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WILDLIFE FOOD HABITS AND HABITAT USE ON REVEGETATED STRIPMINE LAND IN ALASKA

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WILDLIFE FOOD HABITS AND HABITAT USE ON REVEGETATED STRIPMINE LAND IN ALASKA

A

THESIS

Presented to the Faculty of the University of Alaska in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

By

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Fairbanks, Alaska

May 1984

WILDLIFE FOOD HABITS AND HABITAT USE ON REVEGETATED

STRIPMINE LAND IN ALASKA

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ABSTRACT

Food habits and habitat utilization of wildlife species on revegetated stripmine spoils in interior Alaska were studied from 1980 through 1982. Current reclamation techniques were beneficial for tundra voles, short-eared owls and marsh hawks. Caribou, Dall sheep, red fox, coyote, wolf, arctic ground squirrel, waterfowl, and various raptorial birds derived partial benefit from the reclaimed areas. The seeded grasses functioned as minor items in the diets of herbivores while reclaimed sites served as hunting areas for the various carnivores and raptors. Moose, snowshoe hare, red-backed voles, willow ptarmigan and most nongame birds were adversely impacted by the reclaimed areas. Woody vegetation and its associated attributes such as cover and food were the essential habitat components missing from the reclaimed areas.

Stripmining and reclamation procedures currently practiced in interior Alaska result in the formation of 'islands' of grassland interspersed throughout the natural habitat. The availability of undisturbed habitat adjacent to small sized, seeded areas, has made it possible for wildlife to take advantage of the reclaimed sites and still have a sufficient amount of natural food and cover available with which to meet the nutritional and habitat needs of the animal. The detrimental effects of current reclamation procedures increase as the amounts of land disturbed by mining become very large. Present reclamation procedures create grasslands on disturbed sites. As the size of the disturbed area

and subsequent areas of revegetation increases, the resulting loss of native forage and habitat will be very detrimental to the local wildlife. This adverse effect could be ameliorated if reseeded areas are interspersed with trees and shrubs. If recreating wildlife habitat is the major goal of reclamation, it is recommended that the creation of a diverse vegetative structure should be considered as important as the establishment of a ground cover.

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INTRODUCTION

The exploration and development of Alaska has been greatly affected by the region's mineral wealth. The quest for gold in the 1800's, and its subsequent environmental and social impacts, is perhaps the best example of how mineral induced change has influenced the state. Today petroleum exploration and development are the dominant extractive industries (Bliss and Klein 1981); but another natural resource looms as a major factor in Alaska's economic future-- coal.

Interest in Alaskan coal is nothing new, as underground mining started in 1855 at Port Graham on the Alaskan Peninsula (Naske and Triplehorn 1980). As the demand for coal increased and new equipment was developed, underground mining was gradually replaced by open-pit or stripmining. By 1960, underground coal mining had virtually ceased in Alaska (Conwell 1976). Interest in surface mining generally declined during the 1960's, but within the last decade the demand for domestically available energy and energy independence from Middle Eastern countries has refocused attention on Alaskan coal. Alaska's coal reserves have been estimated by state officials to equal the world's known oil reserves in energy equivalence and are almost half of the nation's known coal reserves.

Realizing that coal mining regulations in the contiguous United States may be unsuited to Alaska's northern environment, Congress commissioned the National Academy of Sciences to evaluate the Surface Mining Act of 1977 with respect to Alaska's unique conditions.

The National Research Council was assigned to conduct the study. One of the Research Council's committees, the Committee on Alaskan Coal Mining and Reclamation, examined the effects of coal mining and reported:

> The effects of coal mining on wildlife in Alaska are essentially unknown, and although there is some information on the effects of mining near Healy and from construction activities in several other areas of the state, any assessment of impacts specifically from coal mining must be considered speculative (National Research Council 1980:95).

The value of stripmined lands as wildlife habitat in the contiguous United States has been known for many years (Yeager 1942; Riley 1957; Samuel 1979). Characteristics of surface mined lands that are considered attributes of good wildlife habitat are, topographic diversity, irregularity of vegetation, interspersion of microhabitats and open water bodies (Suchecki and Evans 1978). If wildlife options involving reclamation are to be promoted, their value and feasibility must be established. It must be demonstrated that creation of good wildlife habitat is an attainable product of reclamation, has intrinsic value, can be economically feasible, and is a viable land use alternative. These attributes have been demonstrated for surface mined lands in the coal areas of the eastern and western portion of the United States, but such information for Alaska is nonexistent. The purpose of this study was to provide baseline data concerning wildlife responses to, and use of, revegetated stripmine lands in Alaska. The specific objectives were: 1) to determine the diets of wildlife species utilizing the revegetated stripmine spoils on the Usibelli Coal Mine, Inc., interior

Alaska; 2) to determine what plant species used in present reclamation work are utilized and are important to each animal species on the mine area; 3) to determine if the individual animal diets (including the reseeded plant species) reflect comparable nutritional levels as have been reported for the same wildlife species on corresponding undisturbed, natural habitats; and 4) to recommend how present reclamation methods be altered (or what features and practices retained) to better meet the dietary and habitat needs of wildlife on present and future mining areas.

STUDY AREA

The principal study area was the Usibelli Coal Mine, Inc., located 13 km east of Healy, Alaska (Fig. 1). The Healy area is relatively diverse as it is situated within the northern foothills of the Alaska Mountain Range. Elevations in the region range from 396 m to 914 m. The study area is dissected by a number of streams, the largest being Healy Creek (Fig. 2). Much of the vegetation existing on the study area is within the broadly defined vegetation associations that correspond to the level II classification of Viereck and Dyrness (1980) (Fig. 3).

The conifer forest cover type is a combination of open and closed spruce forest. The open spruce forest is located on upland terraces and consists of sparsely distributed low-growing spruce and low to prostrate growing shrubs. Principal trees and shrubs include black and white spruce (<u>Picea</u> <u>mariana</u> and <u>P</u>. <u>glauca</u>), quaking aspen (<u>Populus</u> <u>tremuloides</u>), mountain cranberry (<u>Vaccinium</u> <u>vitis-idaea</u>),

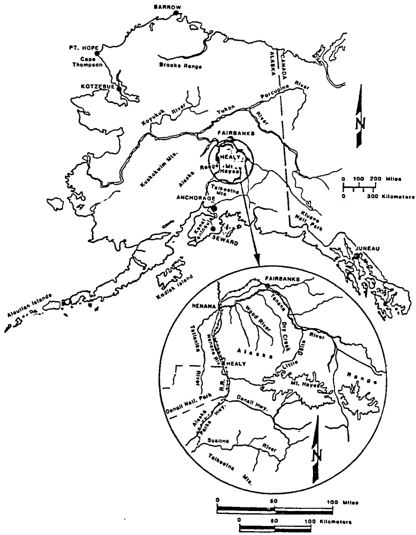


Fig. 1. Location of Healy study region, southcentral Alaska.

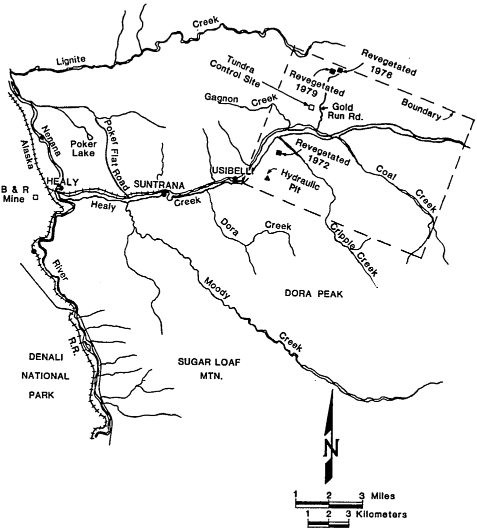


Figure 2. Location of Usibelli Coal Mine, Inc., and B & R Mine study sites.

