counts (Tables 12 and 13). Based on plot counts, the distribution of hares and squirrels are similar, with significantly lower densities occurring in the aspen communities and Pien-Pico stands located at higher elevations. In addition, when comparing the rank order between means calculated from trapping and count data, only minor discrepancies exist.

Snowshoe hares were trapped in 35 stands. The highest frequency of hares in the phases dominated by lodgepole pine overstories is attributed to the abundance of hares in the Caca-Vasc, Vasc-Vaca and Pico/Luar communities (see Table 13).

The apparent preference of the red squirrel for the Pico/ (combined Pico/Luar and Pico/Bere phases), Pico/Caca, and Pico/Vasc types results from significant midden numbers in the Pico/Luar, Caca-Vasc, Caca-Cale, and Vasc-Vaca phases. Red squirrels were trapped in 71% of the stands.

The northern pocket gopher, deer mouse, and least and Uinta chipmunks are considered abundant species. The northern pocket gopher was trapped in every stand containing aspen. With the invasion of conifers into aspen overstories, significant reductions in gopher numbers occur (see Table 11).

The deer mouse was found in 84% of the stands. Significant reductions of its numbers occurred on the moist (Caca-Cale) and higher (Pien-Pico) sites. Deer mice were most commonly trapped in the aspen-lodgepole communities. However, they occurred in every stand of the following phases: Potr/Bere, Vasc-Vaca, Pico/Luar, and Pico/Bere.

Table 12. Summary of snowshoe hare pellets and red squirrel middens counted in each community type (mean number/ .0004 ha).

Community Type (Treatment)	Mean Number	
	Snowshoe Hare Pellets	Red Squirrel Middens
Potr	1.0	0.0
Pico-Potr	5.5[b] (2.84)**	0.1[c] (.26)
Pico/Caca	12.3[a] (1.04)	0.7[b] (.10)
Pico/Vasc	8.1[b] (1.02)	0.6[b] (.09)
Pico/	13.0[a] (1.06)	0.9[a] (.10)
Pien-Pico	6.2[b] (1.21)	0.5[b]
Calculated F	7.09*	3.57*

* Significant $P \leq .05$ degrees of freedom (treatment/error) 4/456.

** Standard Error (s.e.)

a, b, c denotes groups of treatment means which are significantly different.

Table 13. Summary of snowshoe hare pellets and red squirrel middens counted in each community phase (mean number/.0004 ha).

Treatment	Mean Number	
Community Phase	Snowshoe Hare Pellets	Red Squirrel Middens
Potr	1.0	.00
Pico-Potr	5.5^{c}(2.3)**	$.12^{c}$(.26)
Pico/Caca-Cale	9.9^{b}(1.9)	$.72^{b}$(.18)
Pico/Caca-Vasc	13.1^{a}(1.2)	$.73^{b}$(.11)
Pico/Vasc-Rimo	9.1^{b}(1.2)	$.58^{b}$(.11)
Pico/Vasc-Vaca	12.9^{a}(1.9)	$.72^{b}$(.17)
Pico/Luar	14.4^{a}(1.2)	1.05^{a}(.11)
Pico/Bere	6.1^{c}(1.9)	$.66^{b}$(.18)
Pien-Pico/Vasc	6.2^{c}(1.2	$.48^{b}$(.11)
Calculated F	6.53*	2.58*

* Significant at P $\leq$.05, degrees of freedom (treatment/error) 7/456.

** Standard Error (s.e.)

^{a,b,c} denote groups of treatment means which are significantly different.

The two chipmunk species were trapped in community stages characteristic of early and late lodgepole pine succession. The least chipmunk is common in early successional stages and abundant in the early (15 years) regeneration of clearcuts (Table 14). Once tree growth exceeds 5 m, numbers of this species diminish rapidly. While the number of Uinta chipmunks did not differ significantly between community types or phases, the highest number occurred in older stands with opening canopies. Twice as many Uinta chipmunks were trapped in the smaller clearcuts as compared to those trapped in the larger cuts (see Table 14).

The relationship between community classification and big game utilization is presented in Tables 15 and 16. Most moose use occurs in communities with aspen. These communities sustain from 5 to 50 times more use by moose than do the other communities. Small bogs with patches of willow, which are part of the Caca-Cale phase at intermediate elevations and the Pien-Pico/Vasc community at higher elevations are also important to moose.

The major elk use in the area occurred in the Pien-Pico community, particularly near large meadows or wallow sites. Little or no elk use was found in homogeneous aspen stands or the Pico/Bere phase.

Summer deer use concentrates in the Potr/Bere and Caca-Cale phases. The small amount of deer use that was observed in the Potr community is probably an artifact of insufficient sampling.

Table 17 summarizes the scent post visitations by the coyote *(Canis latrans)* and by bobcat and lynx *(Lunx spp.)*. With the exception of the aspen communities, coyote visitations at scent post groups

Table 14. Mean number of *Eutamias spp*. trapped in two sizes of clearcuts.

Species	Clearcut Size (ha)	
	< 2.5 ha	>100.0 ha
Eutamias minimus (least chipmunk)	5.5[a] (1.02)**	4.0[b] (1.12)
Eutamias umbrinus (Uinta chipmunk)	3.5[a] (.82)	1.6[b] (.53)
F calculated	5.64*	5.82*

* Significant at $P \leq .05$, degrees freedom (treatment/error) 1/8.

** Standard Error (s.e.)

a,b, denote groups of treatment means which are significantly different.

Table 15. Summary of big game pellet groups counted in each community type in the study area (mean number/.0004 ha).

Treatment		Mean Number	
Community Type	Moose	Elk	Mule Deer
Potr	2.00	0.00	0.03
Pico-Potr	1.56[a](.17)**	0.63[b](.14)	0.88[a](.15)
Pico/Caca	0.18[b](.06)	0.39[c](.08)	0.28 (.05)
Pico/Vasc	0.13[b](.06)	0.72[b](.08)	0.19[c](.05)
Pico/	0.26[b](.06)	0.63[b](.09)	0.36[b](.06)
Pien-Pico	0.34[b](.07)	1.02[a](.01)	0.33[b](.06)
Calculated F	16.86*	5.71*	5.25*

* Standard Error (s.e.)

** Significant at $P \leq .05$, degrees of freedom (treatment/error) 4/459.

[a,b,c] denote groups of treatment means which are significantly different.

Table 16. Summary of big game pellet-groups counted in each community phase in the study area (mean number/.0004 ha) community reconnaissance plots.

	Big Game Species		
Phase (Treatment)	*Alces alces* (moose)	*Cervus canadensis* (elk)	*Odocoileus hemionus* (mule deer)
Potr	2.00	0.00	0.03
Pico-Potr/Bere	1.56[a](.17)**	0.63[b](.23)	0.88[a](.14)
Pico/Caca-Cale	0.28[b](.12)	0.66[b](.17)	0.63[b](.10)
Pico/Caca-Vasc	0.15[b](.07)	0.30[c](.10)	0.16[d](.06)
Pico/Vasc-Rimo	0.15[b](.07)	0.75[b](.10)	0.18[d](.06)
Pico/Vasc-Vaca	0.08[c](.11)	0.63[b](.16)	0.19[d](.06)
Pico/Luar	0.30[b](.07)	0.86[b](.10)	0.35[c](.06)
Pico/Bere	0.16[b](.12)	0.03[c](.17)	0.41[c](.10)
Pien-Pico/Vasc	0.34[b](.07)	1.02[a](.10)	0.33[c](.06)
Calculated F	9.93*	6.54*	5.21*

* Significant at $P \leq .05$, degrees of freedom (Treatment/error) 7/456.
** Standard error.
[a,b,c,d] denote groups of treatment means which are significantly different.

Table 17. *Canis latrans* and *Lynx spp.* scent post visitations for each community type in the study area.

	Percent of Scent Groups Visited	
Community	*Canis latrans*	*Lynx spp.*
Potr	0	0
Pico-Potr	0	0
Pico/Caca*	50%	50%
Pico/Vasc*	88%	50%
Pico/**	50%	0
Pien-Pico	75%	12%
Regenerating cut	100%	0

* Remains of snowshoe hare in winter pelage located in plot counts.

** Combined phases of *Pinus contorta/Lupine argentenus* and *P. contorta/Berberis repens*.

were unrelated to community type. Coyote calls heard and visual observations throughout the study area support the scent post trends.

Scent post visitations by *Lynx spp.* corresponded to sites with larger basal areas and the development of a secondary spruce and fir overstory. In addition, the remains of snowshoe hare in winter pelage were observed in these communities. The observation of one *Lynx spp.* (MRI stand) occurred during the twilight hours and positive identification could not be made.

Avian fauna

Avian species nomenclature follows Behle and Perry (1975). Thirty-seven bird species were encountered in 50 stands and three clearcuts (Table 18). Thirty-two percent of the bird species appeared in only one community phase. Less than 62% of the species occurred in four phases, and no bird species was observed in every phase.

The common nighthawk *(Chordeiles minor* [Forester]), and red-tailed hawk (*Buteo jamaicensis* [Gmelin]), were observed only in clearcut areas. Tree swallows (*Iridoprocne bicolor* [Vieillot]) and common flickers (*Colaptes auratus* [Linnaeus]) occurred only in clearcuts and stands with aspen as a major overstory species.

Bird species found only in mixed coniferous-aspen stands were fly catcher *(Empidonax)*, western wood pewee (*Contopus sordidulus* [Sclater]), house wren (*Troglodytes aedon parkmanii* [Audubon]), warbling vireo (*Vireo gilvus* [Vieillot]), yellow warbler (*Dendrocia petechia* [Linneaus]), yellow-bellied sapsucker, (*Sphyrapicus varius nuchalis* [Baird]), and saw-whet owl (*Aegolius acadicus acadius [Gmelin]).*

Table 18. Importance values for birds observed in various community phases within the Barometer Watershed, Mountain View Ranger District, Utah.

Community Type Phase	Pico-Potr/	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/	
	Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc	Clearcut
Trophic Level -Species									
Primary Consumer									
Clark's nutcracker	.	.	.	.	.	.	.	16.2	.
Gray jay	.	8.4	11.5	23.2	22.0	40.1	29.4	15.8	23.1
Pine grosbeak	.	16.1	11.0	12.6	9.3	7.0	.	24.9	6.4
Pine siskin	.	.	18.2	8.3	.	14.0	21.1	10.2	.
Red crossbill	.	.	.	.	.	.	6.5	.	.
Cassin's finch	8.9	.	10.1	.	18.6	26.1	22.0	.	12.5
Gray-headed junco	.	22.7	23.4	36.4	54.1	31.8	29.3	33.7	21.5
White-crowned sparrow	4.2	9.3	.	.	.	.	.	4.2	.
Total Species	2	4	5	4	4	5	5	6	4
Secondary Consumer									
Common nighthawk	.	.	.	.	.	.	.	.	14.1
Empidonax spp.	8.4	.	.	.	.	.	.	.	.
Tree swallow	20.4	.	.	.	.	.	.	.	10.4
Western wood pewee	16.9	.	.	.	.	.	.	.	.
Audubon's warbler	.	14.5	11.9	.	28.7	19.1	8.3	12.3	.
House wren	8.9	.	.	.	.	.	.	.	.
Ruby-crowned kinglet	.	12.4	11.0	10.2	9.3	.	.	10.9	.
Western tanager	5.4	19.2	.	14.1	.	10.9	.	.	.
Warbling vireo	13.2	.	.	.	.	.	.	.	.
Yellow warbler	14.4	.	.	.	.	.	.	.	.
Hairy woodpecker	.	13.7	7.8	9.7	.	.	17.5	3.5	.
Williamson's sapsucker	5.4	10.5	.	.	.	.	.	.	.
Yellow-bellied sapsucker	16.1	.	.	.	.	.	.	.	.
Brown creeper	.	6.0	11.0	9.3	.	.	.	7.0	.
Mountain chickadee	.	24.6	24.2	10.6	22.8	14.0	19.2	22.4	.
Red-breasted nuthatch	.	4.0	7.4	.	.	.	.	6.3	.
American robin	23.5	22.5	6.5	15.1	10.1	15.3	.	25.3	22.2
Chipping sparrow	18.6	14.1	21.9	.	16.8	15.9	.	8.4	17.5

Table 18. Continued

	Importance Value*								
Community Type Phase	Pico-Potr/	Pico/Vasc		Pico/Vasc		Pico/		Pien-Pico/	Clearcut
	Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc	
Common flicker	13.2	.	.	.	.	.	.	.	7.7
Hermit thrush	.	9.3	12.8	10.2	.	.	.	.	.
Mountain bluebird	11.9	.	.	24.2	.	.	12.8	.	21.2
Townsend's solitaire	.	.	.	.	8.4	.	22.0	.	14.1
Vesper sparrow	.	.	.	.	.	.	11.9	.	26.6
Broad-tailed hummingbird	7.7	3.2	.	.	.	.	.	.	.
Goshawk	.	.	8.3	.	.	.	.	.	.
Great horned owl	.	.	2.8	3.9	.	.	.	.	.
Red-tailed hawk	.	.	.	.	.	.	.	.	13.4
Saw-whet owl	2.9	.	.	.	.	.	.	.	.
Sharp-shinned hawk	.	.	.	.	.	5.8	.	.	6.4
Total Species	15	12	11	9	6	6	6	8	10
GRAND TOTAL	17	16	16	13	10	11	11	14	14

* Importance value = relative density + relative frequency (After Bond, 1957).

Observations of the Clark's nutcracker (*Nucifraga cyanocephalus* [Wied]) were confined to the Pien-Pico/Vasc community. Red crossbills (*Loxia curvirostra* [Linnaeus]) were observed only in the Pico/Bere phase.

Major differences in the numbers of hairy woodpeckers (*Dendrocopos villosus* [Linnaeus]), mountain bluebirds (*Sialia currucoides* [Bechstein]), and American robins (*Turdus migratorius propinquus* [Ridway]) were found between community types (see Table 18). The number of hairy woodpeckers was noticeably higher in the Caca-Cale and Pico/Bere phases than in other phases. The largest numbers of mountain bluebirds were observed in the Vasc-Rimo phase and clearcut areas. Fewer robins were observed in the Caca-Vasc, Vasc-Rimo, Vasc-Vaca, and Pico/Luar phases. The Pico/Bere phase was the only phase in which robins were not observed.

Important differences in the numbers of gray jays (*Periosorius canadensis capitalis* [Ridway]) and pine grosbeaks (*Pinicola enucleator montana* [Ridway]) were found in the Pico/Luar and Pico/Vasc phases. When compared to the overall mean, the importance values for gray-headed juncos (*Junco caniceps caniceps* [Woodhouse]) and Audubon's warblers (*Dendrocica coronata auduboni* [Linnaeus]) were approximately 50% higher in the Vasc-Vaca phase. The Cassin's finch (*Carpodacus cassinii* [Baird]) was most common in the pole stand communities. Townsend's solitaires (*Myadestes townsendi townsendi* [Audubon]) and vesper sparrows (*Pooecetes gramineus* [Gmelin]) were found only on clearcuts and areas with early stages of pole stand development.

The occurrence of pine siskins (*Spinus pinus* [Wilson]) and ruby-crowned kinglets (*Regulus calendula* [Linnaeus]) was confined to five coniferous communities. Kinglets were not observed in Pico/Luar and Pico/Bere communities while siskins were important in these communities. Mountain chickadees (*Parus gambeli* [Ridway]) were observed in every coniferous community. However, the largest numbers appeared in the Pico/Caca and Pien-Pico communities. In addition, the red-breasted nuthatch (*Sitta passerina* [Bechstein]) was observed only in the Pico/Caca and Pien-Pico communities. Brown creepers (*Certhia familiaris* [Linnaeus]) were associated with communities characterized by average basal areas (3.1 - 3.9 $m^2/375m^2$) and lower crown ratios (26 to 31%).

Of the three raptors that were observed within coniferous overstories, only the sharp-shinned hawk (*Accipiter striatus velox* [Wilson]) was observed on clearcuts and in the Pico/Luar phase. Goshawks (*Accipiter gentilis atricapillus* [Wilson]) appeared only in the Caca-Vasc phase, while great horned owls (*Bubo virginianus* [Gmelin]) were observed in this phase and the Vasc-Rimo phase.

Broad-tailed hummingbirds (*Selasphorus platycerus platycerus* [Swainson]) and Williamson's sapsuckers (*Sphyrapicus thyroideus nataliae* [Malherbe]) were observed in the Potr/Bere and Caca-Cale phases. The chipping sparrow (*Spizella passerina* [Bechstein]) was present in every community except the Vasc-Rimo and Pico/Bere phases. Observations of the hermit thrush (*Catharus guttafus*[Pallas]) were limited to the Pico/Caca and Vasc-Rimo communities. The white-crowned sparrow (*Zonotrichia leucophrys* [Forster]) associated with the moist sites of the Potr/Bere, Caca-Cale, and Pico/Vasc communities. The western tananger (*Piranga ludoviciana* [Wilson]) was most abundant in the Caca-Cale and Vasc-Rimo phases.

A summary of bird species by Salts' (1957) feeding categories is presented in Table 19.

More bird species were observed in the mixed coniferous-aspen communities than any other phase type. Among the coniferous overstories, larger numbers of bird species were associated with taller trees (13 to 16 m), dense overstories (59-65%), low crown ratios (26-30%), and stem basal area diversities between 3.13 and 3.62 (see Tables 20 and 60). Stands with shorter trees (10.7 to 11.9 m), canopy coverages between 54 and 59%, high crown ratios (39-51%), and stem basal area diversities of 2.88 to 2.97 had fewer bird species.

Twelve percent of the bird species in the Pico-Potr communities were primary consumers. Forty-five percent of the bird species in the Pico/Luar and Pico/Bere communities were considered primary consumers (see Table 19). Throughout the other communities, including the clearcuts, approximately 31% of the bird species listed are primary consumers.

Raptors were most abundant in clearcuts.

Avian diversity

Figure 3 presents the overall relationship between the understory plant species diversity and bird species diversity. In general, more diverse understory communities are associated with more diverse avian communities.

Significant differences in bird diversities were noted between phase types. However, the statistic J' (species eveness) did not differ appreciably between community phases (Table 20). With the

Table 19. The number of bird species in the various feeding categories (Salt, 1957) in each plant community type within the Barometer Watershed, Mountain View Ranger District, Utah.

	Pico-Potr	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/	Clearcuts
Feeding Category	Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc	
Foliage-seed	.	2	3	3	2	3	3	4	2
Ground-seed	2	2	2	1	2	2	2	2	2
Nectar-feeding	1	1	.	.	.	.	.	.	.
Air-soaring	3	.	.	.	.	.	.	.	.
Foliage-insect	4	3	2	2	2	2	1	2	.
Timber-drilling	2	2	1	1	.	.	1	1	.
Timber-searching	.	3	3	2	1	1	1	3	.
Ground-insect	4	3	3	3	3	2	3	2	6
Raptor	1	.	2	1	.	1	.	.	2
No. of Species	17	16	16	13	10	11	11	14	14

Table 20. Bird diversity index and distribution of bird species (J') for each community phase.

	Pico-Potr	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/		
Diversity Index	Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc	Clear-cuts	F Cal.
H'	3.33^{a}	2.53^{a}	2.08^{b}	2.02^{b}	1.89^{b}	1.62^{b}	1.95^{b}	2.13^{b}	2.73^{a}	4.26*
J'	0.95	0.94	0.89	0.88	0.96	0.90	0.93	0.92	0.94	0.83

* Significant F value ($P \leq .05$)

^{a,b} denote groups of means which are significantly different ($P \leq .05$).

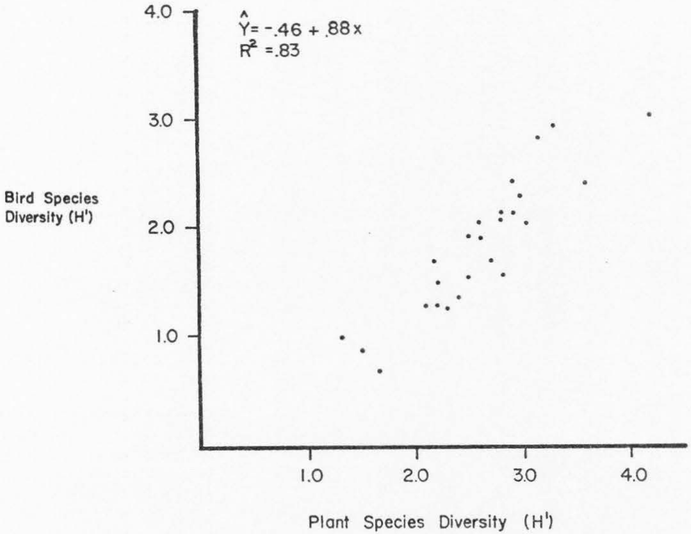


Figure 3. The relationship between understory plant species diversities and bird species diversity for reconnaissance in 1974.

exception of the Caca-Cale phase, high diversity indices (H') were associated with clearcuts and coniferous-aspen overstories. The high diversity of the Caca-Cale phase is attributed to the abundance of plants associated with moist sites.

Vertebrate Response to Community Structures

Mammals

In order to relate fauna to structures common to all plant communities, reconnaissance sites were organized into related groups by cluster analysis. For example, the basal area cluster (see Fig. 2) depicts intersite relationships, based on the amount each coniferous species contributes to the total basal area. Sites were placed in classes (treatments) based on major changes in the coefficients of similarity. These ranged from 70 to 95%. Obviously, dissimilar stands were eliminated prior to the development of a treatment class. Table 21 presents a summary of significant changes in the numbers of selected mammal species as they relate to various structural classes.

Basal area

Of all the small mammal species trapped, only the number of Uinta chipmunks noticeably varied between basal area classes (Table 22). A significant number of Uinta chipmunks were trapped in the intermediate basal area class (3.3 $m^2/375m^2$). The abundance trends of the boreal redback vole and flying squirrel were similar to that of the Uinta chipmunk. The density of these species generally increased until the basal area exceeded 3.3 $m^2/375m^2$. The opposite response

Table 21. Recapitulation of statistically significant mammal response to structural classes developed from cluster analyses of site parameters.

	Type of Community Structure					
	Basal Area	Fuel (Height)	Herbage (kg)	Canopy	Downed Woody	Plant
<u>Species</u> (trapped)						
Boreal redback vole					+	+
Uinta chipmunk	+			+	+	+
Northern flying squirrel				+	+	+
Deer mice					+	+
<u>Species</u> (plot counts)						
Snowshoe hare	+	+	+	+		+
Red squirrel			+			+
Mule deer		+	+			+
Elk	+	+	+	+	+	+
Moose	+	+		+		+
Similarity index*	95%	85%	65%	95%	70%	95%
Number of classes (treatments)	5	4	6	6	4	5

+ Significant F test ($P \leq .05$).

* Coefficient of similarity at class cutoff.

Table 22. The relationship between the numbers of small mammals trapped on the reconnaissance plots (0.6 ha) and tree basal area classes.

	Basal Area Classes ($m^2/375m^2$)					
	2.5 (9)*	3.0 (12)	3.3 (11)	3.6 (10)	3.8 (8)	Cal F
Species						
Boreal redback vole	.88	1.08	1.18	1.10	1.00	.089
	(.38)**	(.33)	(.35)	(.37)	(.40)	
Least chipmunk	.67	.00	.00	.10	.25	2.338
	(.19)	(.16)	(.17)	(.18)	(.20)	
Uinta chipmunk	3.00[b]	3.25[b]	6.54[a]	3.70[b]	2.63[b]	2.620***
	(1.04)	(.90)	(.94)	(.99)	(1.11)	
Northern flying squirrel	1.11	1.50	2.36	1.60	1.13	1.158
	(.50)	(.43)	(.45)	(.46)	(.53)	
Deer Mice	3.22	2.00	1.64	2.70	4.25	2.058
	(.73)	(.63)	(.66)	(.70)	(.78)	

* Number of reconnaissance sites included in each class.

** Standard Error (s.e.).

*** Significant at $P \leq .05$, degrees of freedom (treatment/error) 4/45.

[a,b] denote groups of means which are significantly different.

response was found in the number of deer mice trapped. Deer mice appear to be closely associated with the early and late stages of basal area development. The least chipmunk was most frequently trapped at sites with low basal areas. This finding was consistant with the close association this species has with regenerating lodgepole pine. The relative abundance of snowshoe hares and red squirrels was reported from both trapping data and pellet or midden counts (Table 23).

Comparative trends between the abundance estimates calculated from the two methods were similar. However, only significant class differences were found in the abundance of snowshoe hares. The highest hare densities were associated with basal areas above 3.6 $m^2/375m^2$. Basal area alone did not appear to be a significant criterion for red squirrel stand selection.

The presence of elk and moose was related to basal area (Table 24). Mule deer numbers did not differ appreciably among basal area classes. The largest number of elk pellet groups were associated with the 3.6 $m^2/375m^2$ basal area class. Among coniferous overstories, the highest moose use occurred on sites with basal areas less than 3.3 $m^2/375m^2$.

Fuel height

The mean number of small mammals trapped did not significantly differ between fuel height class means (Table 25).

Observation of the general trends suggests boreal redback vole numbers increased with deep fuel depths, while numbers of least chipmunks and red squirrels declined.

Table 23. The relationship between the number of snowshoe hare and red squirrels trapped on the reconnaissance plots (0.6 ha) and tree basal area classes.

	Basal Area Classes ($m^2/375m^2$)					
	2.5 (9)*	3.0 (12)	3.3 (11)	3.6 (10)	3.8 (8)	Cal F
Species						
Snowshoe hare						
Trapped (df 4/459)	1.11 (.31)**	.92 (.27)	.82 (.28)	1.30 (.29)	1.25 (.33)	.512
Pellet counts (df 4/459)	8.82[c] (1.15)	7.64[c] (1.05)	7.47[c] (1.18)	16.42[a] (1.15)	11.94[b] (1.41)	8.549***
Red squirrel						
Trapped (df 4/45)	1.13 (.39)	1.08 (.34)	1.36 (.36)	1.20 (.37)	1.63 (.42)	.279
Midden counts (df 4/459	.73 (.11)	.68 (.10)	.59 (.11)	.74 (.11)	.92 (.13)	1.011

* Number of reconnaissance sites included in each class.

** Standard Error (s.e.).

*** Significant at $P \leq .05$, df = degrees of freedom (treatment/error).

a,b,c denote groups of means which are significantly different.

Table 24. The relationship between big game pellet counts on reconnaissance plots (0.6 ha) and tree basal area classes.

	Basal Area Classes ($m^2/375m^2$)					
	2.5 (9)*	3.0 (12)	3.3 (11)	3.6 (10)	3.8 (8)	Cal F
Species						
Mule deer	.36 (.06)**	.28 (.06)	.30 (.06)	.34 (.06)	.23 (.76)	.656
Elk	.68[b] (.10)	.77[b] (.11)	.56[b] (.10)	1.00[a] (.10)	.19[c] (.11)	8.085***
Moose	.36[a] (.17)	.37[a] (.07)	.28[a] (.08)	.11[b] (.07)	.13[b] (.09)	2.812***

* Number of reconnaissance sites included in each class.

** Standard Error (s.e.).

*** Significant at $P \leq .05$, degrees of freedom (treatment/error) 4/459.

a,b,c denote groups of means which are significantly different.

Table 25. The relationship between the number of small mammal species trapped on the reconnaissance plots (0.6 ha) and the height of downed woody material in the study area.

	Height Classes of Downed Woody Material (cm)				
	11 (20)*	18 (15)	28 (7)	72 (6)	Cal F
Species					
Boreal redback vole	.3 (.44)**	.8 (.28)	1.3 (.24)	1.1 (.41)	1.50
Least chipmunk	.5 (.24)	.3 (.15)	.1 (.13)	.0 (.23)	1.42
Uinta chipmunk	3.5 (1.40)	5.1 (.88)	3.6 (.76)	3.4 (1.3)	.69
Northern flying squirrel	1.5 (.40)	1.5 (.63)	1.7 (.35)	1.9 (.50)	.09
Deer mice	2.5 (.96)	2.2 (.61)	3.2 (.53)	2.1 (.89)	.59
Red squirrel	1.5 (.47)	1.6 (.29)	1.3 (.26)	.6 (.44)	1.34

* Number of class observations.

** Standard Error (s.e.).

The accumulation of downed woody material has a positive effect upon the number of snowshoe hare, mule deer, elk, and moose (Table 26). These species increased significantly as fuel depths approached 28 cm. However, hare and deer pellet counts declined above this level, suggesting there are optimum fuel heights for these species. Trapping results support this conclusion. Approximately twice (1.7) as many hares were caught in the 28 and 72 classes.

Herbage biomass

Of the small mammals trapped only the numbers of red squirrels varied significantly between forage classes (Table 27). This species was most abundant on sites where the total herbage biomass was low and dominated by forb species. Midden counts substantiate this finding. The abundance trends of deer mice and the least chipmunk were similar to red squirrel trends. Boreal redback vole numbers tend to increase with the production of grass and forbs. Snowshoe hares were most numberous among herbage classes with below average production and consisting predominately of forbs, with similar amounts of grass and browse.

The distribution of deer and elk pellet groups was significantly different between herbage class means (see Table 27). Deer groups were most abundant in classes characterized by high herbage biomass dominated by grass and forb species. Elk groupings were associated with high browse species biomass.

Table 26. Snowshoe hare, mule deer, elk, and moose abundance as related to fuel heights within the study area (based on reconnaissance plot pellet counts).

	Height Classes of Downed Woody Material (cm)				
	11 (172)*	18 (140)	28 (84)	72 (52)	Cal F
Species					
Snowshoe hare	6.0[b] (1.5)**	8.2[b] (.9)	13.3[a] (.8)	7.1[b] (1.2)	10.91***
Mule deer	.23[b] (.08)	.29[b] (.05)	.44[a] (.05)	.15[b] (.07)	4.85***
Elk	.29[b] (.13)	.49[b] (.08)	.89[a] (.07)	.76[a] (.10)	7.78***
Moose	.33[b] (.10)	.26[b] (.06)	.37[b] (.06)	.59[a] (.08)	3.65***

* Number of class observations.

** Standard Error(s.e.).

*** Significant $P \leq .05$, degrees of freedom (treatment/error) 3/444.

a,b,c denote groups of means which are significantly different.

Table 27. The relationship of the herbage structures to mammal abundance on the reconnaissance plots (0.6 ha).

	Herbage Structure Classes						
	1	2	3	4	5	6	Cal F
Component Parts * (kg/ha)							
Number of observations	14	3	14	3	3	12	
Grass	6.92	19.27	2.70	.42	5.14	2.20	6.91***
	(1.34)**	(2.90)	(1.34)	(2.90)	(2.53)	(1.45)	
Forbs	18.63	65.11	5.75	4.22	1.65	3.29	109.22***
	(1.21)	(2.61)	(1.21)	(2.61)	(2.26)	(1.30)	
Browse	5.21	4.09	2.61	.97	3.91	42.16	13.08***
	(3.84)	(8.32)	(3.84)	(.83)	(7.10)	(4.15)	
Total	30.80	88.50	11.10	5.60	10.70	47.70	
Animal Species (trapped)							
Boreal redback vole	1.28	1.66	1.36	.67	.59	.58	1.237
	(.29)	(.63)	(.29)	(.64)	(.55)	(.32)	
Least chipmunk	.21	.00	.21	.66	.00	.08	.584
	(.16)	(.35)	(.16)	(.35)	(.30)	(.18)	
Uinta chipmunk	3.43	4.00	4.57	2.33	4.00	4.08	.288
	(.92)	(1.99)	(.92)	(1.99)	(1.72)	(.99)	
Northern flying squirrel	1.28	2.33	1.57	.66	3.00	1.50	1.210
	(.40)	(.86)	(.40)	(.86)	(.74)	(.43)	
Snowshoe hare	1.00	.33	1.43	.66	.75	1.08	1.061
	(.24)	(.53)	(.24)	(.53)	(.45)	(.26)	
Deer mice	2.64	3.33	3.00	4.66	3.25	1.33	1.504
	(.60)	(1.29)	(.60)	(1.29)	(1.17)	(.65)	
Red squirrel	1.14[b]	1.00[b]	1.57[b]	3.33[a]	1.00[b]	.83[b]	3.156***
	(.28)	(.60)	(.28)	(.60)	(.52)	(.30)	
Animal Species (plot counts)							
Number of observations	116	20	144	20	40	124	df 5/458
Snowshoe hare	10.70[b]	5.80[c]	13.06[a]	6.70[c]	6.07[b]	8.13[b]	4.641***
	(1.06)	(2.56)	(.95)	(2.56)	(1.81)	(1.03)	
Red squirrel	.79[b]	.70[b]	.72[b]	1.90[a]	.58[b]	.59[b]	2.35***
	(.10)	(.23)	(.09)	(.23)	(.17)	(.09)	
Deer	.35[b]	1.10[a]	.18[b]	.30[b]	.20[b]	.31	9.219***
	(.05)	(.13)	(.05)	(.13)	(.09)	(.05)	
Elk	.78[a]	.45[b]	.40[b]	.25[b]	.65[b]	.98[a]	6.374***
	(.08)	(.21)	(.29)	(.21)	(.15)	(.08)	
Moose	.33	.45	.20	.30	.15	.27	.939
	(.07)	(.16)	(.06)	(.16)	(.11)	(.16)	

* Cluster attributes.
** Standard Error (s.e.)

*** Significant at $P \leq .05$, df = degrees of freedom (treatment/error).
a,b,c denote mean groups which are significantly different.

Tree canopy

Significant differences in the numbers of Uinta chipmunks, northern flying squirrels, snowshoe hares, elk, and moose associated with each tree canopy class were found (Table 28). The greatest number of Uinta chipmunks and flying squirrels were trapped on sites with the taller trees (15.2 - 17.9 m), lowest percent canopy overstory, and reduced crown ratios (25 - 31%). Snowshoe hares were most common in stands with shorter trees (8.7 - 10.5 m), and crown ratios near 40%. Stands characterized by tree heights near 12 m, large crown ratios (43%), and the sky obscured (60%) by the canopy had the greatest moose use. Elk appeared to avoid stands with shorter trees (10.5 - 8.7 m), and high percent overstories.

Downed woody material

The relationship of downed woody material to the distribution of mammal abundance is summarized in Table 29. Among the downed woody material classes, the numbers of boreal redback voles, Uinta chipmunks, northern flying squirrels, deer mice, and elk varied significantly. The boreal redback vole appears to be closely associated with the numbers of rotting logs and total woody material found on a site. When all classes were compared, nearly twice as many Uinta chipmunks were trapped in the 8255 kg/ha class. The same response was noted for the northern flying squirrel, except that the higher densities were distributed over the 5000 - 8000 kg/ha classes. Deer mice were trapped in the largest number on sites with a relatively high proportion of deadwood in the 0 - 7.6 cm branch size class.

Table 28. The relationship between tree canopy classes and mammal abundance on the reconnaissance plots (0.6 ha).

	Tree Canopy Class						
	1	2	3	4	5	6	F Cal
Structural Part*							
Number of observations	12	11	12	5	4	5	df 5/43
Tree height (m)	13.50	15.20	17.90	11.60	10.50	8.50	3.15***
	(.15)**	(.16)	(.15)	(.23)	(.26)	(.23)	
Percent overstory	.54	.52	.50	.60	.53	.67	2.01
	(.03)	(.03)	(.03)	(.05)	(.06)	(.05)	
Crown ratio (%)	.35	.33	.25	.43	.40	.40	3.29***
	(.03)	(.03)	(.03)	(.04)	(.05)	(.05)	
Animal Species (trapped)							df 5/43
Boreal redback vole	.42	1.18	1.25	1.80	1.75	.60	1.95
	(.31)	(.32)	(.31)	(.48)	(.54)	(.48)	
Least chipmunk	.33	.18	.00	.00	.50	.20	.66
	(.18)	(.18)	(.18)	(.27)	(.31)	(.27)	
Uinta chipmunk	3.00^{b}	5.18^{a}	6.33^{a}	1.80^{b}	1.50^{b}	2.40^{b}	3.56***
	(.85)	(.88)	(.85)	(1.37)	(1.47)	(1.32)	
Northern flying squirrel	1.66^{b}	2.18^{a}	2.67^{a}	$.40^{c}$	$.25^{c}$	$.00^{c}$	5.92***
	(.35)	(.37)*	(.35)*	(.55)	(.61)	(.55)	
Deer Mice	.83	1.00	.92	.80	1.75	1.80	1.45
	(.26)	(.27)	(.26)	(.40)	(.45)	(.40)	
Animal species (plot counts)							
Number of observations	108	100	116	36	44	48	df 5/446
Snowshoe hare	9.21^{b}	6.47^{c}	9.31^{b}	6.56^{c}	16.63^{a}	16.15^{a}	8.70***
	(1.08)	(1.13)	(1.05)	(1.88)	(1.79)	(1.63)	
Red squirrel	.75	.83	.54	.81	.68	.94	1.33
	(.10)	(.11)	(.10)	(.18)	(.16)	(.15)	
Deer	.37	.21	.40	.25	.16	.38	1.94
	(.06)	(.06)	(.06)	(.10)	(.09)	(.09)	
Elk	$.78^{b}$	1.02^{a}	.89	$.92^{b}$	$.32^{c}$	$.35^{c}$	6.86***
	(.09)	(.09)	(.09)	(.15)	(.14)	(.14)	
Moose	.31	$.20^{b}$	$.22^{b}$	$.94^{a}$	$.09^{b}$	$.13^{b}$	8.13***
	(.07)	(.07)	(.07)	(.12)*	(.10)	(.10)	

* Cluster attributes.
** Standard Error (s.e.).
*** Significant at $P \leq .05$, df = degrees of freedom (treatment/error).
a,b,c denote groups of means which are significantly different.

Table 29. The relationship between the structure downed woody material and mammals abundance on the reconnaissance plots (0.6 ha).

	Downed Woody Material Classes				
	1	2	3	4	F Cal.
Structural part* (kg/ha)					
Number of observations	8	24	8	5	df 3/41
0-7.6 cm branches	1597 (176)**	1104 (102)	1014 (176)	815 (223)	3.16
Sound logs	1876 (575)	1817 (332)	3249 (576)	749 (728)	2.66
Rotten logs	1799 (652)	9161 (376)	3992 (652)	1086 (825)	5.23
Total downed wood	5272	12082	8255	2650	
Animal species (trapped)					
Number of observations	8	24	8	5	df 3/41
Boreal redback vole	$.25^{b}$ (.35)	1.58^{a} (.20)	1.25^{a} (.35)	$.20^{b}$ (.44)	5.36***
Least chipmunk	.65 (.21)	.08 (.12)	.00 (.21)	.20 (.27)	1.94
Uinta chipmunk	3.75^{b} (1.10)	3.08^{b} (.63)	7.50^{a} (1.10)	3.20^{b} (1.39)	4.18***
Northern flying squirrel	2.50^{a} (.50)	1.21^{b} (.29)	2.50^{a} (.50)	$.80^{b}$ (.64)	3.20***
Deer mice	5.25^{a} (.72)	2.17^{b} (.42)	1.25^{b} (.72)	3.00^{b} (.92)	6.02***
Animal species (plot counts)					
Number of observations	56	204	88	56	df 3/400
Snowshoe hare	6.86 (1.60)	10.76 (.84)	10.53 (1.28)	9.66 (1.60)	1.63
Red squirrel	.98 (.14)	.73 (.07)	.61 (.11)	.79 (.14)	1.46

Table 29. Continued

	Downed Woody Material Classes				
	1	2	3	4	F Cal.
Deer	.14 (.08)	.26 (.04)	.25 (.07)	.41 (.08)	1.58
Elk	.78[b] (.13)	.58[b] (.07)	.88[b] (.10)	.31[a] (.13)	3.99***
Moose	.25 (.10)	.26 (.15)	.34 (.18)	.16 (.10)	.71

* Cluster attributes.

** Standard Error (s.e.).

***Significant at $P \leq .05$, df = degrees of freedom (treatment/error).

a,b,c denote groups of means which are significantly different.

Elk were the only big game animals with significantly different distributions of pellet groups among the downed woody material classes. Fewer elk pellet groups were counted on sites with the least amount of deadwood.

Regression analysis

In an attempt to explain the distribution of pellet groups and middens (dependent variables), 17 independent variables (X_i) were added to the regression model.

$$\hat{Y} = b_o + b_1X_1 + b_2X_2 \cdots b_{17}X_{17}$$

These independent variables and their contribution to the explaina- tion (R^2) of pellet group and midden numbers are summarized in Table 30. The independent variables that significantly ($P \leq .05$) contributed to the model are asterisked. For these variables the hypothesis that $b_i = 0$ was rejected. While the 17 independent variables explain only 33 to 57% of the variation in the dependent variable, the order in which variables were added to the model is of interest.

In the instance of snowshoe hare pellets, 55% of the total (57%) variation was attributed to the subsequent addition of the following variables:

(1) sapling density

(2) stem density

(3) crown ratio

(4) community

(5) duff height

(6) grass (kg/ha)

(7) rotten logs (kg/ha).

Table 30. Summary of important variables contributing to the distribution of selected mammals in the study area.

Independent Variables (X_i)	Snowshoe Hare Mean Square	Snowshoe Hare Contribution to R^2	Mule Deer Mean Square	Mule Deer Contri. to R^2	Elk Mean Square	Elk Contri. to R^2	Moose Mean Square	Moose Contri. to R^2	Red Squirrel Mean Square	Red Squirrel Contri. to R^2
Community type (X_1)	3320.5	.1057*	6.921	.1094*	14.3	.1348	23.7	.3963*	6.3	.0873*
Canopy										
Tree height (X_2)	485.5	.0019	5.764	.10145	11.5	.0129	.5	.0021	2.3	.0027
Percent overstory (X_3)	3.4	T	1.403	.0598	6.8	.0222	11.1	.0214*	31.5	.0180*
Crown ratio (X_4)	12039.9	.0962*	16.026	.0368*	.3	.0004	2.4	.0078	28.9	.0219
Standing wood										
Basal area (X_5)	412.6	.0030	1.196	.0037	6.0	.0061	.1	T	.4	.0004
Stem density (X_6)	14443.1	.0774*	7.529	.0172*	2.4	.0023	.6	.0011	6.0	.0048
Sapling density (X_7)	16393.8	.1774*	13.568	.0114*	22.9	.0122*	.1	T	4.7	.0026
Seedling density (X_8)	13.4	T	.583	.0011	.4	.0010	.7	.0014	.1	T
Forage										
Grass kg/ha (X_9)	3775.9	.0239*	5.135	.0153	.1	.0001	15.1	.0146*	.3	T
Forbs kg/ha (X_{10})	45.4	.0003	27.359	.2047*	8.5	.0066	6.4	.0119	2.6	.0023
Browse kg/ha (X_{11})	335.6	.0020	.830	.0002	27.4	.1044	.1	T	13.4	.0429
Downed woody material										
Percent rotten wood (X_{12})	510.9	.0020	2.691	.0028	34.2	.0136*	.1	T	5.7	.0035
0–7.6 cm kg/ha (X_{13})	213.5	.0016	12.649	.0114*	.1	T	12.1	.0327*	18.3	.0082
Sound logs kg/ha (X_{14})	1137.7	.0027	.901	.0040	29.3	.0224*	.5	.0037	48.3	.0159*
Rotten logs kg/ha (X_{15})	4537.2	.0220*	.634	.0014	1.1	.0248	.8	.0008	16.6	.0149
Duff depth cm (X_{16})	9691.8	.0541*	.314	.0007	.3	.0003	2.6	.0113	30.8	.1014*
Fuel height m (X_{17})	494.4	.0030	3.567	.0139	44.4	.0474*	.1	.0011	3.4	.0035
R^2	.570*		.509*		.412*		.507*		.330*	
Error	795.420		1.581		5.720		2.406		7.647	
Error degrees of freedom	92		92		92		92		92	

* Significant $P \leq .05$.

The addition of independent variables to the deer regression model was as follows:

(1) forbs (kg/ha)

(2) percent overstory

(3) community

(4) crown-ratio.

These four variables explained 41% of the total variation (R^2 = 51%). To this stage the addition of independent variables was significant ($p \leq .05$).

Approximately 31% of the variation in the distribution of elk pellet groups was explained by four independent variables. These were:

(1) browse (kg/ha)

(2) fuel height (cm)

(3) community type

(4) percent of rotten downed woody material.

At this stage in the analyses, the community type was not significant. The addition of the 13 remaining variables accounted for a total R^2 equal to 41%. Significant additions to the model were sapling density and sound logs (kg/ha).

Within the moose model, the independent variables:

(1) community type

(2) downed woody stems (0 - 7.6 cm)

(3) percent overstory

contributed 45% to the total R^2 of 51%. The kg/ha of grass was the only remaining variable to contribute significantly to the total R^2.