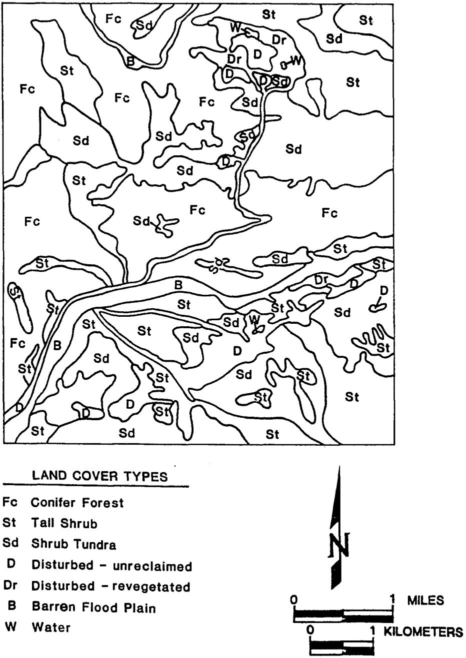


Figure 3. Cover type classification of principal study areas. Area outlined by dashed line on Fig. 2 represents the area depicted in this figure.

willow (Salix spp.), birch (Betula spp.), blueberry (Vaccinium spp.), and alpine bearberry (Arctostaphylos alpina). The closed spruce forest is characterized by dense stands of mature spruce occurring along drainages, ridges, terraces, and south-facing slopes. The tall shrub cover type consists of an alder (Alnus crispa)- willow (Salix alaxensis) association. This habitat occurs most frequently at the bases of north-facing terraces and along creek drainages and floodplains. The tall shrub cover type was also prevalent on the sites disturbed by mine-related activities (eg. road building, active mining) that were never reclaimed but allowed to revegetate via natural succession. The gravelly-rocky areas associated with the main channel of Healy Creek were designated 'barren floodplain'. The disturbed and reclaimed cover type represents the sites on the mine that have been seeded with graminoids and forbs. A disturbed and unreclaimed cover type represents areas which have been disturbed by mining and as yet not reclaimed (the areas support little to no vegetation). The shrub tundra cover type was typified by the glandular birch (Betula glandulosa) and ericaceous shrub - sedge association. A 12 ha study plot was established on the shrub tundra cover type to serve as a 'control' area (the plot will hereafter be referred to as the tundra control site/area).

A reclamation program was instituted in 1972 on the Usibelli Mine. At present there are approximately 1000 ha of reclaimed land. The largest revegetated areas were seeded in 1972, 1976, and 1979. Study plots selected for these areas measured 10, 12, and 12 ha, respectively (Fig. 2).

A brief description of the mining and reclamation procedures used on the Usibelli Mine will provide the background necessary for assessing current reclamation benefits to wildlife.

Current mining activities on the Usibelli Coal Mine are concentrated in the Lower Lignite Creek Basin (Fig. 2). This area contains the Suntrana formation, six layers or 'seams' of coal (designated by numbers one through six-- the lower seam being number one). Coal seams six, four, and three are presently being mined and hold the bulk of surface mineable reserves for the Lower Lignite area (Denton 1980). The soil covering a coal seam (the 'overburden') is removed with a dragline. This is accomplished by making a cut 1220 m (4000 ft) long and 30.5 m (100 ft) wide. Cut number one starts with the original ground surface, taking that amount of overburden and sidecasting it. Cut number two, which would occur when the next coal seam is uncovered, would then place the overburden from the upper seam into the hole made when the coal was removed. As the coal is removed and the dragline progresses along the seam, the remaining overburden piles are graded to, or near, original contour and revegetated. For a more explicit description of the mining techniques employed on the Usibelli Mine see Usibelli (1980).

Areas to be revegetated are scarified and furrowed. Grass seed and fertilizer are aerially applied to the site in late May. The fertilizer currently in use is composed of granular urea, phosphorus, and potash (potassium), applied at the ratio of 32:16:6. Plants seeded on the three study sites are listed in Table 1.

Table 1. Composition of seed mixture applied to revegetated study areas, Usibelli Coal Mine, Healy, Alaska. Date indicates year site was seeded. X indicates species was planted in that year.

Plant Species (Common Name)	1972	1976	1979
Alopecurus pratensis (Meadow Foxtail)	X		X
Agropyron cristatum (Crested Wheatgrass)	X	X	X
Agropyron spp. (Pubescent Wheatgrass)		X	
Astragalus cicer (Cicer Milk-vetch)		X	
Brassica campestris (Field Mustard)		X	X
Bromus inermis (Manchar Bromegrass)	X	X	X
Calamagrostis canadensis (Bluejoint)	X		X
Festuca arundinacea (Alta Fescue)		X	
Festuca elaitor (Meadow Fescue)	X	X	X
Festuca ovina var. duriuscula (Hard Fescue)	X	X	X
Festuca rubra (Boreal Red Fescue)	X	X	X
Lolium perenne (Tetraploid Perennial Ryegrass)	X	X	X
Lolium perenne (Common Perennial Ryegrass)		X	
Lolium temulentum (Common Annual Ryegrass)	X	X	X
Lotus corniculatus (Leo Birdsfoot Trefoil)		X	
Medicago sativa (Alfalfa)	X	X	X
Onobrychis viciaefolia (Melrose Sanfoin)		X	X
Pisum sativum (Winter Pea)		X	
Phalaris arundinacea (Reed Canarygrass)	X	X	

Table 1 (continued)

Plant Species (Common Name)	1972	1976	1979
Phleum pratense (Climax Timothy)	X	X	
Poa compressa (Canada Bluegrass)		X	X
Poa pratensis (Kentucky Bluegrass)	X		
Trifolium hybridum (Alsike Clover)	X	X	X
Trifolium repens (White Dutch Clover)	X	X	
Vicia villosa (Hairy Vetch)		X	X

As a consequence of the site preparation and fertilization the seeded grasses and forbs take root and develop in the bottom of the furrows, resulting in the reclaimed areas resembling plowed agricultural fields (Fig. 4). As time progresses many of the originally seeded plants die-off, until the sites become dominanted by a combination of six species of grasses (ie. Alopecurus pratensis, Festuca rubra, Calamagrostis canadensis, Bromus inermis, Phleum pratensis, and Poa spps.). Evidence of natural invasion on a reclaimed site was rare. On the oldest site examined (the 1972 reclaimed area), fireweed (Epilobium spp.), Carex spp., meadow horsetail (Equisetum arvense) and Grass-of-Parnassus (Parnassia palustris) were the only nonseeded native species present after nine years.

Present land use on the revegetated areas are hunting, wildlife viewing, and off-road vehicle use. Dall sheep (Ovis dalli) are a protected species on the mine but caribou (Rangifer tarandus) and moose (Alces alces) are actively hunted.

The B & R Mine site is situated 6 kms west of Healy, Alaska (Fig. 2). The mine was originally brought into production in 1943, and operated intermittently until 1971. The study area was located on the lower mine section (elev. 640 m), accessible by the Otto Lake Road.

The entire mine area has been revegetated through natural succession. The study area vegetation corresponded to Viereck and Dryness's (1980) level II shrubland - tall shrub- closed tall shrub categories. Salix alaxensis and Alnus crispa were the major shrub species; sedges (Carex spp.), cottongrass (Eriophorum spp.), and bluejoint (Calamagrostis canadensis) were the major understory species.