The 17 independent variables explained only 33% of the variability in the distribution of red squirrel middens. Significant contributions to R^2 were attributed to:

(1) duff depth

(2) sound logs (kg/ha)

(3) community type

(4) percent crown ratio.

These four variables accounted for 27% of the total R^2 (33%).

Special considerations

Mountain meadows. The relationships between the distribution of deer and elk pellet groups associated with the forest canopy adjoining mountain meadows are summarized in Tables 31 and 32. In general, for deer and elk, there is a significant decline in the number of pellet groups/plot as the distance from the meadow edge increases. Except for the distribution of deer pellet groups at Hidden Meadow West, calculated F ratios were significant. Using distance (m) as the independent variable, models are present (see Table 31) which predict the distribution of the dependent variable (pellet groups/plot).

Slope modifies the distance from edge effect (Fig. 4). At meadows with similar stands of peripheral timber, the frequencies of pellet groups increased on the uphill slope. This increase amounted to 33% at Hidden Meadows.

The abundance of plant species, herbage biomass, and elk use that occurs in the ecotone created by the variation in overstory height and the uniformity of stem distribution are summarized in Table 32. Meadow edges have been classed as distinct or tapered

Table 31. Statistical relationships between mountain meadow edge and the distribution of deer and elk pellets under the adjoining forest canopy.

Source of Variation	df*	Mean Square	F Ratio[a]
Deer			
Hidden East Meadow			
Regression	1	12.6487	5.3758***
Error	6	2.3529	
Total	7		
$R^2 = .60$			
$Y = 2.2709 + (-.0026X)$[b]			
Hidden West Meadow			
Regression	1	9.0831	4.0176
Error	4	2.2608	
Total	5		
$R^2 = .64$			
$Y = 2.5827 + (-.0057X)$			
Bull Park			
Regression	1	13.1176	6.1513**
Error	6	2.1325	
Total	7		
$R^2 = .74$			
$Y = 2.525 + (-.0036X)$			
Elk			
Hidden Meadow East			
Regression	1	13.1582	7.961**
Error	6	1.6527	
Total	7		
$R^2 = .89$			
$Y = 2.4329 + (-.0035X)$			
Hidden West Meadow			
Regression	1	8.7451	7.4642**
Error	4	1.1716	
Total	5		
$R^2 = .95$			
$Y = 2.0107 + (-.0031X)$			

Table 31. Continued

Source of Variation	df	Mean Square	F Ratio
Bull Park			
Regression	1	11.3082	12.5803**
Error	6	..8999	
Total	7		
R^2 = .92			
Y = 1.8057 + (-.0017X)			

* degrees of freedom

** Significant P ≤ .05

*** Significant P ≤.10

[a] Significant F ratio rejects the hypothesis $H:b_1=0$ where b_1 is the estimated slope of the regression line.

[b] the independent variable X_i represents distance from the edge formed by the meadow and forest canopy.

Table 32. Number of understory species and herbage biomass as they relate to distance from meadow edge and elk use (1973 data).

	Edge Classification					
	Distinct Edge			Tapered Edge		
Distance from edge (m)	# of Plant Species	Herbage ($gm/.5m^2$)	Pellet Groups ($\bar{x}$)	# of Plant Species	Herbage ($gm/.5m^2$)	Pellet Groups ($\bar{x}$)
edge	6.9	313.0	.80	6.1	352.4	.67
15	5.3	273.3	.87	5.0	294.6	.73
31	4.6	137.0	.67	4.6	266.3	.87
46	3.4	82.4	.53	4.8	158.9	.67
61	2.4	77.6	.60	4.4	116.3	.40
76	2.4	16.2	.47	3.2	132.4	.60
91	1.4	26.2	.53	2.4	98.4	.60
107	1.7	15.4	.33	2.2	29.9	.47
122	1.3	16.8	.40	2.4	19.9	.33
Standard Error	.42	42.9	.06	0.6	73.2	.19
F Cal (df 8/126)**	21.63*	3.91*	7.05*	4.85*	5.21*	1.58

* Significant P $\leq$.05.

** df = degrees of freedom (treatment/error).

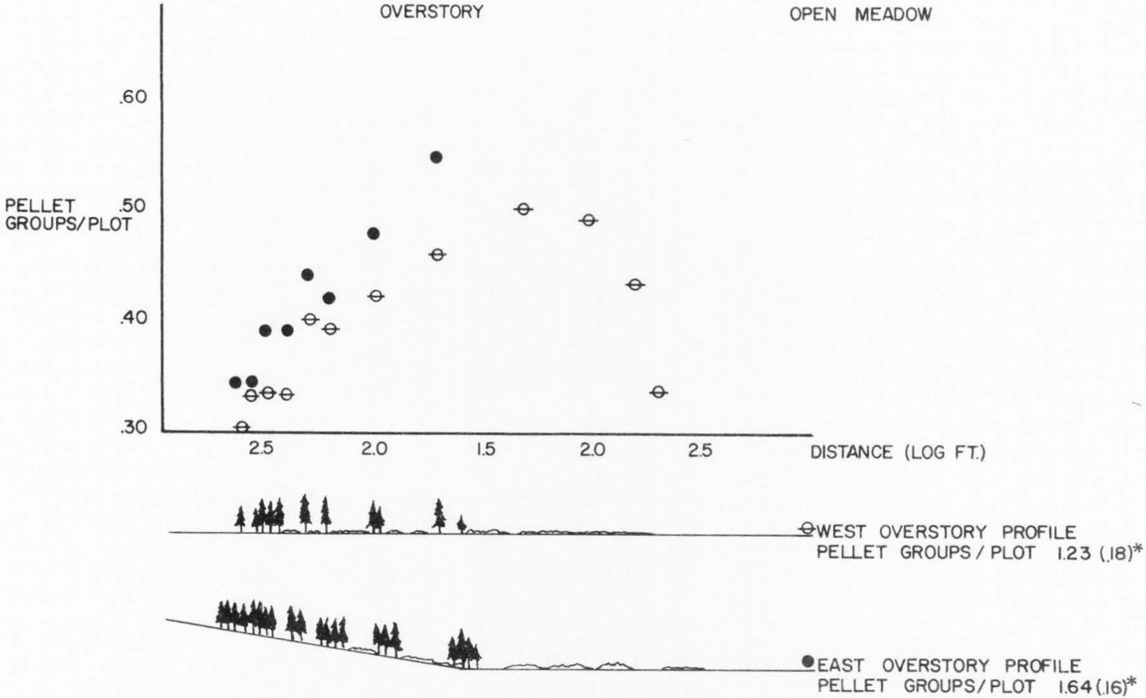


FIGURE 4. The relationship of elk pellet groups to edge and overstory densities associated with a 6 ha meadow [* $\bar{x}$(s.e.)].

based on this variation in tree height and distribution. Meadows with single layered canopies and relatively uniform stem densities at the meadow's edge were referred to as distinct. Overstory canopies with less uniform stem heights and crowns that appear to blend into the meadow were classed as tapered.

Forty-six meters into overstories associated with a distinct edge, herbage biomass declined to 56% of the edge production level. The number of plant species/plot was down 51% from the edge level. Up to this distance, herbage biomass, and the number of plant species are similar for tapered meadows. At distances greater than 46 m from a distinct edge, herbage biomass and understory plant species significantly decline. The decline among these parameters is less pronounced among the tapered edges. In addition, the distribution of elk use is somewhat more uniform to distances approaching 100 m.

The proportion of meadow surface that is utilized also decreases with greater distance from the forest edge. The number of big game tracks that cross directly through a meadow is significantly lower than the number of tracks that skirt the edge (Table 33). Approximately 38% of the big game animals will skirt meadows with widths greater than 300 m. In addition, these observations are supported by the distribution of pellet groups associated with a meadow (Table 34). Among the wider meadows, a marked decline (67%) in the mean number of pellet groups was noted between the forest edge and distances greater than 100 m from that edge.

The reduction in the number of pellet groups counted at a distance 50 m from the edge approached 25%. For meadows classed as

Table 33. A comparison (%) of big game meadow tracks counted at 50 and 100 m from the forest edge.

	Number of Edge Tracks*	Distance from Edge 50 m	100 m
Meadow width (300 m)[a]			
Deer	11.6 (4.9)	52% (4.6)	13% (6.1)
Elk	14.1 (4.1)	59% (5.4)	31% (7.2)
Moose	2.8 (0.4)	73% (3.2)	53% (2.9)
Meadow width (150 m)[b]			
Deer	6.3 (1.2)	80% (3.5)	
Elk	7.8 (2.3)	89% (3.9)	
Moose	3.7 (1.4)	86% (5.7)	

* $\bar{x}$ (Standard Error)

a N = 3

b N = 4

Table 34. The relationship of meadow location, size, and width to the average number of elk pellet groups/plot (1973-1975 data combined).

	Meadow Width					
	10 Times Stand Height			5 Times Stand Height		
Treatments[a]	1	2	3	1	2	3
Distance from Overstory Edge (m)						
15	1.91	1.86	2.79	2.19	2.19	3.54
30	1.51	1.76	2.17	2.09	2.00	3.49
46	1.32	1.62	1.94	1.81	2.04	3.07
61	1.28	1.51	1.87			
76	1.28	1.51	1.63			
91	1.32	1.35	1.66			
107	1.28	1.15	1.74			
122	1.15	1.15	1.26			
$\bar{x}$ (s.e.)	1.38 (.19)[b]	1.49 (.15)	1.89 (.16)	2.03 (.11)	2.08 (.06)	3.37 (.15)
Edge Index[c]	1.55	1.49	1.68	1.73	1.45	1.90

[a] Treatments are distance of meadow from active road.
1. 500 m, 2. 500-1000 m, 3. +1000 m.

[b] Standard Error (s.e.)

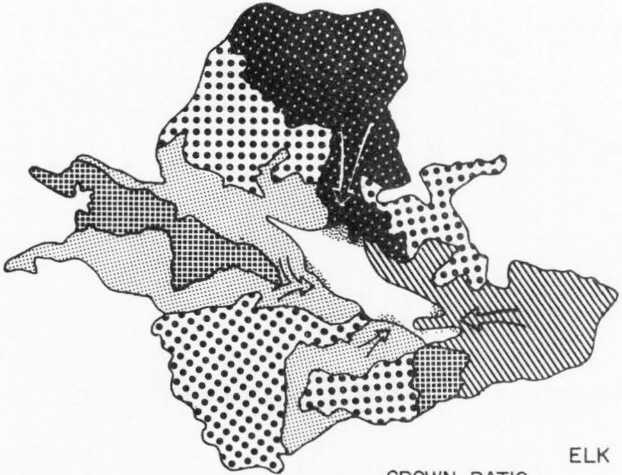
[c] Edge index calculated as outlined by Patton, 1975.

narrow (150 m wide) the number of pellet groups was 13% less than the edge count. More than 80% of the big game species crossed directly through a meadow in the narrow class.

In addition, Table 34 presents the elk use that occurred on two meadow sizes at three different distances from active roads. Two basic phenomena can be observed. First, regardless of meadow width, the total number of pellet groups/plot declines (27 - 40%) in close proximity to active roads. Second, as the distance from active roads increases, the number of pellet groups/plot remains higher toward the center of the meadow.

It was obvious from the study of four meadow complexes that elk access was confined to travel lanes. This results in the uneven distribution of use around the meadow's periphery (Fig. 5). Associated with these travel lanes were significant differences in the number of pellet groups that occurred in the surrounding overstories. Stands of spruce sawtimber in close proximity to wide meadows had four times the pellet groups as did similarly located pole stands of lodgepole pine. The mean number of pellet groups found in stands of lodgepole sawtimber exceed the pole stand means by 1.7 times. Pole stands with crown ratios above 50% are avoided by elk.

Clearcuts. The response of selected small mammals and big game species to four clearcuts are found in Table 35. In general, clearcutting reduces the number of most small mammals and big game species. Notable exceptions were the deer mice and least chipmunk (see Table 14). Clearcuts virtually were not used by moose and red squirrels.



STAND CLASS	CROWN RATIO	ELK PELLET GROUPS / PLOT $\bar{x}$(SE)
1. POLE STANDS		
> 1000 STEMS/.4ha	30 / 55%	
500-1000 STEMS/.4ha	30 / 75 %	.6 (.22)
< 500 STEMS/.4 ha	32/ 80 %	
2. SAW TIMBER		
LODGEPOLE VOLUME 3.0 MBM/.4ha		1.02 (.08)
SPRUCE VOLUME 1.5 MBM /.4 ha		2.50 (.12)

FIGURE 5. Distribution of elk pellet groups within a 40 ha meadow and adjacent lodgepole pine stands.

Table 35. Summary of pellet and midden counts on clearcut reconnaissance plots (mean number/ .0004 ha).

	Clearcut (Mean Number)				
Species	Bridger Cut	Pushover	Island	Stateline	Total $\bar{x}$ (s.e.)
Snowshoe hare	1.42(.31)[a]	.02(.29)	1.13(.35)	.00	.64(.19)
Red squirrel	0.00	.00	0.00	.00	.00
Mule deer	0.58(.19)	.00	0.03(.22)	.03(.25)	.16(.11)
Elk	0.33(.13)	.25(.25)	0.25(.25)	.25(.25)	.27(.09)
Moose	0.00	.00	0.00	.25(.25)	.06(.04)

[a]Standard Error (s.e.)

Significant reductions in the number of snowshoe hares varied from 75 to 90% of the levels present in the various community phases. Of the coniferous community phases, Pico/Bere was most closely associated with clearcuts. This phase represents the intermediate stages of succession. Both the Bridger and Island cuts were classified as Pico/Bere (Table 57). Among the clearcuts, the largest number of hares appeared in cuts less than 25 ha in size and with highly irregular edges.

The greatest frequency of deer pellet groups appeared in the smallest (Bridger) clearcut. The number of deer pellet groups in this cut statistically was similar to the Caca-Cale, Pico/Luar, Pico/Bere, and Pico/Vasc phases (see Table 16). When compared to the Bridger Cut, significantly fewer deer pellet groups were counted in the Vasc-Vaca, Vasc-Rimo, and Caca-Vasc phases. Compared with all of the clearcuts, the Potr/Bere phases had significantly more (52 to 82%) deer pellet groups.

Elk use did not vary significantly between clearcuts. When the mean number of elk pellet groups counted on clearcuts was compared to the uncut community phase, only Pico/Bere and Caca-Vasc were not significantly higher. Pico/Bere was 89% lower and Caca-Vasc was considered equivalent.

The response of deer and elk to edge associated with clearcutting of lodgepole pine is depicted in Table 36 and Figure 6. Both species react similarly to a clearcut edge. The independent variable (distance) explains approximately 70% of the variability in deer pellet group frequency associated with clearcuts. On the larger cuts (100 ha), the association was true for elk (R^2 = .79). However,

Table 36. The statistical relationship between the occurrence of deer and elk pellet groups and the edge of clearcuts (data combined for the years 1973-1975).

Source of Variation	df*	Mean Square	F ratio [a]
Deer			
Bridger Cut (50 ha) R^2 = .80 Y = .3340 + (-.0011X)[b]			
Regression	1	.0780	1.56
Error	2	.0500	
Total	3		
Island (100 ha) R^2 = .59 Y = .3511 + (-.0008X)			
Regression	1	.3654	114.19**
Error	8	.0032	
Total	9		
Pushover (100 ha) R^2 = .73 Y = .3421 + (-.0008X)			
Regression	1	.3010	86.0**
Error	8	.0035	
Total			
Elk			
Bridger Cut (50 ha) R^2 = .07 Y = .0670 + (.0001X)			
Regression	1	.0061	.481
Error	2	.0126	
Total	3		
Island 2 (100 ha) R^2 = .75 Y = .2577 + (-.0006X)			
Regression	1	.1694	105.9**
Error	8	.0016	
Total	9		
Pushover (100 ha) R^2 = .79 Y = .4001 + (-.0009X)			
Regression	1	.3884	65.83**
Error	8	.0059	
Total	9		

* degrees of freedom

** Significant at $P \leq .05$.

[a] Significant F ratio rejects the hypothesis $H: b_1 = 0$ where b_1 is the estimated slope of the regression line.

[b] The independent variable X_1 represents distance from the edge formed by the meadow and forest canopy.

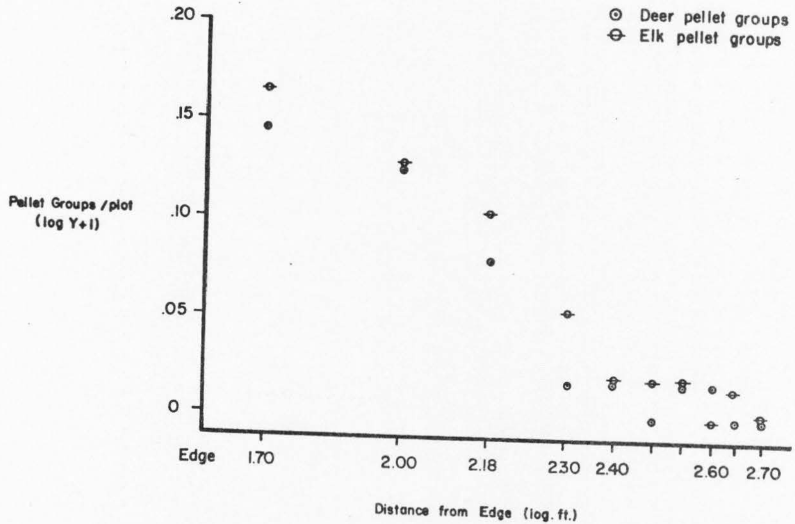


Figure 6. The occurence of deer and elk pellet groups in relation to edges of clearcuts (Pushover combined years 1973-1975).

on the smaller Bridger Cut, distance did not contribute to the distribution of elk pellet groups (R^2 = .07, F ratio = .481).

Home range estimates. Results from live trapping data subjected to home range calculations (Koeppl, et al. 1975) are reported in Table 37. For the Uinta chipmunk, male home range estimates were 42 to 53% larger than for female estimates. The calculated home range for male least chipmunks exceeded the areas used by chipmunk females by 19 to 25%. The average estimated home range for the Uinta chipmunk trapped in stands of mature and regenerating lodgepole pine were equivalent. However, the estimated areas appear to be closely associated with shorter seedling-sapling canopies. Where lodgepole pine regeneration exceeds 100 stem/375m^2, home range estimates are larger (41%) than sites with less regeneration. This phenomenon appears to be closely associated with the cover and concealment the canopy probably provides, rather than mere stem densities.

In addition, the mean home range for Uinta chipmunks corresponds closely with the number of understory plant species and cover provided by fuel heights and downed woody material (Table 38).

Avian fauna

Due to the number of bird species within the study area, only species with significant population differences between structural classes will be discussed (Table 39).

Basal area

Between overstory basal area classes, only significant differences in the numbers of Cassin's finches and red-breasted nuthatches were

Table 37. Seedling-sapling densities and the 95% confidence ellipses for the home ranges (ha) of the least and Uinta chipmunks on five permanent plots.

Site	Animals[1]	Area (95% confidence ellipses)		Number/375m[2]		
				Seedling	Sapling	Total
Uinta						
Gil West	12	.77	1.41	79	98	177
MRI	12	.70	1.48	101	62	173
Gil East	10	.43	.83	7	30	37
Bridger Cut	12	.75	1.30	40	134	174
Least[2]						
Bridger Cut	14	.85	1.14	40	134	174
Pushover	12	.98	1.21	60	260	320

1. The total number of animals that were included in the home range calculation.

2. This species reported for lodgepole pine regeneration sites only.

Table 38. The relation between estimated home ranges for *E. umbrinus* and selected site variables.

Variable	Sites			
	Gil West	MRI	Gil East	Bridger
Herbage (kg/ha)				
Grass	2.01	4.59	1.84	14.87
Forbs	7.34	7.71	2.02	23.86
Browse	12.30	8.08	4.22	.92
Downed woody material (kg/ha)	10,977	5,345	2,156	6,405
Fuel ht (cm)	29.20	20.60	12.30	15.50
Crown-ratio	77.00	81.00	74.00	87.00
Number of plants	33	28	20	28
Mean home range	1.09	1.09	.63	1.03

Table 39. Recapitulation of statistically significant avian response to structural classifications developed from cluster analyses of reconnaissance site parameters.

	Type of Community Structure			
	Basal Area	Herbage (kg/ha)	Canopy	Downed Woody (kg/ha)
<u>Species</u>				
Cassin's finch	++			
Red-breasted nuthatch	+			
American robin		++		
White-crowned sparrow			++	
Hermit thrush			++	++
Audubon's warbler				++
Gray-headed junco				++
Similarity index*	95%	65%	95%	70%
Number of classes (treatments)	5	6	6	4

+ Significant F test ($P \leq .10$).
++ Significant F test ($P \leq .05$).
* Coefficient of similarity at class cutoff.

observed (Table 40). Finch numbers were high (2 to 20 times) in the 3.8 $m^2/375m^2$ basal area class, while the largest number of red-breasted nuthatches occurred in the lowest basal area class (2.4 $m^2/375m^2$).

Herbage biomass

The number of American robins varied significantly among herbage biomass classes (Table 41). However, the differences appeared more related to the proportions of grass, forbs, and browse than total biomass (see Table 27).

Tree canopy

White-crowned sparrow and hermit thrush numbers varied significantly between tree canopy classes (Table 42). White-crowned sparrows were most frequently observed in stands with trees of average height (11.6 m). The stands also were characterized by above average percent overstory and crown ratios (see Table 28). The hermit thrush was most abundant in stands with short trees (8.7 to 11.6 m). These stands had dense canopy covers (67% overstory and crown-ratio fo 40%).

Downed woody material

The significant relationship between downed woody material and bird numbers is summarized in Table 43. For the Audubon's warbler, hermit thrush, and gray-headed junco; downed woody material is an important constituent of the habitat. For all three species, bird numbers significantly increase as downed woody material accumulates.

Table 40. Numbers of Cassin's finch and red-breasted nuthatch associated with tree basal area structure treatments.

	Basal Area Classes ($m^2/375m^2$)					
	3.5 (9)*	3.0 (12)	3.3 (11)	3.6 (10)	3.8 (8)	Cal F
Species						
Cassin's finch	1.55[b]	0.70[b]	0.17[b]	0.75[b]	3.56[a]	2.19***
	(0.84)**	(0.88)	(0.80)	(0.98)	(0.93)	
Red-breasted nuthatch	0.91[a]	0.20[b]	0.17[b]	0.00[b]	0.00[b]	1.95***
	(0.26)	(0.28)	(0.25)	(0.31)	(0.29)	

* Number of reconnaissance sites included in each treatment.