Present land use practices on the area are primarily associated with recreation. Off-road vehicles use the mine area in the summer while hunting constitutes the main fall and winter use.

Soils in the Healy area are a Pergelic cryaquepts-Pergelic cryochrepts association. Pergelic cryaquepts have permafrost at some depth but do not have a thick peaty accumulation on the surface. The depth of summer thaw varies, some areas having a permanently unfrozen zone between the bottom of the seasonally frozen soil and the permafrost table. This occurs particularly where the vegetative cover and any thin organic mat has been removed. In interior Alaska pergelic cryaquepts are mostly on alluvial plains, glacial moraines, or outcrops of coarse-grained rock (Rieger et al. 1979:40). Pergelic cryochrepts have mean annual temperatures below freezing, but in most of these soils the permafrost is relatively deep. They occur on ridges, escarpment edges, steep slopes, and other sites with good surface drainage in alpine tundra areas. The soils are almost always gravelly (Rieger et al. 1979:44).

Mean ambient temperatures on the Usibelli Mine area fluctuate from highs of 18 to 23 C in July to a low of -31 C in December (Table 2). Average precipitation during the summer months ranges from 4 to 14 cm (Table 3).

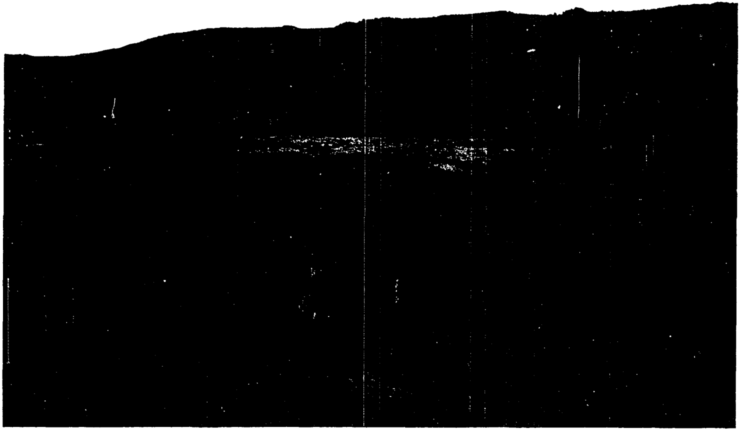


Figure 4a. 1972 revegetated study area, Usibelli Coal Mine, Healy, Alaska, 1980.

Figure 4b. 1976 revegetated study area, Usibelli Coal Mine, Healy, Alaska, 1980.

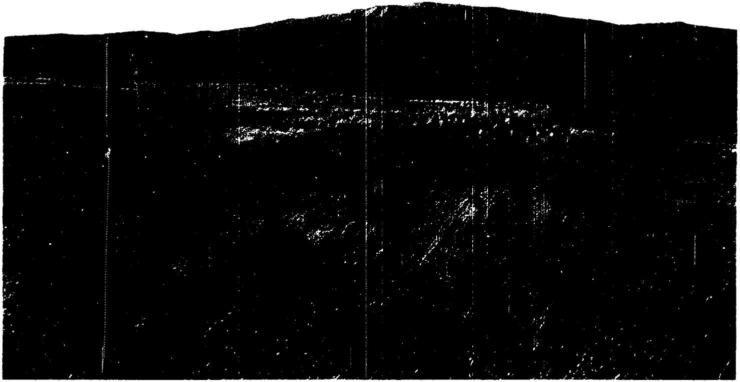


Figure 4c. 1979 revegetated study area, Usibelli Coal Mine, Healy, Alaska, 1980.

Table 2. Average maximum/minimum temperatures (°C) at the Poker Flats (PF) and Goldrun (G) weather stations, Usibelli Coal Mine, Healy, Alaska, 1978-1982.

	1978	1979		1980		1981		1982	
Month	PF	PF	G	PF	G	PF	G	PF	G
Jan.	-	-5/-13	-	-15/-24	-	-3/-8	-	-16/-26	-
Feb.	-	-24/-34	-	-4/-14	-	-8/-13	-	-13/-21	-
March	3/-14	-4/-16	-	-3/-12	-	4/-1	-	-5/-14	-
April	11/-7	7/-5	-	7/-7	-	4/-5	-	-1/-9	-
May	18/0	20/6	-	13/1	-	15/7	-	7/-2	-
June	17/4	20/7	17/6	19/5	19/6	16/7	18/5	13/4	15/7
July	23/6	22/10	20/8	23/7	22/8	16/9	15/8	15/6	17/10
August	19/3	21/11	18/9	17/4	15/4	16/7	13/6	12/3	15/7
Sept.	13/2	12/4	-	8/0	-	9/1	-	7/-1	-
Oct.	2/-10	6/-1	-	1/-5	-	-1/-5	-	-10/-16	-
Nov.	-4/-14	2/-5	-	-10/-13	-	-7/-15	-	-11/-17	-
Dec.	-6/-14	-17/-26	-	-26/-31	-	-10/-17	-	-10/-18	-

Table 3. Average precipitation (cm) at the Poker Flats (PF) and Goldrun (G) weather stations, Usibelli Coal Mine, Healy, Alaska, June-August, 1979-1982.

	1979		1980		1981		1982	
Month	PF	G	PF	G	PF	G	PF	G
June	7.9	8.8	11.1	15.4	4.9	8.1	8.4	7.8
July	5.6	3.9	5.7	8.7	9.3	12.1	9.8	13.5
August	8.7	9.8	7.3	9.7	8.3	7.8	3.7	3.8

METHODS

Vegetation Analysis

Vegetative biomass on the three revegetated study areas and tundra control site was determined by clipping and bagging the vegetation from a predetermined number of 0.25 m^2 plots, drying the vegetation for 42 hrs at 27 C, and separating the contents of each plot into individual species. Plots were combined and the amount of each species was weighed. The areas were sampled the first week of July 1981. Preliminary sampling in 1980 determined that 30 plots clipped on the 1972 study site, 33 plots on the 1976 site, 39 plots on the 1979 site, and 25 plots on the tundra control area, were required to be 95% certain the mean biomass determined per site was within 25% of the true mean for the single most abundant plant species on each area (Subcommittee on Range Research Methods of the Agricultural Board 1962:230). A 50 X 50 cm (0.25 m^2) plot was used to reduce the 'edge effect' encountered when sampling in tall grass vegetation (Tadmor et al. 1975).

Vegetation sampling plots were randomly located using the following procedure. From the northern boundary of each study area, a north-south transect line was established through the middle of the site. The starting point for plot placement was located 5 m from the northern end of the transect line. From this point, the location of a 0.25 m^2 plot was determined by multiplying the transect length by a two digit random number. The random number was regarded as a percent. The resulting product designated a distance from the starting point on the transect line to a sampling location. Sample plots were placed alternately to the right or left of the transect line. Duplicate random numbers were dropped and a new number selected. Before clipping, the litter depth in each sample plot was measured. The depth at each corner and center of the plot was measured to the nearest centimeter.

Cover on the study sites was determined using the point-frequency frame (Subcommittee on Range Research Methods of the Agricultural Board 1962:62). This method was chosen because of its usefulness in meadow and tall grass vegetation (Muller-Dombois and Ellenberg 1974:86) and because of its proven effectiveness on the furrowed soil of stripmine revegetated areas (Hofmann et al. 1978).