** Standard Error (s.e.).

*** Significant $P \leq .05$.

a,b denote groups of means which are significantly different.

Table 41. Number of American robins associated with herbage structure treatments.

	Herbage Classes						
	1	2	3	4	5	6	Cal F
Structural Parts* (kg/ha)							
Number of observations	14	3	14	3	4	12	
Grass	6.92	19.27	2.70	.42	5.43	2.20	6.91***
	(1.34)**	(2.90)	(1.34)	(2.90)	(2.53)	(1.45)	
Forbs	18.63	65.11	5.75	4.22	1.65	3.29	109.22***
	(1.21)	(2.61)	(1.21)	(2.61)	(2.26)	(1.30)	
Browse	5.21	4.09	2.61	.97	3.91	42.16	13.08***
	(3.84)	(8.32)	(3.84)	(.83)	(7.10)	(4.15)	
Total	30.8	88.5	11.1	5.6	10.7	47.7	
Bird Species							
Robin	2.07[b]	5.00[a]	0.64[b]	4.67[b]	1.50[b]	3.83[a]	2.55***
	(0.77)**	(1.68)	(0.77)	(1.68)	(1.46)	(0.84)	

** Standard Error (s.e.).

*** Significant P ≤ .05.

[a,b] denote groups of means which are significantly different.

Table 42. Numbers of white-crowned sparrows and hermit thrush associated with tree canopy classes.

	Tree Canopy Class						
	1	2	3	4	5	6	Cal F
Structural Part*							
Number of observations	12	11	12	5	4	5	df 5/43
Tree height (m)	13.50	15.20	17.90	11.60	10.50	8.70	3.15***
	(0.15)**	(0.16)	(0.15)	(0.23)	(0.26)	(0.23)	
Percent overstory	0.54	0.52	0.03	0.05	0.06	0.05	2.01
	(0.03)	(0.03)	(0.03)	(0.05)	(0.06)	(0.05)	
Crown ratio (%)	0.35	0.33	0.25	0.43	0.40	0.40	3.29***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.05)	(0.05)	
Bird Species							
White-crowned sparrow	0.67[b]	0.00[b]	0.00[b]	2.20[a]	0.00[b]	0.50[b]	2.21***
	(0.40)[a]	(0.42)[a]	(0.40)[a]	(0.62)[a]	(0.69)[a]	(0.57)[a]	
Hermit thrush	0.35[b]	0.65[b]	0.87[b]	1.62[a]	0.00[b]	1.83[a]	2.26***
	(0.29)	(0.30)	(0.29)	(0.45)	(0.50)	(0.41)	

* Cluster attributes.

** Standard Error (s.e.)

*** Significant $P \leq .05$.

[a,b] denote groups of means which are significantly different.

Table 43. The relationship between the structure downed woody material and avian abundance in the study area.

	Downed Woody Material Classes				
	1	2	3	4	Cal F
Structural Part* (kg/ha)					
Number of observations	8	24	8	5	df 3/44***
0-7.6 cm branches	1597 (176)**	1104 (102)	1014 (176)	815 (223)	3.16
Sound logs	1876 (575)	1817 (332)	3249 (576)	749 (728)	2.66
Rotten logs	1799 (652)	9161 (376)	3992 (652)	1086 (825)	5.23
Total downed woody	5272	12082	8255	2650	
<u>Bird Species</u>					
Gray-headed junco	2.13^{c} (2.05)	6.29^{b} (0.09)	8.25^{a} (2.06)	2.10^{c} (1.84)	2.94****
Hermit thrush	0.00^{b} (0.64)	1.33^{a} (0.37)	1.00^{a} (0.64)	0.00^{b} (0.58)	2.56****
Audubon's warbler	0.90 (0.91)	2.55^{a} (0.58)	2.00^{a} (0.01)	0.00^{b} (1.01)	3.13****

* Cluster attribute.
** Standard Error (s.e.).
*** degrees of freedom (treatment/error).
**** Significant $P \leq .05$.
^{a,b,c} denote groups of means which are significantly different.

DISCUSSION

Mammal Response to Community Classifications

Layser (1974) has reviewed the basic ecological features of land classification into habitat types from a silvicultural point of view. In this context habitat type becomes the fundamental ecological unit within the classification scheme. The significance of this tool is attached to its potential of predicting the sequential rates of overstory and understory production that a site is capable of supporting. Its importance to vertebrate management lies in determining the rate and proportional patterns at which vegetation structure can be altered by management practices.

The application of habitat classification schemes to wildlife management results in the separation of large heterogeneous habitats into similar management units. Among the lodgepole pine stands of the north slopes of the Uintas, overstory classification methods based on quantitative evaluation of stand features are useful in providing adequate management.

The application of computers to classification solutions has received a great deal of attention in recent years. Cluster analysis is only one of many methods available. This procedure of mathematically grouping stands with the greatest number of shared attributes is most useful when the groupings naturally occur in the forest. Regardless of the number of attributes combined, the classification system is useful, in a practical sense, only when the resulting units are recognizable in the field. In this regard, simplicity is necessary in overcoming the modification of stands due to chance, disturbance, or successional change.

The coordinated management of habitat types for a variety of plant and animal species presents some obvious trade-offs. For example, the relationship between the quality of deer habitat and selected management practices is fairly well known (Wallmo et al. 1972 and Terrel, 1973). However, it becomes increasingly difficult to objectively judge the trade-offs involved in the simultaneous management of several species. To overcome some of this difficulty, Gill et al. (1975) suggested a numerical timber/wildlife relationship. An example of this systematical relationship is presented in Table 44.

In Table 44, each ratio was calculated from the pellet group or midden abundance presented in Tables 13 and 16. If the ratios are considered as preference indices, plot data convert into a relative community preference between species. For example, one could expect about 2.6 times as many snowshoe hares in the Pico/Luar phase as the Pico-Potr/Bere phase. The community preferred second by hares is Caca-Vasc. Based on pellet counts, approximately 2.4 times as many hare pellets occur in the Caca-Vasc phase as in the Pico-Potr/Bere phase.

For a particular species, the range of ratio values provides a comparative measure to the relative importance of community selection by that species. Larger ranges indicate that community classification schemes contribute more to the explanation of species site

Table 44. Comparison of snowshoe hare, red squirrel, mule deer, elk, and moose ratios calculated from reconnaissance plot observations (Tables 13 and 16).

	Numerator Phase Type							
	Pico-Potr/	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/
Divisor Phase	Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc
				Snowshoe Hare Pellets				
Pico/Luar	.38	.69	.91	.63	.90	1.00	.42	.43
Caca-Vasc	.42	.76	1.00	.69	.98	1.10	.47	.47
Vasc-Vaca	.43	.77	1.02	.71	1.00	1.12	.47	.48
Caca-Cale	.56	1.00	1.32	.92	1.30	1.45	.62	.63
Pico/Rimo	.60	1.09	1.44	1.00	1.42	1.58	.67	.68
Pico/Vasc	.89	1.60	2.11	1.47	2.08	2.32	.98	1.00
Pico/Bere	.90	1.62	2.15	1.48	2.11	2.36	1.00	1.02
Potr/Bere	1.00	1.80	2.38	1.65	2.35	2.62	1.11	1.13
	5.18	9.33	12.33	8.55	12.14	13.54	5.74	5.84
				Red Squirrel Middens				
Pico/Luar	.11	.69	.70	.55	.69	1.00	.63	.46
Caca-Vasc	1.6	.99	1.00	.79	.99	1.44	.90	.66
Caca-Cale	.17	1.00	1.01	.81	1.00	1.46	.92	.67
Vasc-Vaca	.17	1.00	1.01	.81	1.00	1.46	.92	.67
Pico/Bere	.18	1.09	1.11	.88	1.09	1.59	1.00	.73
Vasc-Rimo	.21	1.24	1.26	1.00	1.24	1.81	1.14	.83
Pico/Vasc	.25	1.50	1.52	1.21	1.50	2.19	1.38	1.00
Potr/Bere	1.00	6.00	6.08	4.83	6.00	8.75	5.50	4.00
	2.25	13.51	13.69	10.88	13.51	19.70	12.39	9.02
				Mule Deer Pellet Groups				
Potr/Bere	1.00	.71	.18	.21	.22	.38	.46	.38
Caca-Cale	1.40	1.00	.25	.29	.31	.55	.65	.53
Pico/Bere	2.16	1.54	.39	.45	.48	.85	1.00	.81
Pico/Luar	2.54	1.81	.46	.53	.56	1.00	1.18	.96
Pico/Vasc	2.65	1.89	.48	.55	.59	1.05	1.23	1.00
Vasc-Vaca	4.51	3.22	.82	.94	1.00	1.78	2.09	1.70
Pico/Rimo	4.81	3.43	.87	1.00	1.07	1.90	2.23	1.81
Caca-Vasc	5.50	3.93	1.00	1.15	1.22	2.17	2.55	2.08
	24.57	17.53	4.45	5.12	5.45	9.69	11.39	9.27

Table 44. Continued

	Numerator Phase Type							
	Pico-Potr/	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/
Divisor Phase	Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc
				Elk Pellet Groups				
Pico/Vasc	.62	.65	.29	.74	.62	.84	.03	1.00
Pico/Luar	.73	.77	.35	.87	.73	1.00	.04	1.19
Vasc-Rimo	.84	.88	.40	1.00	.84	1.15	.04	1.36
Caca-Cale	.95	1.00	.45	1.14	.95	1.30	.05	1.55
Vasc-Vaca	1.00	1.05	.48	1.19	1.00	1.37	.05	1.62
Potr/Bere	1.00	1.05	.48	1.19	1.00	1.37	.05	1.62
Caca-Vasc	2.10	2.20	1.00	2.50	2.10	2.87	.10	3.40
Pico/Bere	21.00	22.00	10.00	25.00	21.00	28.67	1.00	34.00
	28.24	29.60	13.45	33.63	28.24	38.57	1.36	45.74
				Moose Pellet Groups				
Potr/Bere	1.00	.18	.10	.10	.05	.19	.10	.22
Pico/Vasc	5.57	.82	.44	.44	.24	.88	.47	1.00
Pico/Luar	5.20	.93	.50	.50	.27	1.00	.53	1.13
Caca-Cale	5.57	1.00	.54	.54	.29	1.07	.57	1.21
Pico/Bere	9.75	1.75	.94	.94	.50	1.88	1.00	2.13
Vasc-Rimo	10.40	1.87	1.00	1.00	.53	2.00	1.07	2.27
Caca-Vasc	10.40	1.87	1.00	1.00	.53	2.00	1.07	2.27
Vasc-Vaca	19.50	3.50	1.88	1.88	1.00	3.75	2.00	4.25
	67.39	11.92	6.40	6.40	3.41	12.77	6.81	14.48

selection. The ratio range (0.38 to 2.62) of the snowshoe hare suggests that community classification contributes less information to site selection by hares than red squirrels (0.11 to 8.75). Plant community classifications explained more about the distribution of elk abundance (0.03 to 28.67) than it did for either deer (0.18 to 5.50) or moose (0.05 to 19.50).

The ratios indicate that some predictions about mammal numbers can be made in areas where large scale community conversions are anticipated. The successful conversion of Pico/Bere sites to Pico/Luar through selective cutting would be beneficial to snowshoe hares, red squirrel, elk, and moose. This manipulation would have little effect on deer use (1.0 to 1.18). The conversion of Pico/Luar to Pico-Potr/Bere would result in substantial changes in hare (2.62 to 1.0) and red squirrel (8.75 to 1.0) numbers. Moose (1.0 to 5.20) and deer (1.0 to 2.54) use should increase.

The premise that certain mammals exhibit some selection for community types has been confirmed by Thilenius (1972), Gill et al. (1975), Marcum (1975), and others. The general distribution of some mammals was closely related to the study area's plant community classifications. Pine martin, red squirrel, boreal redback voles, and long-tailed weasels did not select aspen associated communities. The western jumping mouse, northern pocket gopher, and striped skunk appeared in stands with aspen. The larger predatory species varied in their response to plant community types. Lynx frequented the stands which had spruce and fir, an important community structure which might be attributed to reduced horizontal visibilities and abundant cover. Coyotes did not exhibit a strong preference for particular plant community types, but were not observed in aspen dominated stands.

Clearcutting substantially modified the community response of all species. The least chipmunk and golden mantled squirrel were associated closely with the clearcut seral stages. Coyotes also tended to frequent such sites, probably in response to the increased rodent or prey populations found there.

While the classification of stands into plant community types helps in analysing large amounts of data, a regression analysis implies that the use of community types alone is highly variable among species (see Table 30). A suggested improvement in habitat typing classifications is the inclusion of stand structures such as tree canopy and basal areas, fuel height, abundance of downed woody material, and herbage biomass.

Mammal Response to Structural Types

Analyses of community structures provided insight into the variability between sites of specific mammal populations. While plant communities based on indicator species, are a useful tool in the management of wildlife populations, additional aspects of stand structure provides bases to describe subtle differences in the selection of mammal habitat.

Kirkland and Griffin (1974) suggest that both *P. maniculatus* and *C. gapperi* respond to factors other than the dominant vegetation. McCord (1974) implied that the secretive *Lynx rufus'* hunting habits may dictate it's use of stands with heavy cover. Another example is the recommendation by Phillips (1966) for selective cutting, followed by the lopping and scattering of slash to improve elk calving habitat.

Basal area and canopy structures. Significant differences in the abundance of Uinta chipmunks, northern flying squirrels, snowshoe hares, elk, and moose occurred between the overstory, basal area, and canopy classes. In addition, the observation of pine martin corresponded to the classification of these structures.

Pine martin were observed in stands with above average basal areas and low stem diversity (see table 64). The combination of high basal area and low stem diversity indicates older lodgepole pine stands with considerable amounts of standing deadwood. The appearance of martin in stands of this type, which characteristically have some spruce-fir regeneration, is consistent with the findings of Bergerud (1969) and Koehler et al. (1975). In lodgepole pine communities, the denning habits and arboreal life of the martin apparently require the larger trees associated with mature open stands.

Northern flying squirrel numbers increase in stands with basal areas near $3.4m^2/375m^2$. However, the stems must be tall and have short crowns.

Uinta chipmunks also are associated with the more mature lodgepole pine stands with open canopies. The intermediate basal area classes with high stem diversity indicate this species prefers multi-storied stands with regeneration and generally low crown ratios.

Red squirrels select stands with high tree basal area, comprised predominately of stems and saplings, low herbage biomass, high percent canopy coverage, and long crowns.

Snowshoe hares select two significantly different basal classes. First, they select the high basal areas comprised of high sapling numbers with good canopy coverage, and abundant rotten wood.

Secondary sites have low basal areas, high seedling numbers, and crown ratios (33%) and percent overstory (46%) are average.

Sites with basal areas near $3.5m^2/375m^2$, abundant browse and heavy overstories are selected by elk. Such sites probably represent resting areas.

Moose were most abundant on sites with below average basal areas ($2.36m^2/375m^2$).

Multiple regression analyses did not reflect that basal area was a significant factor in the selection of stands by hares, red squirrels, moose, or elk. However, the percent canopy coverage was important in the selection of stands by moose, red squirrels, hares, and deer.

Herbage structure. No significant differences were found between herbage biomass classes in the numbers of least chipmunk and deer mice. The mammals were most abundant in communities where forbs constituted 83% of the total herbage produced. Total production was generally below average. Krefting and Ahlgren (1974) report that deer mice respond to the high forage production that follows burning. They noted that the largest populations of deer mice occurred in the first seven years following burning. Significant differences in deer mice populations were not found, however, in regeneration older than ten years, populations then appeared to be declining.

The most abundant boreal redback vole populations were associated with a herbage biomass between 30 to 80 kg/ha which was comprised of 60 to 75% forbs. These sites corresponded to the Pico/Caca communities.

Communities with below average herbage biomass (10.7 kg/ha) attracted northern flying squirrels. Grasses and forbs also were well represented on these sites.

Populations of Uinta chipmunks were lowest on sites with low herbage biomass (5.6 kg/ha).

As determined by pellet and midden counts, populations of snowshoe hares, red squirrels, deer, and elk varied considerably between herbage classes.

The largest numbers of hares and squirrels were closely associated with stands having low herbage biomass. On such sites, forbs accounted for 50 to 75% of the total herbage wet weight. For the hare and red squirrel, the independent variable, forb biomass, was the sixth and second variable added to the regression model.

High deer populations were found on sites with high herbage biomass (88.5 kg/ha). On such sites, 74% of the herbage was forbs and 22% was grass. Forb biomass was the first variable added to the regression model. Irwin (1975) reported that within coniferous forests, deer seasonally sought sites where high amounts of preferred forage existed.

Elk selected sites with average herbage biomass of 30 to 40 kg/ha. Browse is the major herbage produced on these sites, and the first independent variable added to the regression model.

Moose abundance was possibly related to sites with abundant grass.

Downed woody material and fuel height. Accumulations of downed woody material and total fuel height contributed significantly to the abundance levels of boreal redback voles, Uinta chipmunks, flying squirrels, deer mice, and elk. It also appears that the distribution of snowshoe hares, deer, elk, and moose increased on sites with above average fuel heights (28.2 cm).

Sites with abundant (8255 to 12082 kg/ha) downed woody material were selected by the boreal redback vole. A high proportion of rotting logs also were important to site selection by voles. Habitats of this nature were commonly found among the Pico/Caca communities. The boreal redback vole was not affected significantly by changes in fuel height. However, the largest populations of voles were found in areas with high fuel heights.

The selection by the least chipmunk and deer mice of areas having 2650 to 5272 kg/ha of downed woody material corresponds to clearcuts or early stages of succession toward lodgepole pine. The even distribution of downed woody material size classes and fuel height verify this observation.

Downed woody material significantly modifies the distribution of Uinta chipmunks. These chipmunks prefer stands with average amounts of deadwood (8255 kg/ha) accumulated in heights up to 18 cm. Equal proportions of sound and rotten logs were important to these animals and indicate the successional reduction of maturing lodgepole pine canopies.

Fuel height was not an important variable in understanding the distribution of flying squirrels. However, sites with 5271 to 8255 kg/ha of downed woody material were most commonly selected. The selection of sites with 5272 kg/ha of downed woody material is attributed to the number of flying squirrels trapped in the Pico-Potr/Bere phase. As one would anticipate, the variables of this community structure play a minor role in the cover requirements of this mammal.

Red squirrels were associated with lower accumulations of downed woody material, and the distribution of their population was not altered significantly by downed woody material.

Fuel height was important in the distribution of snowshoe hares. Hare numbers increased as the mean fuel heights increased to 28.2 cm. More hares are also found on sites where downed woody material was rotten.

Amounts of downed woody material and fuel heights contribute significantly to use of an area by big game. Elk and moose use of an area increases with increased fuel height. However, deer use increases with increased fuel heights up to about 28 cm, then rapidly declines. For deer, fuel height closely correlates to the abundance of downed woody material. High use is found on sites with lower fuel heights and less dead wood. This corresponds to the heavy deer use associated with the Pico-Potr/Bere phase. Both elk and moose prefer stands with abundant downed woody material accumulated to above average fuel heights. These results support Phillips' (1966) observation that downed woody material was a valuable constituent of cover and concealment on preferred elk calving sites.

Special considerations

Mountain meadows. The use of forests peripheral to meadows by deer and elk appears to be related to herbage biomass and the security of concealment cover. The association between distance to meadow opening and the number of deer and elk pellet groups corresponds to the quality and quantity of forage produced. In most instances, the distance to the opening is a useful predictor of deer and elk use. However, the location of the meadow with respect to forest roads and slope can modify this response. In addition to data presented in this study, the results reported by Bumstead (1974) indicate that uncut areas above openings are preferred over those areas below. The reason for this is not clear, but I suggest it is a security response gained from the reduction in the horizontal visual distance, as downhill canopies and uphill trunks obscure meadow openings. This is supported in part by the observation that deer select stands with large crown ratios and elk prefer tapered meadow edges associated with multi-storied stands.

The relationship between forest roads and meadow utilization is not clearly documented. The results of this study suggest that use significantly declines for meadows in close proximity to forest roads. Regardless of meadow size, both pellet groups and track counts imply this conclusion. Ward (1973) suggests that beyond 275 m there is little relationship between forest roads and habitat utilization. He indicates, however, that out-of-vehicle activity, influences elk use up to 800 m. Phillips (1966) stresses the importance of road-elk interactions and recommends that access roads in close proximity to key meadows and calving grounds be closed.

The size and shape of overstory openings play important roles in the overall utilization of openings. Deer and elk seldom venture into the center of large meadows, and among meadows of similar size, use corresponds closely with high edge diversity (see Table 34). MaCaffery and Creed (1969) reported that among the 100 park-like openings they studied, highest deer use occurred on parks between 0.20 and 2.02 ha in area.

This study demonstrated the importance of travel lanes between peripheral forest stands and meadow utilization by elk. Bumstead (1974) reports that elk avoid areas within 400 m of roads and suggested that "leave areas" of dense trees would enhance road crossings by elk.

Clearcuts. Of the small mammals trapped on clearcuts, the least chipmunk and deer mice occurred in substantial numbers. The numbers of long-tailed weasels, vagrant shrews, and snowshoe hares were too low or erratic to indicate useage patterns on clearcuts. Gashwiler (1970, 1971) and Krefting and Ahlgren (1974) reported similar findings.

Wolff and Zasada (1975) indicated that red squirrels vacated clearcuts in Alaska. This was assummed to be the case on the study area, since although red squirrel middens were counted in adjacent stands, they never were found in clearcut openings.

The studies cited imply that build-ups in rodent populations associated with clearcutting are short-term and in response to abundant and diverse forage production. Gashwiler (1971) suggested that 225 meter-wide belts of standing timber were sufficient to inhibit the movement of deer mice between cutover areas.

Between clearcuts, the abundance of big game pellet groups varies considerably. To a large extend, the size and shape of a cutover area determine big game useage patterns on such areas. The size of a clearcut has a greater effect upon deer use than upon elk use. However, both species are closely associated with edge.

Kirsch (1962) reported that 74% of the elk he observed were on clearcuts between 6.2 and 10.2 ha in size. He also reported that peak use of clearcuts occurred in June and September. During other months the elk moved into spruce-fir communities. Moose and deer have similar seasonal patterns (Irwin, 1975).