A ten pin sampling frame was constructed, each pin 4.5 cm apart. Fifty frames (500 sample points) per site were randomly located on each study area using the method outlined for biomass determination. Five hundred points (per site) have been found to give a reliable analysis of the dominant plant species and a reasonably good estimate of the subdominants and less important species in a pasture setting (Brown 1954:73).

The point frame was placed perpendicular to the transect line. Hofmann et al. (1978) determined that as long as point frames were placed completely at random, the orientation would have little influence on the data produced. Each pin in the frame was pushed downward and the first item contacted by the pin recorded.

Density of shrubs in three tall shrub cover types was determined by placing ten, 5 m^2 quadrats per study area. The 5 m^2 quadrat size was recommended by Oldemeyer and Regelin (1980) for use in Alaska. The amount of shrub utilization by wildlife was determined using the Shafer Twig-count method (Shafer 1965; Wolff 1976). Browsing reach was considered to be between 50 cm and 5 m above the ground (Wolff 1976).

Cover of woody vegetation was determined using the point-intercept method. An overhead point sampler was used. This consisted of a periscope-like apparatus which enabled the observer to view the canopy through a 4X rifle scope. When held at eye-level, the view through the device was of a spot above the observer's head, the center of the spot dissected by the cross-hairs of the rifle scope. Using the spot where the cross-hairs intersected as a point, 100 randomly located points were sampled for cover determination in three tall shrub and coniferous forest cover types and three areas on the B & R Mine site.

The density of tree species on three conifer areas were determined using the point-centered quarter method (Dix 1961). Forty points were sampled in each location; the 10 m distance between points and method of analysis followed the procedure described by Wolff (1980). Cover was determined using the point-intercept device outlined above.

Vertical foliage density (VFD) is a measure of security cover--the amount of cover occurring at eye-level between a prey species and predator. Foliage density was measured using a checkerboard placard (for dimensions and photograph see Wolff 1980) placed at ground level 10, 20, 30, 40, and 50 m from the observer. The total number of squares obstructed by vegetation at each distance were counted. Five cover types on the Usibelli Mine, and the B & R site, were sampled in December 1981, before leaf development to obtain a measure of VFD during winter conditions and again in July 1981, to obtain a VFD for the summer.

An estimation of the time required for shrub reinvasion of revegetated and unreclaimed sites was obtained by cutting a representative sample of shrub species found on the areas off at ground level and counting the growth rings. The dendrological analysis method is described by Giddings (1940).

Diet and Habitat Analysis

Percent composition of plants in the diets of caribou, moose, Dall sheep, willow ptarmigan (Lagopus lagopus), arctic ground squirrels (Spermophilus parryii), and snowshoe hares (Lepus americanus) were determined by microhistological examination of fecal material (Hanson and Flinders 1969). Holechek et al. (1982) reviewed the advantages and disadvantages of using fecal analysis for diet determination. Two of the advantages are that it does not interfere with normal habits of the animal and is a nonconsumptive technique (no animals need be killed). Major drawbacks with fecal analysis are that preference indices cannot be accurately assigned because where the food was consumed cannot be determined; and those forage species that are the most digestible often are under-represented in the feces. Microtine diets were determined using the microtechnique but instead of fecal matter, stomach contents of trapped animals were analyzed.

Two alterations were made in the procedure of Hanson and Flinders (1969). Diet slides were prepared using Naphrax high resolution diatom mounting medium (Northern Biological Supply, Martlesham Heath, Ipswich, England) instead of Hertwig's and Hoyer's solution. Five slides per sample, and 20 locations per slide were examined in order to estimate the major species in the diet (Holechek and Vavra 1981).

The percent composition of each plant species identified in the diet was determined following the method outlined by Holechek and Gross (1982). The number of frequency observations of each plant species identified was divided by the total number of frequency observations for all species. This number multiplied by 100 gives the percent by weight composition of the diet.

Fecal matter for caribou diet analysis was collected by direct observation of defecating animals (and subsequent recovery of the material) and by clearing droppings from roadways. All roads on the mine study area were cleared of caribou droppings in early May 1980 and 1981. Thereafter daily searches were made of major roadways. Less traveled roads were checked for fecal material twice a month.

Habitat use was determined by direct observations. Whenever bands of individual animals were sighted the number of animals and cover type in which they were located was noted. Only initial sightings were recorded; this method gave reasonable assurance that the cover type in which the sighting was made was the result of the animal's natural movement, and not the result of observer disturbance. This method was used for all ungulates, carnivores, and raptors observed on the mine.

Moose pellets for diet determination were collected using two methods. Revegetated study areas and the tundra control site were initially searched in May 1981, and twice a month thereafter until August 1981. The search consisted of walking transects through the areas, visually searching for pellet groups. The other method employed the establishment of ten, 250 m^2 circular pellet plots (Wolff 1976) on three sites in each of the tall shrub and coniferous cover types. In each cover type, one 100 m transect per site was placed through areas exhibiting high moose use (use being determined from direct observations, pellet group number and browse sign). All pellet plots were established, marked with a painted wooden stake, and cleared in early September, 1980. Plots were cleared again in May 1981, and August 1981. Pellet groups collected between September and May were designated as winter pellets, May-August groups as summer pellets. All pellets in a group were collected and the entire collection regarded as one sample.

Pellets for diet analysis of Dall sheep were collected in two ways. In winter, bands of sheep on the mine area were located twice a month. During these periods sheep were observed to defecate. The locations of fresh fecal pellets were mentally noted and the pellets collected after the animal moved to another area. This process was repeated until 20 fresh fecal samples per month were accumulated. Summer sheep use of the Usibelli Mine was low, the number of animals sighted per observation on the area during this time ranging from 0 to 9. Trying to find and follow sheep for pellet collection in summer proved impractical. To acquire feces for diet analysis 30, 4 m^2 circular plots (0.001 acre) were located in areas frequented by sheep during the summer of 1980. These plots were marked with painted wooden stakes and cleared on 11 May, 1981, and again on 29 August 1981.

The only colony of arctic ground squirrels on the mine site was located in the 1972 revegetated area (the Hydraulic Pit site) (Fig. 2). Ground squirrel density was determined using the assessment line method outlined by O'Farrell et al. (1977). Two parallel census lines intersected by six assessment lines were established in the center of the Hydraulic Pit area. Each of the parallel lines contained 40 stations; each of the assessment lines consisted of 18 stations with 15 of the stations outside of the configuration (see O'Farrell et al. 1977 for diagram). One live trap (15 X 15 X 48 cm, Tomahawk Trap Co., Tomahawk, Wis.) was placed at each trap station, with stations 10 m apart. Traps were baited with carrots (Daucus carota). Captured squirrels were marked using the toe clipping sequence of Melchior and Iwen (1965), sexed, weighed, and released back onto the grid. The assessment grid was operated during July 1981; during May, June, and August 1981 the 40 station parallel trap lines were functional. While in a trap the ground squirrels would frequently defecate; 25 samples per month of this fresh fecal material was collected for dietary analysis.

Plant biomass on the ground squirrel area was determined using the technique previously described for graminoids, 35 plots being necessary to meet the statistical criteria established for graminoid sampling.

Arctic ground squirrel reproductive performance was determined by counting placental scars of females collected in early August (Davies and Emlen 1948; Martin et al. 1976; Alibhai 1982).

Snowshoe hare density was determined using the pellet census technique (Taylor 1930; Taylor et al. 1935). Using the 100 m transect previously established in the tall shrub and conifer cover types (see moose methods section) and an additional 100 m transect in each revegetated study area, 0.25 m^2 square plots were placed every five meters (N=180 plots). The upper left-hand corner of each plot was marked with a painted wooden stake. The plots were cleared of pellets in September 1980, May 1981, and August 1981. Pellets collected between September and May were considered winter pellets, May-August pellets represented summer depositions. All pellets within a single 0.25 m^2 plot were counted and the collection regarded as one sample. These samples were used to determine the seasonal diets. Four hundred sixty-six pellets deposited per day was the standard used in calculating snowshoe hare density (Bookout 1965). Habitat use was equated with pellet density per cover type.

Forty clusters of willow ptarmigan droppings were collected in December 1981, from a shrub area near the 1972 revegetated site. The clusters were analyzed in an attempt to document the winter diet of ptarmigan associated with the mine area.

Small mammals were sampled on disturbed and reclaimed/unreclaimed, tall shrub, and coniferous forest cover types, and on the B & R Mine site, by installing parallel rows (10 traps/row) of pit traps in each area. Six rows (30 traps/row) 30 m apart were placed in the shrub tundra control site. Pit traps were installed following the design of Boonstra and Krebs (1978). The traps used were 10.5 X 18 cm metal 'juice' cans. The cans were placed in the ground to a point where the top was level with the surface of the substratum. Traps were 10 m apart, open at the top, and half filled with water. Voles collected in pit traps were identified, sexed, weighed, measured, and dissected. Stomachs were removed and used for diet analysis. The reproductive tracts of female voles were removed and placental scars counted using the procedure described by Alibhai (1982). Habitat utilization was determined using pit trapping results.

The density of voles on the tundra control area and a revegetated area (the 1976 site) was determined using the live-trapping method of West (1982). The areas were sampled during the month of July 1982. During the first two week period the trap grids were checked every four hours (every two if it rained). To determine the effective trap area of each grid, assessment lines were initially placed 5 m from the outside boundary of each grid (Van Horne 1982); both sets of live traps (grid and assessment lines) were operated concurrently the last two weeks of June. Assessment lines were progressively moved away from the trap grid boundary, 5 m every three days, until no marked voles were captured.

To decrease the possibility of trap avoidance, voles were not toe-clipped (Fairley 1982) but marked with a rapid drying paint. Small spots of white paint were applied to different portions of the vole's body, making positive identification of individuals possible.

Red fox (Vulpes vulpes), coyote (Canis latrans) and wolf (Canis lupus) scats were collected from the roads that traverse the Usibelli Mine. Actively used roads (Gold Run Road and Poker Flat Road) were checked daily during the summer, lesser used roads were checked twice a month. During the winter the major roads were checked twice a month. Scats were autoclaved and diameter at the widest point determined. Individual scats were assigned as coyote, red fox, or wolf in origin using the scat diameter criteria reported in the literature (Table 4) and using data obtained from feeding trials (Table 4). Scat diameters of red fox from interior Alaska were determined by feeding single and mixed diets of voles, arctic ground squirrels, snowshoe hares, and birds to five captive foxes. Three hundred fifty-one scats were recovered and measured.

The average scat diameters ranged from 12.11 (bird diet) to 14.52 mm (vole diet) (Table 4). The final criteria used for classifying scats in this study is given in Table 4.

Any scats which did not fall within a category were deleted from the analysis. The possibility of erroneously identifying the scat of another predator as fox, coyote, or wolf was considered. The species believed most likely to be misidentified were wolverine (Gulo gulo), lynx (Lynx canadensis), and immature wolf. Interviews with trappers that concentrated their trap efforts on and adjacent to the mine area indicated that no wolverine and only two lynx had been captured near the mine area in the previous two years. No juvenile wolves were observed on the mine during this study. Hence, I believe that the dietary data reported here are representive of the species to which the scat was assigned.

Prey items in each scat were identified by comparing teeth and hair found in the scat with reference samples of skulls and hair from mammals known to occur in the study area (for discussion of this method see Day 1966). Habitat utilization was based on visual sightings and scat locations.

Diets of various raptors (falcons, hawks, eagles, owls) sighted on the study areas were determined through visual observations of birds with prey and by pellet analysis. Pellets are undigested prey material, mainly bone and hair, which raptors regurgitate (Moon 1940). Analyses of the hair and bone found in pellets, when compared with reference samples of skeleton and hair from known

Table 4. Criteria for separating canid scats collected on the Usibelli Coal Mine, Healy, Alaska. N indicates the number of scats measured.

PREVIOUS STUDIES

Species and Scat Dimensions		Reference and Location
Red Fox	16 mm	Green & Flinders (1981)
Coyote	18	Idaho
Coyote	21	Weaver and Fritts (1979)
Wolf	27	Wyoming/Minnesota
Coyote	20	Danner and Dodd (1982)
Gray Fox	15	Arizona
Coyote	24	Thompson (1952)
Wolf	24	Wisconsin

ALASKAN RED FOX FEEDING TRIALS

Items Fed	Mean (+S.D.) Scat Diameter	N
Voles	14.59 ± 2.87	73
Snowshoe Hares	13.77 ± 2.27	102
Arctic Ground Squirrels	13.63 ± 2.12	73
Passerine Birds	12.11 ± 3.42	27
Mixed Diet	12.73 ± 1.77	76

SCAT DIAMETERS USED FOR DETERMINING ORIGIN OF SCATS FOUND ON THE USIBELLI MINE

Red Fox: ≤18 mm Coyote: 21 - 24 mm Wolf: ≥27 mm mammals, were used to determine raptor food habits (for a description of the technique see Glading et al. 1943).

Waterfowl and nongame bird species were identified in the course of daily field work. The species and cover type in which the bird was detected was recorded for each observation. Kessel (1979) has described an avian habitat classification system for Alaska. During the course of this study, bird species sighted were identified and the habitat in which the observation was made classified using Kessel's system. The cover categories used in constructing the vegetation map presented in this volume (Fig. 3) correspond to Kessel's categories as follows: (cover map classification = Kessel's classification): shrub tundra = low shrub thicket and dwarf shrubmat; coniferous forest = coniferous forest and deciduous forest; water and barren floodplain = fluviatile waters and shoreline; tall shrubland = tall shrub thicket and medium shrub thicket; and disturbed and revegetated/unrevegetated = artificial habitats.

The B & R Mine area was visited once a week and bird species observed during a three hour survey recorded. Nests located on the Usibelli and B & R Mine sites were found incidental to a species sighting -- in every case the nest was located because the bird being observed flew to it.

Territories of bird species associated with revegetated mine spoils were measured using the 'flush' method described by Wiens (1969:20). The procedure was slightly modified, a minimum of 40 (not 20) consecutive flush points being used in determining the territory boundaries.

Plant and Soil Analysis

Macro and micronutrients, *in vitro* dry matter disappearance (IVDMD), neutral-detergent fiber (NDF), and acid-detergent fiber (ADF) analysis of vegetation samples followed standard techniques (see Whitten and Cameron 1980). Analyses were performed at the Plant and Soil Analysis Laboratory, Agricultural Experiment Station, Palmer, Alaska. Neutral-detergent fiber is a measure of the cell wall and combined hemicellulose, cellulose, and lignin components in the plant sample; ADF measures combined cellulose and lignin components. Both procedures and IVDMD provide an insight into the digestibility of the forage sample.

Ten soil samples per revegetated site were collected using a standard open slot soil sampler (Soiltest Inc., Evanston, Illinois). Each group of samples per site was pooled and treated as one sample. Each sample was sifted through a two millimeter screen and the soil which passed through examined for texture. Soil texture was determined using the hydrometer (Bouyoucos) method (Day 1965).