As in the case of meadows and parks, the independent variable of distance explains a significant (70%) proportion of the dependent variable (pellet group distribution). Terrel (1973) found a significant decline in the number of mule deer observed at distances greater than 160 m from the edge of pinyon-juniper chainings. Harper and Swanson (1960) also reported that the greatest elk use occurred near the edge of logged timberland in southwestern Oregon.

Home ranges. The relationship between the size of small mammal home ranges and habitat is not clearly understood. Martinsen (1960) judged the dispersion of food plants and reproduction to be the primary factors interacting to produce temporal changes in home range size and shape. Results of this study indicate home range could be a function of cover which is provided by shorter trees, downed woody materials, and the number of plant species. Meredith (1974) reported that large home ranges occurred in low plant densities. His findings would imply that low plant densities require larger foraging areas. However, the availability of forage throughout an area might be largely a function of cover. The estimated densities of Uinta chipmunks for mature stands support this conclusion (see Table 7).

Avian Response to Community Classifications

As the coniferous forest moves through successional stages, each stage is more or less favorable to various groups of forest birds. Thus, one anticipates successional patterns in the avian fauna.

Tomoff (1974) also indicated plant species composition was highly significant in regulating breeding birds in desert shrub communities of Arizona. In this regard, silvicultural manipulations which modify succession patterns can eliminate certain bird communities from the forest mosaic. For example, if the primary objective of management is to speed up overstory rotations, then birds associated with the final stages of succession will disappear. Since the effects of such management options are generally predictable, much can be done to maintain some form of most forest bird communities.

Avian numbers

The number of bird species declined across the elevation gradient from aspen-pine to pine-spruce communities. In this study the lowest number of bird species was associated with pure stands of lodgepole pine (mean = 12.8 species). Taylor (1969) found the average number of bird species among lodgepole pine stands of various ages to be 12.3. Snyder (1950) and Salt (1957) reported approximately 14 bird species were associated with lodgepole pine dominated stands. In this study there was a slight increase in the mean number of birds counted/plot between lodgepole pine (12.8) and lodgepole-spruce (14.0) stands. Among these stand types, Salt (1957) noted a decline from 14.8 to 13.8. In both studies the number of species observed in pine-spruce stands was lower than the number observed in aspen-pine mosaics. However, a more noticeable decline is present in the total number of birds counted in each community type (Fig. 7). Salt (1957) reported mean numbers of birds/count in aspen communities to be 61.7. In spruce-fir communities he reported 14.8 birds/count.

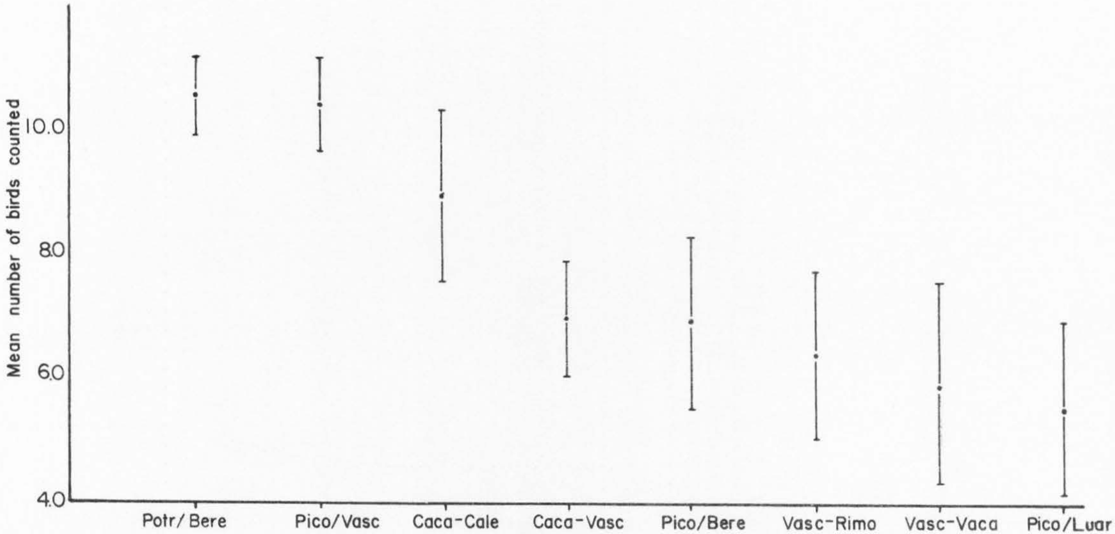


FIGURE 7. Mean number of birds counted in each community phase ($\overline{x} \pm$ s.e. ordered from left to right by decreasing bird densities).

Based on importance values (see Table 18), gray-headed juncos, gray jays, and mountain chickadees were considered to be the most abundant species in the study area. Snyder (1950) listed the mountain chickadee, ruby-crowned kinglet, hermit thrush, and gray-headed junco to be the most abundant species in the lodgepole pine communities they studied.

When foraging categories are compared, the distribution is relatively uniform among phase types (see Table 19). Nectar-feeding species were confined to the Pico-Potr/Bere phase and moist sites associated with the Caca-Cale phase. Raptors were observed in three lodgepole pine dominated phases and clearcuts. Bird species representing the foliage-insect and ground-insect categories appeared in all phases, with a particularly high number (6) of the ground-insect species observed on clearcuts.

In comparisons between all of the communities, the most abundant feeding categories were foliage-insect and foliage-seed. However, the foliage-insect feeders did not appear in the clearcuts and the foliage-seed category was absent in the Pico-Potr/Bere phase. Timber-drilling and timber-search species were also absent in the clearcuts.

Avian species

In this study statistically significant differences between community bird counts were found for the hairy woodpecker, mountain bluebird, and American robin. However, important habitat relationships exist for several species. For example, the abundance of robins, tree swallows, hermit thrushes, white-crowned sparrows, wood pewees, sapsuckers, and broad-tailed hummingbirds closely paralleled meadow edges and moisture gradients. Two of these species, the wood pewee and tree swallow, were observed only in aspen-pine canopies or near clearcut edges. White-crowned sparrows were most frequently associated with the boggy Caca-Cale sites with some willow *(Salix spp.)* present. Common flickers occurred only in aspen related stands and clearcuts. Conner and Crawford (1974) have reported that common flickers actively use clearcuts, especially the edge region, for approximately 12 years following cutting.

The elevational location of the Pien-Pico community appears to be the major factor which determines the abundance of Clark's nutcrackers in that community.

Warbling vireos, and yellow warblers were only observed in mixed deciduous-coniferous canopies. Red-tailed hawks and common nighthawks were only observed in larger clearcuts, which seem to favor their specific hunting technique. The frequency of goshawks and great horned owls was related to phases with taller trees (13 to 16 m), average crown ratios (30 to 31%), high basal areas 3.3 to 3.9 $m^2/375m^2$) and abundant songbird densities.

Among the coniferous canopies associated with the Pico/Luar, Pico/Bere, and Pico/Vasc-Vaca phases, total reduction in species numbers was attributed to the absence of the secondary consumer species (ruby-crowned kinglets, and hermit thrushes). In the Vasc-Vaca phase the absence of the pine siskin is noted. In general, these phases are characterized by shorter trees (10 to 12 m), above average crown ratios (36 to 51%), dense canopies (54 to 59% overstory), below average stem diversity (1.6 to 1.9), small herbage biomass (7 to 22 kg/ha), below average plant diversity (2.9), and small accumulations of downed woody material (5900 to 7250 kg/ha). It is obvious that any three of these traits in combination constitute poor avian habitat.

While community classifications based on the distribution of plant species are not efficient in predicting the numbers of individual bird species, they have useful implications when combined with stand structural characteristics.

Avian Response to Structural Types

It is generally accepted that most birds actively select their habitat on the basis of terrain, substrate, vegetation structure, and the arrangement of these features within the community (Cody, 1974). Using discriminant function analysis, Anderson and Shugart (1974) and others have demonstrated that some bird species are distributed according to specific habitat variables. For example, Whitmore (1975) reported that percent canopy cover and shrub density were important variables in predicting which bird species occupied a particular environment. In addition, Hooper et al. (1973) found that bird densities associated with recreational sites were directly related to forest vegetation. This study suggests that the habitat variables basal area, canopy coverage, forage production, and downed woody material are important criteria in the selection of habitats by birds in lodgepole pine communities (Tables 65 and 66).

Basal area and canopy components

Due to present trends to manage forests with shorter rotation periods, old growth stands come under strong pressure to be harvested. The results presented (see Tables 45 and 65) indicated this management

Table 45. The relationship between overstory basal area, canopy structure, and the distribution of bird species in the study area.

	Basal Area Classes ($m^2/375m^2$)					
	2.5	3.0	3.3	3.6	3.8	
Number of Species	24	17	27	25	15	
	Tree Canopy Class					
	1	2	3	4	5	6
Structural part						
Tree height (m)	13.50	13.20	17.90	11.60	10.50	8.70
Percent overstory	.54	.52	.50	.60	.53	.67
Crown ratio	.35	.33	.25	.43	.43	.40
Number of species	28	26	19	16	8	17

philosophy eliminates specific avian communities from the forest. Within lodgepole pine overstories, it is obvious that the largest number of bird species is associated with older, taller stands (see Table 45). These stands are characterized by open canopies (52 to 45% overstory) and proportionally shorter crowns (crown ratios 25 to 35%). The Clark's nutcracker was only observed in this stand type. The trends associated with ruby-crowned kinglets and mountain chickadees indicate these birds also select advanced stands.

Dilger (1956) lists the hermit thrush as a species most commonly found in the interior forest. In this study, the hermit thrush demonstrated a significant preference for stands with dense overstories and shorter trees.

Cassin's finch selected stands with high basal area (3.8 $m^2/375m^2$), while the most significant number of red-breasted nuthatches occurred on sites with low basal areas (2.5 $m^2/375m^2$). In both species, the crown ratios were small (25 to 35%) indicating a preference for long open trunks. Significant numbers of white-crowned sparrows were found in stands of average height (11.6 m) and dense crowns (60% overstory).

Large dead snags, typically found in stands with taller trees and open canopies are the preferred sites for cavity nesters such as mountain chickadees, mountain bluebirds, hairy woodpeckers, red-breasted nuthatches, and Williamson's sapsuckers. For at least the hairy woodpecker, several studies support this conclusion (Anderson and Shugart, 1974; Hagar, 1960; and Conner et al. 1975). Connors and Crawford (1974) further suggest that leaving standing snags improves habitat for cavity nesters when mature overstories are cut. Where snags are not left, relic stands are needed to provide nesting habitat for these species.

Herbage biomass and bird diversity

The number of bird species and bird diversity appears to be associated with understory herbage biomass (Table 46). The results of this study indicate that as herbage biomass increases so will the number of bird species. Cody (1968) and others have suggested that members of avian communities co-exist by virtue of differences in habitat preferences associated with feeding behavior. Kilgore (1971) found that opening the understory community by selectively thinning the sapling layer, greatly altered the bird species composition. He concluded that the understory and upper canopy were the most important feeding sites.

This study demonstrated that within the lodgepole pine forest along the north slopes of the Uinta mountains, plant species diversity is linearly correlated to bird species diversity (see Fig. 3). It was also found that community types with high bird species diversity had abundant herbage (40 to 50 kg/ha). Karr and Roth (1971) indicate that the measures for standing crop diversity and consuming biomass diversity were significantly correlated with foliage height diversity at $P \leq .05$. They further report that bird species diversity is sigmoidally related to the percent vegetation cover. Hooper et al. (1973) reported that the mean number of breeding pairs was correlated with percent understory. However, these observations do not indicate the response of specific species to the understory vegetation. In addition, some of the lodgepole pine communities such as Pico/Bere are

Table 46. The relationship between the herbage biomass component and the distribution of bird species in the study area.

	Herbage Biomass Class					
	1	2	3	4	5	6
Structural part (kg/ha)						
Grass	6.9	19.3	2.7	0.4	5.1	2.2
Forbs	18.6	65.1	5.8	4.2	1.7	3.3
Browse	5.2	4.1	2.6	1.0	3.9	42.2
Total	30.7	88.5	11.1	5.6	10.7	47.7
Number of bird species	26	22	18	7	11	19

characterized by one a single or double canopy layer.

While only statistically significant differences in the numbers of American robins were found between herbage biomass classes, other species appear closely associated with herbage biomass. For example, of the birds that appeared in more than two herbage biomass classes, the abundance of pine grosbeaks, hairy woodpeckers, and red-breasted nuthatches was associated with levels of herbage biomass between 48 to 89 kg/ha. Anderson and Shugart (1974) determined that the white-breasted nuthatch and downy woodpecker selected habitats based on understory vegetation. Mountain chickadees were most abundant at intermediate herbage levels (31 to 48 kg/ha). Gray jays were frequent on sites with low herbage biomass (6 to 11 kg/ha). Pine siskins, Cassin's finch, gray-headed juncos, western tanagers, and Townsend's solitaires did not occur on sites with high biomass (88 kg/ha). On sites producing less than 12 kg/ha, the number of bird species averages 12.

Downed woody material

Abundant downed woody material was important in the habitats preferred by the Audubon's warbler, hermit thrush, and grayheaded junco (Tables 43, 47, and 66). For the two ground nesting species, downed material, particularly branches, provided nesting cover. Other species which appeared to select sites with accumulations of downed woody material were the mountain chickadee, and ruby-crowned kinglet. Clark's nutcrackers, pine siskins, Cassin's finch, brown creepers, and goshawks were most common on sites with small amounts of downed woody (2650 kg/ha).

Table 47. The relationship between downed woody material and the distribution of bird species in the study area.

	Downed Woody Material Class			
	1	2	3	4
Structural part (kg/ha)				
0-7.6 cm branches	1600	1100	1000	820
Sound logs	1880	1820	3250	750
Rotten logs	1800	9160	3990	1090
Total downed wood	5280	9160	3990	1090
Number of bird species	23	28	18	16

Of the 30 species observed, nine species appeared in every downed woody material class. The Clark's nutcracker and broad-tailed hummingbird were observed in only one class. Hairy woodpecker numbers observed on sites with accumulated downed wood correspond to observations (Conner and Crawford, 1974) that downy and hairy woodpeckers were attracted to insects associated with abundant logging debris.

MANAGEMENT RECOMMENDATIONS

Research finding. Most vertebrates which inhabit the Barometer Watershed exhibit preferences for specific community types.

Recommendation. Timber sales should be developed by drainage, with long-term objectives that insure the distribution of a variety of communities within a drainage. Drainages of a relatively pristine nature should be maintained with the same community proportions and distribution. For drainages of this classification, environmental analyses and reports should address the specific changes resulting from management manipulations and the predicted recovery that is anticipated.

Research finding. Due to the broad definition of present habitat classifications, limited predictions can be made about the general response of wildlife populations on most sites.

Recommendation. The distribution of stem classes throughout the total basal area, grass, forbs, and browse biomass, downed woody material abundance, and overstory constituents should be included in community classifications used to predict successional trends in vertebrate densities.

Research finding. The use of park-like openings and associated peripheral timber by big game animals is closely associated with community width and edge configuration.

Recommendation. Edges developed from clearcutting should be irregular in nature (minimum edge diversity index 1.46). Clearcuts should be long and linear, with an average width approximately five times the adjacent stand height. The edges of larger cuts (<45 ha) should be selectively cut to a depth approximately three times the stand height. Buffers of uncut timber should be wide enough so the cut surface cannot be seen from within the uncut timber. The width of these buffers should approach 250 meters when it is anticipated that small rodents will interfer with regeneration.

Research finding. Big game travel lanes within a meadow complex are important to the efficient use of the complex.

Recommendation. Buffers of uncut timber around meadow and wallow complexes should be wide enough so that the meadow surface cannot be seen from within the uncut stand. Roads associated with cuts near meadows should be irregular in nature (straight line visual distance < 100 m) and have minimum road widths on historical travel lanes.

Research finding. An abundance of downed woody material enhances big game calving and resting areas.

Recommendation. Areas historically used by or areas suitable for resting and calving by big game should be identified in planning of timber sales. If cut, these areas should have contract prescriptions that prevent cutting during 1 May to 1 August. In addition, slash disposal should consist of lopping and scattering woody material up to four inch diameters. Timber access roads to these areas should be closed after tree harvest.

Research finding. The number of bird species is closely associated with understory production and diversity.

Recommendation. Timber sales should include assurance that understories associated with moist sites and selectively cut stands are protected. Part C of the sales contract should specifically define acceptable understory damage and include provisions for a variety of slash disposal methods which will enhance the desired succession of understory communities.

Research finding. Management schemes that speed up the rotation of overstories eliminate avian communities associated with the final successional stages.

Recommendation. Avoidance of relic areas representing the final stages of succession should be planned into the overall drainage sale philosophy.

Research finding. Stands of lodgepole pine, generally classed as pole stands, support sparse avian population with low diversity.

Recommendation. Pole stands should be thinned, leaving a random pattern of stem clumps.

Research finding. Most mammals that use overstory openings prefer small park-like openings (<45 ha).

Recommendations. Drainage sale philosophies should include a variety of cut sizes, with the minimum recommended standing timber buffer between each cut. This buffer will vary with stem densities and crown ratios. However, it should be wide enough to insure that the cut surface cannot be seen from within the uncut timber. Within a drainage, the general age structure, stand size, and edge diversity should not be modified.

Research finding. Mature stands with standing dead trees are required for species such as the pine martin, flying squirrel, and red squirrel.

Recommendation. Long-term sale plans should include relic areas for these species, and the development of a more open overstory by selective cutting. In addition, three to five standing snags/ha should be left in areas selected for dead wood sales.

Specific recommendations for the roadless portion of the Barometer Watershed

Research finding. The roadless part of the Barometer Watershed is relatively undisturbed. As such, it is characterized by a variety of overstory configurations and areas critical to moose, elk, and lynx.

Recommendations. (1) Between 1 May and 1 December, access into the area south of the North Slope Highway and north of the Highline Trail should be limited to foot or horseback use only.

(2) Cutting in this area should be restricted to the following limits:

a. The ratio of 15 ha opening to 85 ha overstory should be maintained.

b. Cuts should be designed that provide edge diversities between 1.55 and 1.85.

c. Cutting should be directed at development and protection of areas critical to resting, calving, breeding, and travel lanes for big game.

d. Relic areas (25-50 ha) of mature lodgepole-spruce overstories should be maintained.

e. Overstory removal and transport should be limited to the period between 1 December and 1 May.

f. No more than 3% of the commercial timber should be clearcut or selectively thinned over a five year period, and the long-term clearcut size should not exceed 40 ha.

(3) To insure the management scheme identified with the preservation of natural overstory mosaics and faunal diversities, the area south of the Highline Trail should be considered for wilderness study. Due to the accumulation of downed woody material in this area, contingency plans should limit fire to approximately 50 ha.

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APPENDIXES

Appendix A

Abbreviations for Important Plant Species

Table 48. Important species and their abbreviations for plants associated with lodgepole pine communities of the Barometer Watershed, Mountain View Ranger District, Utah.

Abbreviation	Scientific Name	Abbreviation	Scientific Name
Shrubs		Forbs	
Aruv	*Arctostaphylos uva-ursi*	Clla	*Claytonia lanceolata (Clay)*
Bere	*Berberis repens*	Copa	*Collinsia parviflora*
Juco	*Juniperus communis*	Epan	*Epilobium angustifolium*
Loin	*Lonicera involucrata*	Epbr	*Epilobium brevistylum*
Pamy	*Pachistima myrsinites*	Eqar	*Equisetum arvense (Eqca)*
Pofr	*Potentilla fruticosa*	Erpe	*Erigeron peregrinus*
Rimo	*Ribes montigenum*	Ersp	*Erigeron speciosus*
Ronu	*Rosa nutkana*	Erur	*Erigeron ursinus*
Shca	*Shepherdia canadensis*	Frvi	*Fragaria Virginiana*
Vaca	*Vaccinium caespitosum*	Gabo	*Galium boreale*
Vasc	*Vaccinium scoparium*	Geaf	*Gentiana affinis (Gent)*
		Gefr	*Geranium fremontii*
Graminoids		Gema	*Geum macrophyllum (Geum)*
Agtr	*Agropyron trachycaulum*	Geri	*Geranium richardsonii*
Bran	*Bromus anomalus*	Hahy	*Habenaria hyperborea*
Brci	*Bromus ciliatus*	Hial	*Hieracium albiflorum*
Caca	*Calamagrostis canadensis*	Higr	*Hieracium gracile*
Cage	*Carex geyeri*	Lepy	*Lewisia pygmaea*
Caro	*Carex rossii*	Lodi	*Lomatium dissectum (Carr)*
Bain	*Danthonia intermedia*	Luar	*Lupinus argentenus*
Deca	*Deschampsia caespitosa*	Lydr	*Lychnis drummondii*
Elgl	*Elymus glaucus*	Meob	*Mertensia oblongifolia*
Feid	*Festuca idahoensis*	Osde	*Osmorhiza depauperata (Osch)*
Feov	*Festuca Ovina*	Pebr	*Pedicularis bracteosa*
Juba	*Juncus baldicus*	Pepr	*Penstemon procerus*
Lusp	*Luzula spicata*	Pera	*Pedicularis racemosa*
Mebu	*Melica bulbosa*	Pewh	*Penstemon whippleanus*
Phal	*Phleum alpinum*	Phmu	*Phlox multiflora*
Phpr	*Phleum pratense*	Phse	*Phacelia sericea*
Poca	*Poa canbyi*	Pobi	*Polygonum bistortides*
Pofe	*Poa fendleriana*	Podo	*Polygonum douglasii*
Pone	*Poa nervosa*	Pogr	*Potentilla gracilis*
Sihy	*Sitaion hystrix*	Popu	*Polemonium pulcherrimum*
Stco	*Stipa columbiana*	Pych	*Pyrola chlorantha*
Trsp	*Trisetum spicatum*	Pyse	*Pyrola secunda*
		Sesp	*Sencia pseudaureus*
Forbs		Sest	*Sedum stenopetalum*
Acmi	*Achillea millefolium*	Seun	*Senicio uintahensis*
Aggl	*Agoseris glauca (Agau)*	Sipr	*Sibbaldia procumbens*
Albr	*Allium brevistylum*	Sode	*Solidago decumbins*
Anpa	*Antennaria parvifolia*	Stja	*Stellaria jamesiana*
Anro	*Antennaria rosea*	Taof	*Taraxacum officinale*
Aqca	*Aquilegia caerulea*	Thmo	*Thlaspi montanum (Drab)*
Arco	*Arnica cordifolia*	Thfe	*Thalictrum fendleri*
Arco2	*Arenaria congesta (Arc_2)*	Trlo	*Trifolium longipes*
Ardr	*Arabis drummondii (Arib)*	Vewo	*Veronica wormskjoldii*
Asch	*Aster chilensis*	Vior	*Viloa orbiculala*
Asfo	*Aster foliaceus*	Ziel	*Zigadenus elegans*
Asmi	*Astraglus miser*		
Cale	*Caltha leptosepala*	Trees	
Carh	*Castelleja rhexifolia*	Abla	*Abies lasiocarpa*
Case	*Castelleja septentrionalis*	Pico	*Pinus contorta*
Ciar	*Cirsum arvense (Cirz)*	Pien	*Picea engelmannii*
		Potr	*Populus tremuloides*

*When the computer code does not agree with the genus species abbreviation it is enclosed in parenthesis following the scientific name.

Appendix B

Key to Community Types

Anticipated habitat types are referenced to previous classification developed by:

[1]Proctor (1971)

[2]Pfister (1972)

[3]Steel, Pfister, Ryker, and Kittams (1973 & 1974).

Definition of terms

% of canopy coverage		0%	1%	5%	25%	50%	75%	100%
Representation	Absent	Poor	Common	Well	Abundant			
Coverage Class		+	1	2	3	4	5	

Table 49. Key* to selected *Pinus contorta* communities and their approximated habitat type for the Barometer Watershed, Mountain View Ranger District, Utah.

	Community type	Approximated Habitat type
1. Potr only tree present.	Potr/?	Potr/?
1. Conifers present		
2. Potr**>1% of total basal area, Pico major overstory component	Pico-Potr/Bere	Abla/Bere[2]
2. Potr <1% of total basal area		
3. Pico only conifer present, Vasc usually not present		
4. Luar well represented (>5% coverage)	Pico/Luar	Pico/Poa[1]
4. Luar poorly represented (<5% coverage)	Pico/Bere	Pico/Poa[1]
3. Pico and other conifers present, Vasc usually well represented		
5. Pien and Abla 10% of total basal area, Pico sole dominant		
6. Caca present		Abla/Vaca-Caca or Abla/Cabe-Caca
7. Cale present, Vaca common (>1% coverage).	Pico/Caca-Cale	
7. Cale absent, Vaca scarce (<1% coverage)	Pico/Caca-Vasc	Abla/Caca[3]
6. Caca absent		
8. Vaca present, Rimo absent, Caro poorly represented (<5% coverage)	Pico/Vasc-Vaca	Abla/Vasc[2]
8. Vaca absent, Rimo present, Caro usually common	Pico/Vasc-Rimo	Abla/Vasc[2]
5. Pien and Alba >10% of total basal area, Pico not dominant . . .	Pien-Pico/Vasc	Abla/Vasc[2] or Pien/Vasc[1]

* I am indebted to Dr. Robert D. Pfister for his critical review and suggestions for improving this key.

Appendix C

Overstory Summaries

Mid-point class 3.3 cm includes seedlings from 0.1 to 1.4 m tall.

Numbers of trees and basal areas are listed per 375 square meters (0.09 acre).

Species abbreviation codes are listed in Table 48.

Table 50. Overstory summaries for *Pinus contorta-Populus tremuloides* stands, Barometer Watershed, Mountain View Ranger District, Utah.

Stand Identification	Species	Mid point diameter class (cm at breast ht) 3.3	8.0	15.4	25.9	36.4	46.1	55.8	Basal Area Live	Dead
		Number of stems *Berberis repens* phase							$m^2/375m^2$	
DAF	Pico			9	10	2			1.8	
	Abla	28							.1	
	Potr	36	4	48					1.9	.2
DHM	Pico	14		34	8				2.1	
	Potr		1	9	2				.6	
GR1	Pico	69	2	6					.4	
	Abla	17	2						.1	
	Potr	26	1	9	5	1			1.1	.4
GR2	Pico	35		44	6				2.3	
	Abla	36	9	29	1				1.3	
	Potr	23							.1	
		Number of stems *Populus tremuloides* community								
DAS	Potr	18	19	30	8	3			2.8	

Table 51. Overstory summaries for stands comprised solely of *Pinus contorta* trees, Barometer Watershed, Mountain View Ranger District, Utah.

Stand Identification	Species	Midpoint diameter class (cm at breast ht) 3.3	8.0	15.4	25.9	36.4	46.1	55.8	Basal Area Live	Dead
		Number of stems (*Lupinus argenteus* Phase)							$m^2/375m^2$	
HDE	Pico	8	1	18	16	1			2.6	.2
HDW	Pico	7		11	9	2			1.8	
PIP	Pico	9	3	12	6	1			1.3	
401	Pico	129	130	48					3.3	
40E	Pico	192	9	38	6				2.5	
40W	Pico	132	2	16	11				2.0	
403	Pico	4	7	11	12	2			2.1	
		Number of stems (*Berberis rebens* Phase)								
DHR	Pico	30	33	56	5				3.0	.1
GR3	Pico	28	22	72	9				3.9	.1
ISL	Pico	28	7	23	8	1			2.0	.4
J50	Pico	135	140	57					3.8	

Table 52. Overstory summaries for *Pinus contorta/Vaccinium scoparium* stands, Barometer Watershed, Mountain View Ranger District, Utah.

Stand Identification	Species	3.3	8.0	15.4	25.9	36.4	46.1	55.8	Basal Area Live	Basal Area Dead
		Number of stems (*Ribes montigenum* phase)							$m^2/375m^2$	
DC1	Pico	2	1	5	15	3			2.4	.5
	Pien		2						.1	
	Abla	1	2						.1	
GC1	Pico	51	7	22	22	4	2		4.7	1.5
	Abla	2							.1	
GEE	Pico	23		13	9	2	1		2.2	.7
	Pien	1							.1	
JN1	Pico	221	1	20	11	1			2.5	.7
	Pien	1	1						.1	
MRM	Pico	19	20	82	4				3.7	
	Pien	2							.1	
MRI	Pico	170	1	3	8	3	1	1	2.7	.2
	Pien	26	1	1					.1	
	Abla	1							.1	
NBP	Pico	41	1	13	9	8	1	2	4.5	.3
	Pien	20	1						.1	
SBG	Pico	32		4	14	8	1		3.7	.8
	Pien	2	1	1	4				.5	

Table 52. continued

Stand Identification	Species	Midpoint diameter class (cm at breast height) 3.3	8.0	15.4	25.0	36.4	46.1	55.8	Basal Area Live	Dead
		Number of stems (*Vaccinium caespitosum* phase)							$m^2/375m^2$	
DR1	Pico	28	29	45	8				2.9	.1
	Pien	1							.1	
ET1	Pico	5	1	3	6	4			1.6	
	Pien	2							.1	
GR4	Pico	13	28	70	4				3.3	.1
	Pien	2							.1	
JUC	Pico	86	1	35	25	2			4.5	.4
	Pien	2	1						.1	

Table 53. Overstory summaries for *Pinus contorta/Calamagrostis canadensis* stands, Barometer Watershed, Mountain View Ranger District, Utah.

Stand Identification	Species	Midpoint diameter class (cm at breast height) 3.3	8.0	15.4	25.9	36.4	46.1	55.8	Basal Area Live	Dead
		Number of stems (*Caltha leptosepala* phase)							$m^2/375m^2$	
DEL	Pico	5	44	4	13	1	2		2.9	.5
	Pien	1	11						.1	
	Alba	14							.1	
GRM	Pico	81		66	18				2.4	.3
	Pien	2							.1	
HW1	Pico	123	32	10	7	3	1		2.6	.1
	Abla	2	1	2					.1	
SBW	Pico	24	21	58	9				3.4	.3
	Pien	9							.1	
ST1	Pico	230	20	82	4				3.1	
	Pien	2							.1	
ST2	Pico	70	10	13	7		3		2.4	.5
	Pien			1					.1	
		Number of stems (*Vaccinium scoparium* phase)								
AR1	Pico	44		29	17	3			3.6	.9
	Abla	13							.1	
AR2	Pico	29		27	20	4			4.0	.5
	Abla	16	1	4	1				.3	

Table 53. continued

Stand Identification	Species	Midpoint diameter class (cm at breast height) 3.3	8.0	15.4	25.9	36.4	46.1	55.8	Basal Area Live	Dead
		Number of stems (*Vaccinium scoparium* phase)							$m^2/375m^2$	
DAH	Pico	5	2	19	13	2			2.5	.6
	Pien	5		1					.1	
	Abla	4	2	3					.2	
DR2	Pico	10	9	28	8				2.0	
	Pien	2	1	1					.1	
DR4	Pico	1	3	26	13				2.4	.3
	Pien	5		1					.1	
GM2	Pico	15		14	13	1			2.1	.3
	Pien	1		1					.1	
GRE	Pico	51	1	16	11	6			3.1	.1
	Pien	6	1	2	1				.2	
GRW	Pico	62	3	17	6	4		1	2.7	.2
	Pien	31		2	1				.2	
	Abla	7							.1	

Table 54. Overstory summaries for *Picea engelmanii/Pinus contorta* stands, Barometer Watershed, Mountain View Ranger District, Utah.

Stand Identification	Species	Midpoint diameter (cm at breast height) 3.3	8.0	15.4	25.9	36.4	46.1	55.8	Basal Area Live	Dead
		Number of stems (*Vaccinium scoparium* phase)							$m^2/375m^2$	
HEB	Pico	8	2	2	5	2	1	1	1.9	
	Pien	5	5		3	2			.9	
HEE	Pico	6	1	2	3	2	1		1.2	1.2
	Pien	30		1	4	2	1		1.3	
HEN	Pico	1	2	3	5	3	1	1	2.1	
	Pien	5	4	1	3	3	1		1.4	
HES	Pico	1		5	6	3	1		1.8	.1
	Pien	3	2	1	3	3	1		1.3	
HET	Pico	25	2	4	4	1	1		1.2	.8
	Pien	34	1	4	2	1			.6	
HEW	Pico	2		2	9	7	3		3.5	.3
	Pien	15		2	3	1	1		1.0	
	Abla	2	1			2			.4	
LAP	Pico	258		1	6	4	3	1	3.4	.5
	Pien	32	1	3	2	1			.6	
UPL	Pico	1	1	7	7	3	1	1	2.5	.9
	Pien	23		2	2	1			.5	
	Abla	11		1	1				.2	

Appendix D

Aspect, elevation, slope, and understory vegetation (Tables 55-63).

Number on left of colon is percent coverage within macroplots (+ is less than 1.0%).

Number on right of colon is frequency (%) of occurence among microplots.

Basal area caclculated in $m^2/375m^2$.

Table 55. Aspect, elevation, slope, and understory vegetation associated with *Pinus contorta-Populus tremuloides* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification						
	Berberis repens phase						*Populus tremuloides* phase
	DAF	DHM	GRI	GR2			DAS*
Aspect	NE	SE	E	SE			NE
Elevation	9240	9300	8880	9160			9120
Slope (%)	15	30	8	8			2
	Stand Understory Vegetation						
Species					Const.	Freq.(%)	
Shrubs							
Aruv	.	.	2:20	+:	50	5.0	.
Bere	2:28	2:13	2:15	+:	100	11.3	.
Juco	2:10	2:5	3.63	1:5	100	20.6	+:5
Loin	.	.	+:	.	25	.	.
Potr	.	.	1:5	+:5	50	2.5	+:8
Ronu	2:8	+:	1:15	1:18	100	10.0	.
Graminoids							
Agtr	.	.	+:5	+:3	50	1.9	2:38
Bran	1:29	+:8	+:5	+:8	100	11.9	+:7
Brci	.	.	.	.	.	.	1:15
Cage	.	.	1:47	.	25	11.9	.
Caro	.	+:3	+:8	+:	75	2.5	1:80
Feid	.	.	+:5	.	25	1.3	1:10
Juba	.	.	+:10	1:8	50	4.4	.
Mebu	.	.	.	.	.	.	.
Phpr	.	.	+:3	.	25	0.6	.
Poca	.	.	+:3	.	25	0.6	+:18
Pote	.	.	+:3	.	25	0.6	1:12
Pone	.	2:20	+:5	.	50	6.3	1:27
Stco	.	+:10	+:3	+:8	75	5.0	1:17
Trsp	.	1:4	+:5	+:8	75	3.1	1:13
Forbs							
Acmi	2:3	2:23	+:28	1:53	100	26.3	2:87
Agau	.	.	.	.	.	.	+:8
Albr	.	.	+:8	.	25	1.9	.
Anro	.	.	.	.	.	.	+:3
Aqca	1:15	+:	+:5	+:3	100	5.6	+:5
Arco	2:96	2:40	+:15	2:92	100	61.3	.
Arc2	.	+:3	.	.	25	0.6	+:5
Arib	.	.	+:3	.	25	0.6	+:3
Asfo	.	1:2	2:58	1:25	75	20.6	+:5
Asmi	2:30	2:20	+:13	+:3	100	16.3	2:55
Carh	.	+:	.	.	50	1.3	1:10
Case	.	+:	.	.	25	.	1:10
Cirz	.	.	1:23	1:8	50	7.5	1:10
Epan	.	+:8	.	+:	50	1.9	.
Eqca	.	.	+:5	+:	50	1.3	.
Erpe	3:8	+:85	+:	1:	100	23.1	.
Frvi	1:5	1:2	2:32	2:35	100	18.1	.
Gabo	1:10	+:	2:48	1:20	100	19.4	1:33

Table 55. Continued

	Stand Identification						
	Berberis repens phase						*Populus tremuloides* phase
	DAF	DHM	GRI	GR2			DAS*
Aspect	NE	SE	E	SE			NE
Elevation	9240	9300	8880	9160			9120
Slope (%)	15	30	8	8			2
	Stand Understory Vegetation						
Species					Const.	Freq. (%)	
Geri	+:	.	.	+:	50	.	+:10
Luar	1:10	2:10	+:	1:18	100	9.4	2:48
Lydr	.	+:	+:5	+:3	75	1.9	.
Meob	.	.	.	.	.	.	+:12
Pepr	.	.	.	.	.	.	+:3
Phmy	.	.	.	.	.	.	+:7
Phse	.	.	.	.	.	.	+:2
Pyse	.	.	.	1:	25	.	.
Stja	.	.	.	+:5	25	1.3	+:13
Taof	.	+:3	+:8	+:5	75	3.8	+:13
Thfe	+:	+:3	2:38	+:5	100	11.3	.
Trlo	2:3	2:10	.	2:35	75	11.9	2:80
Vewo	.	.	+:8	.	25	1.9	.
Vior	.	.	.	+:10	25	2.5	1:87
Ziel	.	.	1:18	.	25	4.4	.
No. of Species	15	25	37	31	45	.	36

* Community type not replicated.

Table 56. Aspect, elevation, slope, and understory vegetation associated with *Pinus contorta/Lupinus argenteus* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification								
	HDE	HDW	PIP	401	40E	40W	103		
Aspect	W	W	N	NE	SE	S	NW		
Elevation	9730	9720	9380	9160	9220	9240	9260		
Slope (%)	13	2	1	1	1	1	6		
Species	Stand Understory Vegetation							Phase Const.	Phase Freq. (%)
Shrubs									
Aruv	.	.	+:1	.	.	2:3	.	29	0.7
Bere	.	.	+:3	.	1:2	+:	+:6	57	1.6
Juco	+:	.	.	.	.	2:4	+:	43	0.6
Rimo	+:	.	.	.	.	.	.	14	.
Vaca	1:	.	.	+:1	.	.	.	29	0.1
Graminoids									
Caro	1:5	+:3	2:28	1:3	2:9	+:3	2:8	100	9.2
Feov	.	.	+:3	+:1	.	+:11	+:1	57	2.1
Poca	.	.	.	.	.	.	+:1	14	0.2
Pone	1:10	+:19	2:35	1:23	2:32	2:34	2:62	100	32.1
Sihy	+:	+:1	+:11	+:2	+:2	+:2	+:3	100	3.3
Trsp	+:7	.	+:	.	+:10	+:11	.	57	4.3
Forbs									
Acmi	+:2	+:3	+:1	.	.	1:9	2:14	71	4.2
Anpa	.	.	.	.	.	+:2	+:2	29	3.2
Anro	+:1	.	1:5	1:1	+:14	2:18	.	71	1.6
Arco	+:23	+:6	.	2:15	2:21	2:23	2:13	86	14.8
Arc2	1:3	1:10	2:33	.	+:3	2:5	2:28	86	11.1
Arib	+:	+:3	+:10	.	+:	.	.	57	1.8
Asfo	.	.	.	+:3	+:6	+:5	+:6	57	3.5
Asmi	.	.	.	.	.	.	2:8	14	1.1
Carr	.	.	+:7	.	.	.	.	14	1.0
Copa	.	.	.	.	.	+:1	.	14	0.1
Drab	+:1	.	.	.	.	.	.	14	0.1
Epan	+:3	+:2	.	.	+:3	.	+:3	57	1.4
Epbr	.	.	.	+:3	.	+:1	+:11	43	2.1
Erpe	.	.	1:16	+:1	.	+:1	.	43	2.5
Ersp	+:3	+:	.	.	.	.	.	29	0.4

Table 56. Continued

	Stand Identification								
	HDE	HDW	PIP	401	40E	40W	403		
Aspect	W	W	N	NE	SE	S	NW		
Elevation	9730	9720	9380	9160	9220	9240	9260		
Slope (%)	13	2	1	1	1	1	6		
Species	Stand Understory Vegetation							Phase Const.	Freq. (%)
Frvi	+:8	+:2	+:1	.	+:1	+:1	.	71	1.8
Gefr	.	.	+:	.	1:2	.	2:3	43	0.7
Geri	.	.	.	.	.	+:1	+:1	29	0.2
Hahy	.	.	.	.	1:2	+:4	.	29	1.2
Higr	.	.	.	1:	+:1	+:1	.	43	0.2
Lepy	.	.	+:13	.	.	+:3	.	29	2.4
Luar	2:8	2:28	2:53	2:1	2:12	2:2	2:43	100	19.6
Lydr	.	.	+:	.	.	+:	+:1	43	0.1
Phmu	.	.	+:3	.	1:2	+:1	1:7	57	1.8
Pogr	+:2	+:1	.	.	+:1	+:1	+:2	71	0.7
Pyse	+:	.	.	.	.	.	.	14	.
Sest	+:2	+:3	+:5	.	1:1	2:3	2:13	86	3.7
Sode	+:6	+:4	+:6	1:1	2:16	2:15	2:55	100	14.6
Stja	.	.	.	.	.	.	+:1	14	0.1
Taof	.	.	+:1	.	.	.	.	14	0.1
Vior	.	.	+:1	.	.	.	.	14	0.1
No. of Species	21	14	23	13	20	28	24	42	

Table 57. Aspect, elevation, slope, and understory vegetation associated with *Pico contorta/ Berberis repens* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification					
	DHR	GR3	ISL	J50		
Aspect	N	E	W	NE		
Elevation	9180	9340	9540	9300		
Slope (%)	15	13	8	3		
	Stand Understory Vegetation				Phase	
Species					Constancy	Frequency(%)
Shrubs						
Aruv	1:8	.	.	.	25	1.9
Bere	+:	+:	+:	+:	100	0.3
Juco	1:1	.	.	1:2	50	1.3
Pamy	+:5	1:13	+:	.	75	2.8
Ronu	1:16	.	.	+:2	50	5.0
Shca	1:31	.	.	.	25	7.8
Graminoids						
Caro	+:9	+:	1:4	+:	100	3.1
Pone	+:13	+:3	1:18	1:20	100	15.6
Sehy	+:	+:	+:	+:2	100	0.6
Trsp	+:5	+:	+:4	+:3	100	3.4
Forbs						
Acmi	.	.	.	+:1	25	0.6
Anpa	+:8	.	+:1	+:6	75	4.4
Anro	+:	.	.	1:	50	.
Arco	1:16	+:45	+:3	1:55	100	30.9
Arc2	+:3	+:	+:	+:1	100	0.9
Arib	+:	.	+:	.	50	.
Copa	+:1	.	.	.	25	0.3
Epan	+:11	.	+:	+:7	75	5.3
Epbr	+:	.	.	.	25	.
Erpe	+:1	.	.	.	25	0.3
Frvi	+:1	+:	+:1	+:2	100	1.6
Gefr	.	.	.	1:12	25	4.4
Hahy	+:	.	.	+:2	50	0.6
Higr	+:	.	.	+:1	50	0.3
Lepy	.	.	.	+:2	25	0.6
Luar	.	+:5	+:6	+:	75	2.2
Lydr	+:3	.	.	+:	50	0.6
Podo	+:1	.	.	+:1	50	0.6
Pych	+:1	.	.	.	25	0.3
Sest	+:1	.	+:1	.	50	0.6
Sode	1:26	+:18	1:6	1:27	100	20.3
Taof	.	.	+:	.	25	.
No. of Species	27	11	16	22	32	.