Permafrost depth on the tundra control site was determined by excavating ten holes and measuring distance from the surface to the ice layer.

Scientific nomenclature for mammals follows Honacki et al. (1982); birds, Armstrong (1980); and plants, Welsh (1974).

LITERATURE REVIEW

To interpret the affect of surface mining reclamation on the various wildlife species that occupy the Usibelli area, it is necessary to understand what comprises the native, undisturbed habitat of each animal. The following review of what is known about the natural food habits and habitat needs of each mammal or animal group on the Usibelli Mine will 'set the stage' for later discussions of the adequacy of revegetated mine spoils as wildlife habitat. An attempt was made to review only material pertaining to Alaska, specifically interior Alaska.

BIRDS

PASSERINE BIRDS

Habitat Utilization

The impact and subsequent use of stripmined areas by passerine birds in the contiguous United States has been well documented (Brewer 1958; Smith 1964; Karr 1968; Terrel and French 1975; Yahner and Howell 1975a; Allaire 1978a, b; Whitmore and Hall 1978; Whitmore 1980; Krementz and Sauer 1982). Avian fauna on surface mines allowed to revegetate naturally were examined by Brewer (1958) and Terrel and French (1975). They observed the older a disturbed site the lower the bird density-- but the greater the species diversity. The differences in bird populations apparently was the result of individual species response to successional changes in vegetation and local site conditions.

Revegetating stripmines with graminoids results in the creation of a habitat often vastly different from the previous or surrounding environment. Birds rapidly respond to these habitat changes (Whitmore and Hall 1978; Whitmore 1980), certain species preferring the new situation (Allaire 1976; Whitmore and Hall 1978; Krementz and Sauer 1982). However, data have been reported that indicate avian species diversity on reclaimed mines is related to habitat structure (Karr 1968). More structurally diverse sites have a greater number of niches to be exploited, and hence a greater avian species diversity (Yahner and Howell 1975a, b).

WATERFOWL

Habitat Utilization

Water bodies created as a result of stripmining activities have been shown to provide habitat useful to waterfowl (Olson and Barker 1979). Studies in Ohio found 15 species of waterfowl utilized stripmine lakes while two species, the wood duck (*Aix sponsa*) and mallard, were found to be nesting on such areas (Riley 1954).

Tarbox et al. (1979) recorded ten species of ducks and four species of sandpipers in the Healy area, documenting local nesting for the mallard, green-winged teal (*Anas crecca*), American wigeon (*Anas americana*), bufflehead (*Bucephala albeola*), and spotted sandpiper (*Actitis macularia*).

GALLINACEOUS BIRDS

Habitat Utilization

Aspen is the preferred habitat of ruffed grouse (Rusch and Keith 1971), conifers are apparently unessential (Gullion and Marshall 1968). Shrub areas are important as brood habitat in early spring (Berner and Gysel 1969).

The shrubby interface between forest and tundra is the natural winter habitat preferred by all ptarmigan species in central Alaska (Weeden 1969). This area provides escape and thermal cover for the birds.

Food Habits

Spring and summer diets for adult and young ruffed grouse are composed of seeds and fruits (King 1969). McGowan (1973) found rose hips (Rosa acicularis), highbush cranberry (Viburnum edule), and aspen twigs and buds to be the major food items of ruffed grouse in interior Alaska. Aspen and willow twigs and buds comprised the winter diet.

Weeden (1969) found Salix was the most frequent (78%) food item found in willow ptarmigan crops collected during autumn in interior Alaska. Willow buds and stems made up 97% of the ptarmigan diet reported by Moss (1974). In addition, West and Meng (1966) found willow was also preferred by wintering birds in northern Alaska.

RAPTORS

Habitat Utilization

Gabrielson and Lincoln (1959:542-545) reported the range and habitat frequented by short-eared owls (Asio flammeus) in Alaska. They described the owl as a bird of the open tundra, grassland, and marshes-- making its nest on the ground and using tussocks, hummocks, and rocks as lookout points for hunting. Lein and Boxall (1979) studied wintering short-eared owls near Calgary, Alberta, Canada, and found stubblefields, road ditches, and sloughs to be the preferred habitats.

Lowe (1978) described the nesting habitat of interior Alaskan red-tailed hawks (Buteo jamaicensis). White spruce was the predominant nest tree used, with balsam poplar (Populus balsamifera), quaking aspen, and paper birch (Betula papyrifera) being used to a lesser extent. Nest trees averaged 19 m (62.7 ft) in height. Spruce with large, open branches near their tops were most often chosen.

Hawk owls prefer open coniferous and deciduous forests (Kertell 1982). These habitats contain dead trees and stumps which function as hunting perches, nest sites (Bent 1961b; Kertell 1982), and cover in which to escape mobbing by passerines (Gabrielson and Lincoln 1959:537).

Murie (1944:222-229) studied golden eagles (Aquilla chrysaetos) in Denali National Park. He noted they arrived in the park in March and departed in October, rarely overwintering in the area. The birds were reported to range widely over the park, frequently being observed soaring over the mountain ridges and foothills. All nests Murie found were built in cliffs, which were located at various altitudes from the base of a ridge to near its summit.

American kestrels (Falco sparverius) are considered birds of the open country and borders of woodlands. Hunting primarily for food on the ground the falcon frequents high, exposed perches from which it can command a view of the surrounding grassland or pasture (Bent 1961b:116). In Canada, kestrels are most abundant in the aspen parklands south of the boreal forest. In the boreal forest proper they occur only in burns, in semi-open aspen stands, or adjacent to river flood plains. Kestrels are totally absent from large areas of dense coniferous forests unless these sites have been opened by fire or logging operations (Beebe 1974).

Breeding kestrels are uncommon in the state but have been reported in southeastern Alaska and as far north as the Yukon and, in the interior, as far west as Mt. McKinley (Gabrielson and Lincoln 1959:289).

Within Alaska, the marsh hawk (Circus cyaneus) is occasionally observed along the open areas in river valleys, but more often it is found above timberline. In these regions it frequents open mountain meadows and bog areas (Gabrielson and Lincoln 1959:275).

The goshawk (Accipiter gentilis) in Alaska is closely associated with timbered areas. McGowan (1975) found paper birch to be an important component of nesting habitat, pure stands of birch being used more commonly than any other forest type. Although usually associated with trees, the sharp-shinned hawk (Accipiter striatus) is not, even when on breeding territory, a bird of deep, unbroken woods. In the boreal forest it shows a strong preference for areas of young regenerating forest with an interlocking variety of spruce thickets, meadows, or lightly treed areas of aspen or pine (Beebe 1974).

Food Habits

Hughes (1982) documented the food habits of short-eared owls on Farm Island in southeastern Alaska. He examined 80 owl pellets and found the meadow vole (Microtus pennsylvanicus) and long-tailed vole (*M. longicaudus*) constituted the majority (78%) of the prey items identified. Pruitt (1959) found microtines (tundra voles and lemmings) to compose 100% of the short-eared pellets he examined in northwestern Alaska.

Dotson and Mindell (1979) reported prey items found in red-tailed hawk nests along the Kuskokwim River in northcentral Alaska. They found red squirrels (*Tamiasciurus hudsonicus*), microtines, and passerines to be the most common items captured. Lowe (1978) examined the life history and food habits of red-tailed hawks in interior Alaska. Birds composed 36% of the diet, red-backed voles 23%, red squirrels 17%, and snowshoe hares 15%. He compared diets of Alaskan red-tailed hawks with other studies and reported birds were of greater dietary importance in Alaska then in any other region (except those areas in which introduced bird species, eg. ring-necked pheasants (*Phasianus colchicus*), were common). Lowe (1978) postulated that large numbers of breeding waterfowl, shorebirds, and passerines in interior Alaska provide red-tailed hawks with more opportunities to prey on birds than in other areas studied. Based on biomass, snowshoe hares were the most important prey species despite their low population during Lowe's study.

Microtines were the major items reported in stomachs of 21 hawk owls (*Surnia ulula*) in Maine (Mendall 1944). Gabrielson and Lincoln (1959:538) described the summer diet of the hawk owl as consisting largely of mice, lemmings, ground squirrels, and insects. During the winter this owl has been reported to kill ptarmigan, ruffed grouse, and small birds. Hawk owls in interior Alaska have been reported to feed on red-backed voles and tundra voles (Kertell 1982). They have also been seen to capture and cache microtines (Ritchie 1980).

Murie (1944:225) documented the food habits of golden eagles in Denali National Park. Of the 632 pellets he examined, 544 or 86% contained arctic ground squirrel, 6% contained hoary marmot (Marmota caligata), and 5% contained microtines.

The food of the American kestrel includes insects, birds, mammals, reptiles and amphibians (Heintzelman 1964; Balgooyen 1976). Its diet varies considerably according to season and locality. Where grasshoppers and insects are abundant, they make up the hawk's principal food, but during winter in northern latitudes kestrels are restricted to preying on birds and small mammals (Bent 1961b:112).

Due to its hunting method of skimming over the ground at slow speeds, prey items most commonly taken by the marsh hawk are small marsh and grassland rodents. Next to small mammals, birds are taken, usually fledgings, but also adults of grassland and marsh species up to the size of rails and coots (Errington 1933; Beebe 1974).

During a three year nesting study of goshawks in interior Alaska, McGowan (1975) found snowshoe hares comprised the major items in the diet although red squirrels and passerine birds were also commonly taken. Sharp-shinned hawks consume mainly passerines but do occasionally take small mammals (Storer 1966).

SNOWSHOE HARES

Habitat Utilization

Many investigators (eg. Bider 1961; Keith 1966; Wolfe et al. 1982) have noted the importance of suitable vegetative cover as a habitat component for snowshoe hares. Wolff (1980) examined the role of cover and habitat patchiness on a population of interior Alaskan snowshoe hares. He found hares tended to move from winter to summer ranges in response to the availability of food and cover. A patchy environment which provided cover like dense black spruce or willow-alder thickets in winter and open summer range, allowed hares to shift their habitat use seasonally in response to changes in diet and to take advantage of changing environmental conditions. During summer, Wolff found hares fed on herbaceous material and low shrubs in open areas; during winter they moved into the dense thickets to feed on spruce, willow, and alder. These dense spruce or willow-alder thickets provided the greatest amount of cover, and were designated as 'refuge' areas. Refuge areas were defined as regions which provide protection for a nucleus population of hares which are able to survive the heavy predator pressure that follows a hare population high. Wolff (1980) determined that as a population declines, those animals in marginal or suboptimal habitats were the most vulnerable and suffered the greatest mortality. The only hares to survive the population crash were those which were able to stay in the refuge.

Food Habits

Trapp (1962) found the winter diet of snowshoe hares near Fairbanks, Alaska, consisted primarily of bluegerry twigs, Labrador tea (Ledum groenlandicum), rose, and willow. Birch bark and twigs were also important food items; but the bark and twigs of alder, balsam poplar, aspen and spruce were not consumed until late winter.

Wolff (1978) determined the seasonal food habits of snowshoe hares in interior Alaska. Hare diets changed from hardwood browse and spruce bark and needles in the winter to leaves and other herbaceous plant material in the summer. The amount of spruce and woody browse in the diet decreased from 82% in winter to 56% in April and to 25% in May as the intake of herbs increased from 1.5 to 8 and 49% over the same time period. Leaves of blueberry and mountain cranberry which remained on branches from the previous summer and were exposed by receding snows were heavily utilized in early spring. The proportion of shrub leaves in the summer diet was 69% (excluding spruce); the amount of woody browse and forbs consumed having declined noticeably. The fall food habits indicated a gradual change in use from herbaceous plant material back to spruce and other woody browse.

ARCTIC GROUND SQUIRRELS

Habitat Utilization

Arctic ground squirrels concentrate their activity around resident burrows. The structures serve as hibernacula in winter and nurseries in summer (Batzli and Sobaski 1980). These perennial burrow systems are situated in well-drained places on hillsides, creek or ocean banks, or on raised mounds of porous material in flats. All of these locations have a comparatively deep permafrost level (Quay 1951; Carl 1971).

Food Habits

Arctic ground squirrels are ubiquitous in Alaska, being found throughout the state and having been successfully introduced to the Aleutian Islands (Hall 1981:390).

Howell (1938) reported arctic ground squirrels consume alpine bearberry and mountain cranberry, as well as seeds of Polygonum spp. and milk-vetch (Astragalus spp.) and mushrooms. Quay (1951) examined the cheek pouches of several ground squirrels collected on the Seward Peninsula. The pouches contained flowers, buds, and leaves of Ledum spp., Eriophorum spp., and Vaccinium spp. Mayer (1953a, b) studied squirrels near Barrow and observed them eating Dryas integrifolia, Pedicularis spp., sedge, Douglasia spp., Oxytropis spp., and Eriophorum spp., and to store alpine bistort (Polygonum viviparum) seeds. Mayer conducted a food preference study in which he offered caged squirrels a choice of six forage species and laboratory chow. After 24 hours, arctic sweet coltsfoot (Petasites frigidus) had been consumed, dupontia (Dupontia fisheri) and pendent grass (Arctophila fulva) were partially eaten while polargrass (Arctagrostis latifolia), bluegrass (Poa spp.), and polar willow (Salix polaris) were only 50% consumed eight days later. Squirrels were noted to take almost any offered greens, eg. holygrass (Hierochloe spp.), foxtail (Alopecurus spp.), nodding saxifrage

(Saxifraga cernua), foliose saxifrage (Saxifraga foliolosa), and brook saxifrage (Saxifraga punctata).

Krog (1954) examined items stored in a squirrel winter nest near Kotzebue and found it to contain green willow leaves, spikes of northern wheatgrass (Agropyron boreale), and capsules containing ripe seeds of arctic rush (Juncus arcticus). Melchior (1961) examined the affects of Spermophilus parryii on the vegetation of Ogotoruk Creek Valley near Cape Thompson. He listed 19 species of plants used as food by the local squirrel population. Salix planifolia ssp. pulchra was the only shrub eaten while sedge, meadow horsetail, tall cottongrass, and alpine holygrass comprised the graminoids ingested.

Batzli and Sobaski (1980) determined the distribution and foraging patterns of arctic ground squirrels near the village of Atkasook (100 km south of Barrow). Analyses of stomach contents revealed squirrels ate mostly dicotyledons, including a wide variety of forbs and shrubs. The single most common plant found in squirrel stomachs was meadow horsetail (Equisetum arvense). The squirrels ignored lichens and evergreen shrubs and only consumed small amounts of mosses and insects. Forb shoots, seeds, and meadow horsetail made up over 80% of the diet in middle and late summer, while mosses, monocotyledon shoots, deciduous shrub leaves, docotyledon roots, and animal matter contributed half the diet in early summer. Batzli and Sobaski conducted palatability trials and found that forbs were highly palatable to the squirrels, particularly members of the families Cruciferae, Leguminosae, Scrophulariaceae, and Saxifragaceae. Deciduous shrubs were moderately palatable, of which Salix alaxensis was the most palatable and S. phlebophylla the least palatable. The most palatable grasses were sheep fescue (Festuca brachyphylla) and downy oatgrass (Trisetum spicatum), the least palatable were dunegrass (Elymus arenarius) and arctic brome (Bromus pumpellianus). Evergreen shrubs were the least palatable group; with only Dryas integrifolia leaves being taken in substantial amounts.