Table 58. Aspect, elevation, slope, and understory vegetation associated with *Pinus contorta/Vaccinium scoparium - Ribes montigenum* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification									
	DCI	GCI	GEE	JNI	MRM	MRI	NBP	SBG		
Aspect	E	NE	NW	NW	NW	NW	NE	SE		
Elevation	9820	9680	9850	9500	9560	9840	9980	10100		
Slope (%)	8	10	3	8	6	4	6	5		
Species	Stand Understory Vegetation								Phase Const.	Freq. (%)
Shrubs										
Aruv	.	.	.	+:1	+:	+:	.	.	38	0.1
Bere	.	.	+:	.	.	.	.	.	13	.
Juco	1:6	1:2	.	+:1	+:	.	.	1:	63	1.4
Loin	.	+:	.	.	+:	+:	.	.	38	.
Pamy	+:1	.	.	.	.	.	.	.	13	0.2
Rimo	+:	2:16	1:1	+:1	+:	+:1	+:	+:3	100	2.8
Ronu	.	+:	.	.	+:	.	.	.	25	.
Shca	+:	+:1	.	.	.	.	.	.	25	0.1
Vasc	2:30	1:3	2:14	1:8	2:2	2:18	3:84	1:21	100	21.0
Graminoids										
Bran	2:2	.	.	.	.	.	.	.	13	0.5
Caro	1:6	1:11	1:6	1:15	1:1	1:14	1:16	1:13	100	10.0
Elgl	:4	.	.	.	.	.	.	.	13	0.7
Feov	.	+:23	.	.	.	.	+:1	+:4	38	3.8
Lusp	+:	+:2	.	.	.	+:1	+:1	+:1	63	0.7
Pofe	.	.	.	.	.	+:	.	.	13	.
Pone	+:10	1:32	1:27	1:39	+:15	1:46	1:12	1:29	100	25.8
Sihy	+:2	+:3	+:	+:	.	.	.	.	50	0.7
Trsp	+:11	1:38	+:2	1:23	+:12	1:9	1:14	1:17	100	15.9
Forbs										
Acmi	+:12	1:18	+:1	+:3	1:2	+:1	1:8	1:10	100	7.4
Agau	.	+:	.	.	.	+:1	.	.	25	0.1
Albr	+:1	.	.	.	.	.	.	.	13	0.1
Anpa	.	+:4	.	.	.	.	.	.	13	0.6
Anro	1:1	1:8	+:	+:7	+:1	+:4	+:4	+:	100	3.0
Arco	1:46	1:15	1:3	+:12	1:63	1:29	1:9	1:19	100	24.0
Arc2	.	.	1:3	+:	.	.	.	.	25	0.5
Arib	.	.	+:2	+:1	.	+:1	.	.	38	0.5
Asfo	.	1:7	.	.	+:8	+:4	.	+:6	50	2.8
Carr	.	.	.	.	.	.	+:1	.	13	0.1

Table 58. continued

	Stand Identification									
	DCI	GCI	GEE	JNI	MRM	MRI	NBP	SBG		
Aspect	E	NE	NW	NW	NW	NW	NE	SE		
Elevation	9820	9680	9850	9500	9560	9840	9980	10100		
Slope (%)	8	10	3	8	6	4	6	5		
Species	Stand Understory Vegetation								Phase Const.	Freq. (%)
Cirz	.	.	.	+:	.	.	.	+:	25	.
Drab	.	+:1	.	.	.	.	.	+:2	25	0.3
Epan	1:16	+:	1:7	+:5	+:1	+:26	+:1	+:2	100	7.4
Epbr	+:8	+:1	.	+:2	.	.	.	.	38	1.7
Erpe	+:2	1:8	+:	+:	.	.	+:4	1:	75	1.9
Erur	.	+:2	.	.	+:	.	.	.	25	0.2
Frvi	+:10	1:28	+:1	+:5	+:16	+:4	+:	+:13	100	10.0
Gabo	.	+:11	.	.	.	.	.	.	13	1.5
Geri	2:26	+:4	.	.	.	.	+:7	.	38	5.9
Geum	.	+:	.	.	.	.	.	+:	25	.
Hahy	+:9	.	.	.	.	.	.	.	13	1.7
Higr	+:	+:6	.	+:1	+:	+:8	.	+:2	75	2.3
Lepy	+:3	.	.	.	+:	+:1	+:1	.	50	0.7
Luar	+:	1:3	2:18	1:22	2:3	2:32	+:	1:8	100	10.0
Lydr	+:1	+:8	.	+:2	+:	+:	+:2	.	75	1.9
Osch	+:1	+:2	.	.	+:4	+:1	.	.	50	0.8
Pebr	+:1	.	.	.	.	.	.	.	13	0.1
Pera	1:10	+:13	+:	+:	+:	+;1	+:	+:	100	3.9
Pobi	.	+:	.	.	.	.	+:6	+:1	38	0.7
Pogr	+:2	+:19	+:	+:	+:1	+:	+:3	+:3	100	3.8
Pyse	2:9	+:	.	+:2	+:	+:5	.	.	63	2.4
Sest	.	+:1	+:8	+:	+:1	+:1	+:1	+:4	88	2.2
Seun	+:1	.	.	.	.	.	.	.	13	0.1
Sipr	+:1	.	.	.	.	.	.	.	13	0.1
Sode	+:11	1:15	1:7	+:11	+:1	1:	+:12	+:	100	7.6
Stja	+:2	+:13	.	.	.	.	+:8	+:	50	2.7
Taof	+:2	+:1	.	+:5	+:	+:	.	.	68	1.1
Vewo	.	.	.	.	.	.	.	+:3	13	0.3
Vior	.	+:5	.	.	.	.	.	.	13	0.7
Ziel	.	+:3	.	.	+:	.	.	.	25	0.3
No. of Species	36	41	20	27	28	28	24	27	58	.

Table 59. Aspect, elevation, slope, and understory vegetation associated with *Pinus contorta/Vaccinium scoparium* - *Vaccinium caespitosum* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification						
	DHA	DRI	ERI	GR4	JUC		
Aspect	E	NE	NW	NE	E		
Elevation	9820	9660	9760	9400	9320		
Slope (%)	12	14	15	12	10		
	Stand Understory Vegetation					Phase	
Species						Const.	Freq. (%)
Shrubs							
Aruv	.	.	.	.	1:8	20	0.8
Bere	.	.	.	.	+:5	20	0.6
Juco	+:	2:4	1:2	.	2:18	80	3.9
Pamy	.	+:23	.	.	.	20	7.5
Ronu	.	1:5	.	.	1:18	40	3.6
Shca	+:	+:2	.	.	+:	60	0.6
Vaca	1:3	1:4	2:20	+:8	1:10	100	10.0
Vasc	2:20	2:21	1:14	1:3	1:10	100	15.3
Graminoids							
Bran	.	.	.	.	+:5	20	0.6
Caro	+:3	+:3	1:3	+:3	+:5	100	3.1
Feov	.	+:	.	.	+:	40	.
Lusp	.	+:1	.	.	+:3	40	0.8
Pone	+:8	1:12	+:21	+:23	+:12	100	15.6
Sihy	+:	.	+:6	.	+:	60	1.9
Trsp	+:5	+:16	+:2	+:3	+:18	100	8.6
Forbs							
Acmi	.	+:13	+:3	+:	+:10	80	6.1
Anro	.	+:1	+:3	+:3	+:20	80	3.6
Arco	1:20	1:40	1:15	1:45	+:28	100	28.3
Arc2	.	+:1	1:16	+:	.	60	5.6
Arib	.	.	+:3	.	.	20	0.8
Asmi	.	.	.	.	+:	20	.
Drab	.	.	.	.	+:3	20	0.3
Epan	+:10	+:1	+:1	+:3	+:3	100	2.2
Epbr	.	.	.	.	+:5	20	0.6
Erpe	.	+:1	.	.	2:45	40	5.3
Ersp	.	1:30	.	.	.	20	10.3

Table 59. Continued

	Stand Identification						
	DHA	DRI	ETI	GR4	JUC		
Aspect	E	NE	NW	NE	E		
Elevation	9820	9660	9760	9400	9320		
Slope (%)	12	14	15	12	10		
	Stand Understory Vegetation					Phase	
Species						Const.	Freq. (%)
Frvi	+:3	+:25	+:3	+:	1:30	100	12.5
Gabo	.	.	.	.	1:25	20	2.8
Gent	.	+:3	.	.	.	20	0.8
Geri	+:	+:1	.	.	1:30	60	3.6
Hahy	.	.	.	.	+:	20	.
Higr	+:	.	.	.	+:30	40	3.3
Lepy	.	+:1	.	.	.	20	0.6
Luar	.	.	2:20	+:8	.	40	7.5
Lydr	.	+:	1:1	+:	+:5	80	0.8
Osch	.	+:	.	.	.	20	.
Pera	+:	+:9	.	.	.	40	3.1
Pewh	.	+:1	.	.	.	20	0.3
Pobi	.	+:	.	.	.	20	.
Pogr	.	+:2	.	.	.	20	0.6
Pyse	+:	+:1	.	.	+:	60	0.3
Sest	.	+:1	+:13	+:3	.	60	5.0
Sode	+:	1:24	1:18	+:5	+:	100	14.7
Taof	.	.	.	.	+:	20	0.3
Trlo	.	.	.	.	+:5	20	0.6
Vewo	.	.	.	.	+:5	20	0.6
Vior	.	+:	.	.	.	20	.
Ziel	.	+:3	.	.	+:2	40	1.4
No. of Species	16	33	18	15	34	48	

Table 60. Aspect, elevation, slope, and understory vegetation associated with *Pinus contorta/Calamagrostis canadensis - Caltha leptosepala* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification							
	DEL	GRM	HWI	SBW	ST1	ST2		
Aspect	NE	NW	NE	NW	NW	NW		
Elevation	9920	9890	9520	10140	9620	9640		
Slope (%)	5	5	5	8	2	6		
Species	Stand Understory Vegetation						Phase Const.	Freq. (%)
Shrubs								
Juco	.	1:	1:	.	+:	.	50	.
Pamy	.	.	+:1	.	.	.	17	0.3
Rimo	.	1:	1:9	+:	1:10	+:	83	0.3
Ronu	.	.	+:17	.	.	.	17	6.3
Vaca	2:8	2:5	1:12	3:30	2:45	1:10	100	10.3
Vasc	+:10	+:8	+:4	+:3	.	.	66	10.3
Graminoids								
Bran	+:5	.	1:30	.	+:10	+:3	66	13.4
Caca	2:63	2:33	1:4	1:	2:35	1:10	100	18.8
Caro	.	+:10	+:7	+:8	1:23	1:23	83	10.3
Dain	.	.	+:1	.	.	.	17	0.3
Deca	1:23	.	.	+:3	+:8	.	50	4.1
Elgl	.	.	+:8	.	+:3	+:3	50	3.1
Feov	.	.	.	.	+:3	+:3	33	0.6
Juba	+:3	+:	.	+:	+:	.	66	0.3
Lusp	+:3	+:	+:3	.	1:13	+:8	83	4.1
Phal	+:5	+:	+:3	.	+:	.	66	1.9
Pofe	.	.	.	.	1:10	.	17	1.3
Pone	1:53	+:5	1:29	1:23	1:18	1:28	100	25.6
Trsp	+:5	+:30	1:33	1:20	1:18	1:43	100	26.9
Forbs								
Acmi	1:63	+:40	2:57	2:58	2:85	2:63	100	59.7
Agau	.	.	+:3	.	.	.	17	0.9
Albr	.	.	+:8	.	.	+:3	33	3.4
Anro	+:	+:10	+:3	1:3	+:8	+:8	100	3.4
Aqca	1:30	.	+:2	.	.	.	33	4.4
Arco	1:18	1:53	1:44	2:48	1:8	+:10	100	32.5
Arc2	.	+:	.	.	.	+:3	33	0.3
Asfo	2:65	.	1:46	+:	.	+:3	66	25.6
Asmi	.	.	1:8	.	.	.	17	2.8

Table 60. Continued

	Stand Identification							
	DEL	GRM	HWI	SBW	ST1	ST2		
Aspect	NE	NW	NE	NW	NW	NW		
Elevation	9920	9890	9520	10140	9620	9640		
Slope (%)	5	5	5	8	2	6		
Species	Stand Understory Vegetation						Phase Const.	Freq. (%)
Cale	1:20	1:18	+:3	+:5	+:3	+:	100	6.9
Carh	+:5	.	+:3	.	.	.	33	1.6
Cirz	.	.	1:12	.	+:3	.	33	4.7
Drab	.	.	+:3	.	+:5	+:5	50	2.5
Epan	.	1:15	+:2	.	.	.	33	2.5
Epbr	+:5	.	.	.	1:25	1:25	50	6.9
Erpe	+:	+:35	1:;4	1:23	1:38	1:33	100	21.3
Ersp	+:	.	.	.	+:5	1:35	50	5.0
Frvi	1:15	2:42	2:47	1:8	+:10	+:8	100	27.8
Gabo	1:23	.	1:28	+:	+:3	1:33	83	17.5
Geri	+:	+:	2:72	.	.	+:	66	27.2
Higr	.	.	+:	.	.	1:73	33	9.1
Lepy	.	.	+:1	.	+:5	.	33	0.9
Luar	.	+:3	+:2	+:2	.	+:	66	0.9
Lydr	.	+:	.	+:5	+:5	.	50	1.3
Osch	.	+:3	+:9	+:3	+:3	1:10	83	5.3
Pebr	+:	.	+:1	.	.	.	33	0.3
Pera	+:5	.	+:3	.	.	.	33	1.6
Pobi	1:13	+:	+:	+:3	1:22	1:25	100	7.8
Pogr	+:18	1:8	+:15	+:10	1:30	+:6	100	14.4
Pyse	1:13	+:12	+:	+:3	.	.	66	3.4
Sesp	.	.	.	.	+:3	.	17	0.3
Sest	.	+:	.	+:3	.	+:5	50	0.9
Seun	.	+:3	.	.	+:	.	33	0.3
Sipr	1:15	.	.	.	+:25	+:10	50	6.3
Sode	.	+:	1:7	+:3	.	.	50	2.8
Stja	.	.	+:3	.	+:10	+:5	50	3.1
Taof	+:3	.	+:1	+:5	+:	+:3	83	1.6
Trlo	1:43	+:8	+:18	1:45	1:30	1:28	100	25.9
Vewo	+:10	+:8	+:4	1:	.	.	66	3.8
Vior	+:5	+:10	+:19	1:5	1:28	+:3	100	13.4
Ziel	+:13	+:8	1:13	1:5	+:3	2:48	100	14.1
No. of Species	34	33	48	30	39	36	60	

Table 61. Aspect, elevation, slope, and understory vegetation on stands in the *Pinus contorta/Calamagrostis canadensis - Vaccinium scoparium* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification									
	AR1	AR2	DAH	DR2	DR4	GM2	DRE	GRW		
Aspect	W	E	NE	N	NW	NW	NW	NW		
Elevation	9820	9850	9900	9700	9650	9810	9850	9820		
Slope (%)	3	4	8	8	2	8	3	8		
Species	Stand Understory Vegetation								Phase Const.	Freq (%)
Shrubs										
Aruv	.	.	.	+:	.	.	.	.	13	.
Bere	.	.	.	+:1	.	.	+:1	+:1	38	0.3
Juco	.	.	1:2	1:3	+:	+:	.	1:	63	0.6
Loin	.	.	.	.	.	.	.	+:	13	.
Pamy	.	.	+:1	+:6	.	.	.	.	25	0.9
Rimo	+:	1:3	.	.	.	1:1	1:14	1:7	63	2.7
Ronu	.	1:1	.	+:5	+:	.	.	.	38	0.8
Shca	.	.	+:	+:	+:	.	.	.	38	0.1
Vaca	.	.	.	.	.	.	.	+:7	13	0.9
Vasc	3:29	3:21	2:8	3:56	+:	2:10	3:32	2:33	100	24.1
Graminoids										
Bran	+:1	.	1:	.	.	.	.	+:1	38	0.2
Caca	1:4	+:2	+:1	+:3	1:4	+:3	1:3	1:2	100	2.4
Caro	+:11	1:11	+:2	+:3	1:6	1:6	1:10	1:13	100	7.6
Deca	.	+:1	.	.	+:1	.	.	.	25	0.2
Feov	.	+:2	.	.	+:	.	.	.	25	0.2
Lusp	1:4	1:4	+:	.	.	.	.	+:2	50	1.4
Pone	1:18	2:39	+:10	+:12	1:20	1:27	+:24	1:25	100	21.7
Sihy	.	.	.	+:2	+:3	.	.	.	25	0.5
Trsp	+:23	1:13	+:11	+:9	1:20	+:4	+:5	+:23	100	13.7
Forbs										
Acmi	+:10	1:29	+:1	+:	2:76	.	+:5	+:15	88	14.9
Albr	.	.	.	.	1:24	.	.	.	13	2.2
Anpa	1:5	+:2	.	.	.	.	.	.	25	2.1
Anro	1:1	1:11	+:	+:2	1:3	.	+:3	+:	88	2.3
Arco	2:33	2:52	1:54	1:38	1:7	+:12	2:38	1:40	100	35.2
Arc2	.	.	.	+:1	.	.	.	.	13	0.1

Table 61. continued

	AR1	AR2	DAH	DR2	DR4	GM2	GRE	GRW		
Aspect	W	E	NE	N	NW	NW	NW	NW		
Elevation	9820	9850	9900	9700	9650	9810	9850	9820		
Slope (%)	3	4	8	8	2	8	3	8		
Species									Phase Const.	Freq. (%)
Arib	.	.	.	.	.	+:2	.	.	13	0.3
Asfo	1:1	+:	1:13	+:1	2:56	.	+:20	1:20	88	11.7
Asmi	.	.	.	.	1:3	.	.	.	13	0.2
Cirz	.	.	+:	.	.	.	.	+:	25	.
Drab	.	.	.	.	+:3	.	.	.	13	0.1
Epan	+:1	+:1	+:11	+:10	1:10	+:1	+:9	1:21	100	7.7
Epbr	.	+:6	.	.	.	.	.	.	13	0.8
Erpe	1:33	2:24	1:1	.	+:3	.	.	.	50	8.2
Ersp	.	+:88	+:	+:3	+:	.	.	.	50	0.6
Frvi	2:28	+:15	1:2	+:4	2:38	.	1:10	1:23	88	14.3
Geri	+:2	+:1	1:10	.	+:1	.	+:	+:	75	1.8
Hahy	.	.	+:2	.	+:	.	.	.	25	0.3
Hial	1:1	.	.	.	.	.	.	+:	25	0.1
Higr	+:10	.	1:8	+:4	.	.	.	.	38	3.0
Lepy	+:3	1:2	+:3	+:3	1:13	+:	.	.	75	2.4
Luar	1:7	1:14	.	+:1	.	2:25	+:5	2:14	75	8.8
Lydr	+:	1:2	.	+:	+:1	+:	+:	+:3	88	0.8
Osch	.	1:1	+:	+:	+:	.	1:3	1:5	75	1.0
Pera	.	.	2:18	1:8	+:	+:1	+:1	+:2	75	4.1
Pewh	.	.	.	.	.	.	+:4	.	13	0.3
Pobi	+:	+:2	.	.	.	.	.	.	25	0.2
Pogr	1:14	1:11	+:	+:	1:12	.	+:4	+:3	88	5.4
Pyse	.	.	+:5	+:2	+:3	.	.	+:4	50	1.7
Sest	.	.	.	+:	.	+:1	+:1	.	38	0.23
Sipr	+:1	.	.	.	.	.	.	.	13	0.1
Sode	+:23	1:8	1:8	2:18	1:22	+:	1:4	1:45	100	16.0
Stja	.	+:1	.	.	+:5	.	+:3	+:3	50	1.3
Taof	.	.	.	.	+:1	.	.	+:1	25	0.2
Trlo	.	1:7	.	.	+:1	.	+:3	+:13	50	3.0
Vewo	.	+:1	.	.	+:3	.	.	.	25	0.3
Vior	.	+:	.	.	+:1	.	.	+:	38	0.1
Ziel	.	+:	.	+:2	1:6	.	+:	+:9	63	2.1
No. of Species	26	33	28	31	37	16	25	33	57	.

Table 62. Aspect, elevation, slope, and understory vegetation associated with *Picea engelmanii - Pinus contorta/Vaccinium scoparium* community stands, Barometer Watershed, Mountain View Ranger District, Utah.

	Stand Identification									
	HEB	HEE	HEN	HES	HET	HEW	LAP	UPL		
Aspect	NE	N	N	N	NE	W	NW	W		
Elevation	10295	10460	10420	10475	10380	10450	10120	10540		
Slope (%)	10	17	18	16	8	42	8	18		
Species	Stand Understory Vegetation								Phase Const.	Freq. (%)
Shrubs										
Juco	.	2:3	1:3	1:2	2:	3:30	+:1	1:2	88	5.3
Pamy	+:8	.	.	.	.	1:3	.	.	25	2.1
Rimo	.	.	.	.	.	+:2	.	1:	25	0.2
Vasc	5:88	5:90	5:97	5:96	5:91	4:64	4:73	5:85	100	85.0
Germinoids										
Caro	+:10	1:6	1:9	+:7	1:13	.	+:8	+:3	88	6.7
Feov	.	.	.	.	.	.	.	+:1	13	0.1
Phpr	.	.	.	.	.	.	.	+:	13	.
Poca	.	.	.	.	.	.	+:1	.	13	0.1
Pone	+:5	+:8	1:24	+:10	1:8	+:9	1:1	1:19	100	13.3
Trsp	+:2	1:10	1:17	1:8	2:11	+:2	1:15	+:4	100	9.3
Forbs										
Acmi	.	.	.	.	.	.	2:30	+:2	25	4.2
Anro	.	+:6	+:4	+:	1:12	.	1:30	+:1	75	3.4
Arco	+:25	+:33	+:23	+:21	+:38	+:16	1:54	1:48	100	33.4
Arc2	.	+:3	+:2	+:1	+:4	.	.	.	50	1.3
Arib	.	.	.	.	.	.	.	+:1	13	0.1
Asfo	.	.	+:1	+:	.	.	+:18	+:	50	2.4
Cale	.	.	.	.	.	.	+:2	.	13	0.2
Clay	.	+:1	.	.	.	+:1	.	.	25	0.2
Drab	.	+:1	.	.	.	.	.	.	13	0.2
Epan	.	+:4	+:1	+:	+:5	.	1:6	+:11	75	3.6
Epbr	+:3	.	.	.	.	.	.	.	13	0.1
Erpe	.	1:7	.	+:2	1:	.	+:	+:11	63	2.7
Ersp	.	.	.	.	.	.	+:1	.	13	0.1
Frvi	.	.	.	.	.	.	+:11	+:2	25	1.7

Table 62. continued

	Stand Identification									
	HEB	HEE	HEN	HES	HET	HEW	LAP	UPL		
Aspect	NE	N	N	N	NE	W	NW	W		
Elevation	10295	10460	10420	10475	10380	10450	10120	10540		
Slope (%)	10	17	18	16	8	42	8	18		
Species	Stand Understory Vegetation								Phase Const.	Freq. (%)
Gefr	.	.	.	.	.	.	+:4	.	13	0.6
Gent	.	.	.	.	.	.	+:1	.	13	0.1
Higr	.	.	+:1	+:	.	.	+:	+:12	50	2.1
Lepy	.	.	+:1	+:	+:10	.	+:	+:1	63	1.6
Luar	.	.	.	.	.	.	1:29	1:11	25	5.5
Lydr	.	.	.	.	.	.	+:23	1:	25	3.1
Osch	.	.	.	.	.	.	+:4	.	13	0.6
Pera	.	.	+:2	+:1	+:2	.	+:2	1:17	63	3.0
Pobi	.	.	.	.	+:	.	1:1	.	25	0.1
Pogr	.	+:1	+:1	+:	+:1	+:1	+:2	+:3	88	0.9
Popu	.	.	.	.	+:3	.	.	.	13	0.5
Sest	.	+:3	+:4	+:1	+:3	+:2	.	.	63	1.8
Sipr	.	.	.	.	+:2	.	+:	+:1	38	0.3
Sode	+:8	+:3	+:3	+:4	1:28	+:1	+:2	.	88	5.8
Trlo	.	1:5	+:5	+:1	1:25	.	.	.	50	4.2
No. of Species	8	16	17	18	19	11	27	23	39	

Table 63. Summary of elevation, overstories and understories associated with community types found in the Barometer Watershed, Mountain View Ranger District, Utah.

	Community Type								
Type	Potr*	Pico-Potr/	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/
Phase		Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc
Elevation									
Low		8880	9520	9650	9500	9320	9160	9180	10,120
Mean	9120	9145	9788	9800	9791	9592	9387	9340	10,393
High		9300	10140	9900	10100	9820	9720	9540	10,540
Trees									
Species	Mean Percent Basal Area ($m^2$375m^2)								
Pico	.	53	97	96	97	99	100	100	66
Pien	.	0	2	2	2	1	.	.	33
Abla	.	10	1	2	1	.	.	.	1
Potr	100	37	.	.	.	.	.	.	.
	Total Basal Area ($m^2/375m^2$)								
	2.8	2.9	3.2	3.0	3.4	3.2	2.2	3.2	3.2
Species	Understory Constancy								
Shrubs									
Aruv	.	50	.	13	38	20	29	25	.
Bere	.	100	.	38	13	20	57	100	.
Juco	+	100	50	63	63	80	43	50	88
Loin	.	25	.	13	38	.	.	.	.
Pamy	.	.	17	25	13	20	.	75	25
Pofr	+	50	.	.	.	.	.	.	.
Rimo	.	.	83	63	100	.	14	.	25
Ronu	.	100	17	38	25	40	.	50	.
Shca	.	.	.	38	25	60	.	25	.
Vaca	.	.	100	13	.	100	29	.	.
Vasc	.	.	66	100	100	100	.	.	100
Graminoids									
Agtr	2	50	.	.	.	.	.	.	.
Bran	+	100	66	38	13	20	.	.	.
Brci	+	.	.	.	.	.	.	.	.
Caca	.	.	100	100	.	.	.	.	.
Cage	.	25	.	.	.	.	.	.	.
Caro	1	75	83	100	100	100	100	100	88
Dain	.	.	17	.	.	.	.	.	13
Deca	.	.	50	25	.	.	.	.	.
Elgl	1	1	50	.	13	.	.	.	.
Feid	1	25	.	.	.	.	.	.	.
Feov	.	.	33	25	38	40	57	.	13
Juba	.	50	66	.	.	.	.	.	.
Lusp	.	.	83	50	63	40	.	.	.
Mebu	+	.	.	.	.	.	.	.	.
Phal	.	.	66	.	.	.	.	.	.
Phpr	.	25	.	.	.	.	.	.	13
Poca	+	25	.	.	.	.	14	.	13
Pofe	1	25	17	.	13	.	.	.	.
Pone	1	50	100	100	100	100	100	100	100
Sihy	.	.	.	25	50	60	100	100	.

Table 63. Continued

			Community Type						
Type	Potr*	Pico-Potr/	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/
Phase		Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc
Stco	1	75	.	.	.	.	.	.	.
Trsp	.	75	100	100	100	100	57	100	100
Forbs									
Acmi	2	100	100	88	100	80	71	25	25
Agau	+	.	17	.	25	.	.	.	.
Albr	.	25	33	13	13	.	.	.	.
Anpa	.	.	.	25	13	.	29	75	.
Anro	+	.	100	88	100	80	71	50	75
Aqca	+	100	33	.	.	.	.	.	.
Arco	.	100	100	100	100	100	86	100	100
Arc2	+	25	33	13	25	60	86	100	50
Arib	+	25	.	13	38	20	57	50	13
Asch	.	.	.	.	.	.	.	25	.
Asfo	+	75	66	88	50	.	57	.	50
Asmi	2	100	17	13	.	20	14	.	.
Cale	.	.	100	.	.	.	.	.	.
Carh	1	50	33	.	.	.	.	.	13
Carr	.	.	.	.	13	.	14	.	.
Case	1	25	.	.	.	.	.	.	.
Cirz	1	50	33	25	25	.	.	.	.
Clay	.	.	.	.	.	.	.	.	25
Copa	.	.	.	.	.	.	14	.	.
Drab	.	.	50	13	25	20	14	.	13
Epan	.	50	33	100	100	100	57	75	75
Epbr	.	.	50	13	38	20	43	25	13
Eqca	.	50	.	.	.	.	.	.	.
Erpe	.	100	100	50	75	40	43	25	63
Ersp	.	.	50	50	.	20	29	.	13
Erur	.	.	.	.	25	.	.	.	.
Frvi	.	100	100	88	100	100	71	100	25
Gabo	.	100	83	.	13	20	.	.	.
Gefr	.	.	.	.	.	.	43	25	13
Gent	.	.	.	.	.	20	29	.	13
Geum	.	.	.	.	25	.	.	.	.
Geri	+	50	66	75	38	60	.	.	.
Hahy	.	.	.	25	13	20	29	50	.
Hial	.	.	.	25	.	.	.	.	.
Higr	.	.	33	38	75	40	43	50	50
Lepy	.	.	33	75	50	20	29	25	63
Luar	2	100	66	75	100	40	100	75	25
Lydr	.	75	50	88	75	80	43	50	25
Meob	+	.	.	.	.	.	.	.	.
Osch	.	.	83	75	50	20	.	.	13
Pebr	.	.	33	.	13	.	.	.	.
Pepr	+	.	.	.	.	.	.	.	.
Pera	.	.	33	75	100	40	.	.	63
Pewh	.	.	.	13	.	20	.	.	.
Phmu	+	.	.	.	.	.	57	.	.
Phse	+	.	.	.	.	.	.	.	.
Pobi	.	.	100	25	38	20	.	.	25
Podo	.	.	.	.	.	.	.	50	.
Pogr	.	.	100	88	100	20	71	.	88
Popu	.	.	.	.	.	.	.	.	13

Table 63. Continued

	Community Type								
Type	Potr*	Pico-Potr/	Pico/Caca		Pico/Vasc			Pico/	Pien-Pico/
Phase		Bere	Cale	Vasc	Rimo	Vaca	Luar	Bere	Vasc
Pych	.	.	.	.	.	.	.	25	.
Pyse	.	25	66	50	63	60	14	.	.
Sesp	.	.	17	.	.	.	.	.	.
Sest	.	.	50	38	88	60	86	50	63
Seun	.	.	33	.	13	.	.	.	.
Sipr	.	.	50	13	13	.	.	.	38
Sode	.	.	50	100	100	100	100	100	88
Stja	+	25	50	50	50	.	14	.	.
Taof	+	75	83	25	68	20	14	25	.
Thfe	.	100	.	.	.	.	.	.	.
Trlo	2	75	100	50	.	20	.	.	50
Vewo	1	50	66	25	13	20	.	.	.
Vior	.	25	100	38	13	20	14	.	.
Ziel	.	25	100	63	25	40	.	.	.
No. of Species	36	45	60	57	58	48	42	32	40

* Due to the lack of community type replications, the coverage class is listed.

Appendix E

Table 64. Summary of the overstory, downed woody material, and herbage structures associated with community types found in the Barometer Watershed, Mountain View Ranger District, Utah.

	Community								
Type	Potr	Pico-Potr	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/
Phase	[3]*	Bere [12]	Cale [24]	Vasc [66]	Rimo [72]	Vaca [27]	Luar [63]	Bere [16]	Vasc [75]
Overstory component									
Percent overstory	52 (4)**	59 (6)	65 (5)	59 (3)	48 (2)	54 (8)	57 (2)	59 (11)	47 (2)
Tree height (m)	12.8(.6)	14.3(.7)	16.5(.9)	13.7(.6)	16.5(19)	11.9(.9)	10.9(.9)	10.7(1.5)	15.5(.9)
Crown ratio (%)	57 (5)	31 (4)	26 (3)	30 (5)	31 (4)	39 (4)	36 (2)	51 (5)	29 (2)
Total basal area ($m^2/375\ m^2$)	2.8(.7)	3.2(.6)	3.1(.3)	3.3(.3)	3.9(.4)	3.6(.5)	2.3(.5)	3.3(.4)	3.7(.4)
*Stem class diversity	1.9(.1)	1.8(.1)	1.2(.2)	2.2(.1)	2.1(.1)	2.0(.1)	1.7(.3)	1.6(.2)	2.3(.2)
Downed woody material									
Duff depth (cm)	3.3(.2)	2.8(.2)	2.9(.2)	1.8(.2)	1.7(.2)	1.9(.3)	2.0(.2)	2.1(.5)	1.7(.2)
Fuel height (cm)	19.6(2.2)	33.5(4.3)	22.1(3.8)	41.2(9.1)	28.5(8.9)	28.2(14.9)	26.7(7.6)	17.8(3.1)	20.3(2.5)
Twigs (kg/ha)	928	1931(110)	1120(59)	900(40)	1050(70)	1039(103)	852(88)	1376(70)	922(70)
Sound logs (kg/ha)	202	1931(268)	2459(8443)	2235(617)	2202(660)	1351(771)	334(110)	723(294)	2349(734)
Rotten logs (lg/ha)	1983	5558(2496)	8510(1494)	8414(1127)	2716(477)	4802(1138)	4802(.248)	5106(1909	3524(1541)
Total woody (kg/ha)	3113	9420(2312)	12089(1428)	11549(1420)	5968(991)	7243(1211)	5988(1211)	7205(2.29)	6795(1872)
Forage Component									
Grass (kg/ha)	18.9(1.8)	3.7(.7)	24.4(2.2)	2.6(.4)	3.7(.9)	2.0(.7)	3.1(.9)	1.8(.8)	2.8(.7)
Forbs (kg/ha)	32.5(4.7)	28.6(9.9)	42.6(9.2)	10.3(2.2)	4.6(1.1)	8.4(2.8)	6.4(2.0)	4.4(1.1)	2.6(.7)

Table 64. Continued

	Community								
Type	Potr	Pico-Potr	Pico/Caca		Pico/Vasc		Pico/		Pien-Pico/
Phase	[3]*	Bere [12]	Cale [24]	Vasc [66]	Rimo[72]	Vaca [27[	Luar [63]	Bere [16]	Vasc [75[
Browse (kg/ha)	0	8.6(.6)	6.4(4.6)	6.4(1.8)	3.1(4.8)	11.8(1.5)	.2(.2)	1.3(3.5)	58.6(6.1)
Total	51.4	40.9(9.2)	73.4(9.5)	73.4(9.5)	19.3(2.8)	22.2(2.6)	9.7(2.8)	7.5(5.5)	64.0(6.6)
Understory diversity (based on % canopy cover)	3.63(.12)	3.16(.23)	3.62(.09)	3.13(.11)	3.29(.16)	2.97(.27)	2.88(.21)	2.89(.07)	1.89(.19)
Number of understory species	36	27.0(4.5)	36.7(2.6)	28.6(2.3)	28.9(2.4)	23.2(4.3)	20.4(2.0)	19.0(3.5)	17.4(2.2)

* Sample size.

** Standard error.

Appendix F

Number of bird species associated with the overstory, basal area, forage, overstory canopy, and downed woody material structures.

Table 65. The mean number of each bird species, observed on at least two reconnaissance plots, grouped by basal area and overstory canopy, Barometer Watershed, Mountain View Ranger District, Utah.

Species	Overstory Basal Area Treatment					Overstory Structure Treatment					
	1	2	3	4	5	1	2	3	4	5	6
Clark's nutcracker			3.1			1.0	1.2				
Gray jay	2.6	3.3	1.4	4.1	2.2	2.4	2.4	2.2	4.8	2.5	2.8
Pine grosbeak	3.1	1.6	1.2	2.5	0.6	1.2	3.0	1.8	3.6		0.5
Pine siskin	0.4	2.0	1.7	1.4	1.0	1.2	1.5	1.5			1.7
Cassin's finch	1.6	0.7	0.2	0.8	3.6	2.6	1.4		0.4	2.3	1.2
Gray-headed junco	2.3	8.0	5.8	5.1	4.4	4.9	3.6	3.8	9.4	10.0	4.0
White-crowned sparrow		0.8	1.2			0.7			2.2		0.5
Empidonax spp.			0.3	0.5		0.2	0.4				
Tree swallow	0.4		0.7	0.6		0.4	0.5		1.2		
Western wood pewee	0.2		0.4	0.8		0.7	0.7				
Audubon's warbler	1.5	2.2	2.0	3.8	1.7	0.4	1.6	1.2	3.2	3.0	2.8
Ruby-crowned kinglet	2.0	1.0	1.3	0.9		0.4	2.0	0.7		2.5	1.5
Western tanager		0.2	1.1	0.4	0.7		0.6	0.3	1.0	0.8	1.0
Warbling vireo			0.3	0.9		0.2	0.6		0.2		
Yellow warbler	0.5		0.3	0.5		0.7	0.4				
Hairy woodpecker	1.2	0.3	0.3	0.8	1.3	0.4	1.1	1.1			1.0
Williamson's sapsucker	0.6		0.4		0.9	0.4	0.7	0.5			
Yellow-bellied sapsucker	0.4		0.3	0.4		0.5	0.3		0.4		
Brown creeper	0.7	0.2	0.3	0.8	0.2	0.6	0.6	0.7	0.2		
Mountain chickadee	3.1	4.1	4.8	1.0	2.3	5.2	1.5	3.2	3.0	3.0	3.0
Red-breasted nuthatch	0.9	0.2	0.2			0.3	0.4	0.5			
American robin	2.9	2.6	1.7	2.5	2.3	2.0	3.1	3.1	4.0		0.7
Chipping sparrow	2.7	0.1	2.8	2.3	1.3	0.7	3.4	1.6	3.4	0.8	1.7
Common flicker	0.4		0.5			0.7			0.4		
Hermit thrush	1.0	1.4	0.5	1.1		0.4	0.7	0.9	1.6		1.8
Mountain bluebird	0.1	2.6	1.1	0.4	0.9	1.0	2.1	1.3			
Townsend's solitaire	0.4			0.6	0.8	0.6		0.3			0.8
Broad-tailed hummingbird			0.4	0.3		0.3	0.2				0.3
Goshawk	0.6			0.4		0.2	0.4	0.3			
Great horned owl	0.1	—	0.1	—	—	—	—	0.3	—	—	0.2
TOTAL SPECIES	24	17	28	24	15	28	26	19	16	8	17

Table 66. The mean number of each bird species, observed on at least two reconnaissance plots, grouped by forage and downed woody material structural treatments, in the Barometer Watershed, Mountain View Ranger District, Utah.

Species	Forage Structural Treatments						Downed Woody Structure Treatment			
	1	2	3	4	5	6	1	2	3	4
Clark's nutcracker					1.0	1.8				2.1
Gray jay	1.8	1.7	2.2	6.3	3.5	3.2	2.8	3.0	2.0	2.3
Pine grosbeak	0.2	3.7	1.4	1.7	2.8	3.3	0.9	1.5	4.1	1.4
Pine siskin	0.8		2.3	1.7		1.3	1.5	1.2	0.5	1.9
Cassin's finch	1.8		1.6	2.0		0.9	2.5	0.4	0.6	3.0
Gray-headed junco	4.6		4.1	10.0	3.8	7.3	2.1	6.3	8.3	2.1
White-crowned sparrow	0.4	1.0				1.1	0.4	0.6	0.6	
Empidonax spp.	0.3	0.3					0.5	0.2		
Tree swallow	0.9	2.7					0.9	0.2		
Western wood pewee	0.6	2.7					1.0	0.3		
Audubon's warbler	2.1	1.0	1.1	2.7		2.0		2.6	2.0	0.9
Ruby crowned kinglet	1.1	1.3	1.2			1.4		1.1	2.8	0.5
Western tanager	0.7		0.6		1.0	0.2	0.5	0.5	0.8	0.3
Warbling vireo	0.2	2.3					0.3	0.3		
Yellow warbler	0.6	1.3					1.0	0.2		
Hairy woodpecker	0.7	2.3	0.9		1.3	0.3	0.9	1.0		0.8
Williamson's sapsucker	0.9	2.0					0.6	0.3	0.8	
Yellow-bellied sapsucker	0.6	1.0					0.8	0.2		
Brown creeper	0.1	0.7	0.6		0.3	0.8		0.5	0.5	0.7
Mountain chickadee	4.6	2.0	2.8		1.0	3.9	2.3	3.8	5.0	1.3
Red-breasted nuthatch		1.3	0.3			0.5		0.1	1.0	0.4
American robin	2.1	5.0	0.6	4.7	1.5	3.8	3.8	2.0	2.1	2.3
Chipping sparrow	2.0	2.7	3.2		2.3	0.3	1.6	2.8	1.3	1.3
Common flicker	0.4	1.3					1.0	0.1		
Hermit thrush	0.4	1.0	1.4			0.9		1.3	1.0	
Mountain bluebird	1.4	1.3	1.2		2.8		3.0	0.8	1.1	
Townsend's solitaire			1.1				1.4	0.2		
Broad-tailed hummingbird	0.4	0.7					0.4			
Goshawk			0.5			0.2		0.1	0.4	0.4
Great horned owl	0.1					0.3	0.4	0.1		
TOTAL SPECIES	26	22	18	7	11	19	23	28	18	16

Appendix G

Table 67. List of reconnaissance and permanent plot symbols and map locations* (refer to Fig. 1 for approximate map location).

Symbol	Map Location				
AR1	SW/4	NE/4	SEC. 25	T. 3 N.	R. 13 E.
AR2	NW/4	SE/4	SEC. 25	T. 3 N.	R. 13 E.
BRD	NE/4	NE/4	SEC. 20	T. 3 N.	R. 14 E.
DAH	NE/4	SW/4	SEC. 27	T. 3 N.	R. 14 E.
DAS	NW/4	NE/4	SEC. 27	T. 3 N.	R. 14 E.
DAF	SW/4	SW/4	SEC. 27	T. 3 N.	R. 14 E.
DC1	NE/4	SW/4	SEC. 28	T. 3 N.	R. 14 E.
DEL	SE/4	SE/4	SEC. 28	T. 3 N.	R. 14 E.
DHA	SW/4	NE/4	SEC. 28	T. 3 N.	R. 14 E.
DHM	SW/4	NE/4	SEC. 28	T. 3 N.	R. 14 E.
DHR	NE/4	SW/4	SEC. 15	T. 12 N.	R. 115 W.
DR1	Sw/4	NE/4	SEC. 28	T. 3 N.	R. 14 E.
DR2	Ne/4	NE/4	SEC. 21	T. 3 N.	R. 14 E.
DR4	SE/4	SE/4	SEC. 21	T. 3 N.	R. 14 E.
ET1	NW/4	SW/4	SEC. 36	T. 3 N.	R. 13 E.
GC1	SE/4	NW/4	SEC. 34	T. 3 N.	R. 13 E.
Gee	SE/4	NE/4	SEC. 35	T. 3 N.	R. 13 E.
GM2	NE/4	SE/4	SEC. 35	T. 3 N.	R. 13 E.
GRE	SE/4	SE/4	SEC. 35	T. 3 N.	R. 13 E.
GRM	SW/4	NE/4	SEC. 35	T. 3 N.	R. 13 E.
GRW	SE/4	SE/4	SEC. 35	T. 3 N.	R. 13 E.
GR1	Sw/4	SW/4	SEC. 8	T. 12 N.	R. 115 W.

Table 67. Continued

Symbol	Map Location				
GR2	NW/4	SE/4	SEC. 18	T. 12 N.	R. 115 W.
GR3	SE/4	SE/4	SEC. 24	T. 12 N.	R. 116 W.
GR4	NW/4	SE/4	SEC. 14	T. 3 N.	R. 13 E.
HDE	NW/4	SW/4	SEC. 25	T. 3 N.	R. 13 E.
HDW	NE/4	NE/4	SEC. 26	T. 3 N.	R. 13 E.
HEB	SW/4	SW/4	SEC. 25	T. 2 N.	R. 13 E.
HEE	NW/4	NW/4	SEC. 36	T. 2 N.	R. 13 E.
HEN	NW/4	NW/4	SEC. 36	T. 2 N.	R. 13 E.
HES	SW/4	NW/4	SEC. 36	T. 2 N.	R. 13 E.
HET	NW/4	NW/4	SEC. 36	T. 2 N.	R. 13 E.
HEW	NE/4	NE/4	SEC. 35	T. 2 N	R. 13 E.
HW1	NE/4	SE/4	SEC. 32	T. 3 N.	R. 13 E.
ISL	SW/4	SE/4	SEC. 15	T. 3 N.	R. 13 E.
JN1	NE/4	SW/4	SEC. 24	T. 3 N.	R. 13 E.
JUC	NE/4	SW/4	SEC. 22	T. 3 N.	R. 14 E.
J50	SW/4	NE/4	SEC. 18	T. 12 N.	R. 114 W.
LAP	NW/4	SW/4	SEC. 15	T. 2 N.	R. 13 E.
MRI	NW/4	SE/4	SEC. 35	T. 3 N.	R. 13 E.
MRM	NW/4	SE/4	SEC. 21	T. 3 N.	R. 14 E.
NBP	NE/4	SE/4	SEC. 10	T. 2 N.	R. 13 E.
PIP	SE/4	SE/4	SEC. 24	T. 12 N.	R. 115 W.
PUS	SE/4	SE/4	SEC. 22	T. 3 N.	R. 13 E.
SBG	SE/4	NW/4	SEC. 15	T. 2 N.	R. 13 E.

Table 67. Continued

Symbol	Map Location				
SBW	SW/4	SE/4	SEC. 15	T. 2 N.	R. 13 E.
ST1	NW/4	NW/4	SEC. 32	T. 3 N.	R. 13 E.
ST2	NE/4	NE/4	SEC. 31	T. 3 N.	R. 13 E.
UPL	SE/4	SW/4	SEC. 22	T. 2 N.	R. 13 E.
40E	SW/4	NE/4	SEC. 18	T. 12 N.	R. 114 W.
40W	NW/4	SE/4	SEC. 18	T. 12 N.	R. 114 W.
401	NE/4	NE/4	SEC. 24	T. 12 N.	R. 115 W.
403	SW/4	SE/4	SEC. 24	T. 12 N.	R. 115 W.

* The Salt Lake Base Meridian is the reference point for map locations. All plots are located on the Buck Fever Ridge, Table Mountain, Kings Peak, Utah, and Mount Powell, Utah, 7.5 minute series (Topographic) quadrangles.