Guthrie (1982) determined the food habits of a ground squirrel colony near Bison Gulch (185 km south of Fairbanks). Willow, northern sweet-vetch (Hedysarum mackenzii) and arctic lupine (Lupinus arcticus) were the dominant items in June diets while arctic lupine, seeds, and sweet-vetch were the main items in July stomachs.

In addition to vegetation, arctic ground squirrels are known for their consumption of animal matter (Geist 1933; Batzli and Sobaski 1980), at times even exhibiting cannibalistic behavior (Cade 1951; Mayer 1953b).

SMALL MAMMALS

Habitat Utilization

Surface mining for coal in North America has resulted in the destruction of habitats utilized by all categories of wildlife. Small mammals appear to be very resilient to habitat perturbations, often being the first animal group to permanently repopulate mined areas (Verts 1957; de Capita and Bookout 1975; Sly 1976; Kirkland 1976; Hansen and Warnock 1978; Voight and Glenn-Lwein 1979; Brenner et al. 1982).

Tundra voles prefer grass habitats. In central Alaska, Microtus oeconomus reaches its highest densities on sites supporting relatively dense herbaceous ground cover, typically early successional stages characterized by high coverage of grass (Calamagrostis spp.) (West 1982). West (1979) noted the patchy distribution and transitory, successional nature of optimal Microtus habitat results in low density Microtus spp. populations, a condition that may favor early entry and local persistence of the red-backed vole. Thus the successional dynamics of central Alaskan vegetation favor red-backed voles, and sharp habitat segregation between red-backed voles and Microtus spp. does not occur. Current evidence supports the contention that red-backed voles may exclude Microtus species form forests, but also that Microtus species never completely exclude red-backed voles from early successional (grass) sites (West 1982).

Food Habits

Tast and Kalela (1971) investigated the feeding habits of tundra voles in Finland. Through feeding experiments and field observations, they found cottongrass (Eriophorum angustifolium) to be the highest ranking food item throughout the year. During most of the summer the voles ate the above ground portions of the plant, in the winter underground organs were consumed. This preference for graminoids was also noted for tundra voles inhabiting northern Alaska (Pruitt 1966). Quay (1951) found leaves and stalks of Carex spp., cotton grass, Vaccinium uliginosum, and sprigs of moss in the digestive tracts of tundra voles trapped on the Seward Peninsula.

Dyke (1971) examined the stomach contents of northern red-backed voles in five habitats of northern Canada. He found the vole ate great quantities of green material, the volume increasing throughout May and early June as spring foliage reached full development. Material consumed consisted of soapberry (Shepherdia canadensis), feather moss (mainly Hylocomium splendens), quaking aspen leaves and bearberry. Aboreal lichens (Alectoria jubata and Parmelia spp.) and mushrooms (mainly Russula spp.) were important just before the fruiting season. When berries became available, bearberry and mountain cranberry were consumed. Winter and early spring diets consisted of overwintered fruits-- with mountain cranberry comprising over half the diet.

In interior Alaska, West (1982) found red-backed voles relied heavily upon the fruits of several plants for food. Overwintered berries constituted the primary winter food. Lichens were consumed only during winter and spring. The summer diet showed a significant consumption of moss, although fruit was still the main food category. The summer diet suggested that in early summer, when the previous year's berries are no longer available and the current crop has not matured, mosses are eaten as an alternate food source (West 1982).

CARNIVORES

Habitat Utilization

Jones and Theberge (1982) studied habitat utilization of red foxes in the tundra of northwest British Columbia, Canada, and found a preference for willow communities. The foxes tended to avoid the open lichen-Empetrum habitats although grass communities were used in proportion to their availability. In northern Alaska red foxes have taken advantage of roads for dispersal into remote areas, and use buildings and other man-made objects, such as steel pipes, for den sites (Rudzinski et al. 1982).

Certain farming and logging methods have been found to improve habitat for gray foxes (Urocyon cinereoargenteus) by increasing edge and vegetation diversity (Wood et al. 1958). Similarly, creating interspersion was thought to increase habitat quality for red foxes (Ables 1969). Yearsley and Samuel (1980) discussed the use of reclaimed surface mines by red foxes in West Virginia. They noted revegetation of mine areas was beneficial to foxes if it created grasslands, rows of shrubs, and pole-stage woods. This multilayered vegetation was felt to provide more edge and diversity than usually results from the current reclamation practice os seeding grasses and legumes.

There is little information regarding habitat preference of coyotes in Alaska. Murie (1944:97) observed the coyote was absent from the mountainous regions of Denali National Park, but did occur near the willow and alder thickets inhabited by snowshoe hares.

Wolves are extremely mobile animals, traveling great distances in their daily and seasonal movements. Murie (1944:42) wrote the following about the wolf pack he studied in interior Alaska (in Denali National Park):

> The East Fork wolves were known to move readily over a range of at least 50 miles across. During the denning

> period their movements radiated from the den, and ordinarily the wolves traveled a dozen or more miles from it. But greater distances were readily traveled. In the spring of 1941, when a band of five or six thousand caribou calved some 20 miles away, the wolves traveled this distance nightly to prey on the calves.

Ballard et al. (1981b) determined the territory size for 19 wolf packs in southcentral Alaska. The areas ranged from 275 to 3077 km^2. Because of their vagile life-style Alaskan wolves have been found to utilize all of the habitat types available to them.

Food Habits

The food habits of red foxes within interior Alaska have been reported by Murie (1944:212-217) and Hobgood (in prep.). Over a three year period (1939-41) Murie examined 662 summer scats and 124 winter scats from Denali National Park. Based on frequency of occurrence, microtines (*Microtus*, *Lemmus* and *Clethrionomys* spps.) and arctic ground squirrels comprised 50% and 37% of the total summer diet. Microtines and blueberry were the major items in winter scats, having been found in 53% and 29% respectively. Snowshoe hares were extremely scarce where the scats were collected, thus explaining (according to Murie) why there were so few hares in the diet.

Hobgood (in prep.) examined 167 summer and 57 winter scats collected in the Upper Susitna River drainage. Arctic ground squirrels and microtines (*Microtus pennsylvanicus*, *M. oeconomus*, *M. miurus*, and *Cleithrionomys rutilus*) accounted for 77% and 39% of the summer diet. Microtines (mainly *C. rutilus*) and unidentified cervids comprised 49% and 36% of the prey found in winter scats.

Once again hares were not abundant in the area and consequently did not appear in the diet.

Food information regarding the coyote in Alaska is scarce. Murie (1944:97) noted reports of Dall sheep weakened by unusually severe winter conditions being killed by coyotes. Murie also observed coyotes were very scarce in the high country of Denali National Park, preferring instead to seek areas where snowshoe hares were available. Bergeron and Demers (1981) examined the diets of coyotes inhabiting the forested agricultural land of southeastern Quebec, Canada. They found that although domestic animal carrion was the most important food group for coyotes, snowshoe hares regularly occurred in the diet.

Murie (1944:50-59) examined 1174 wolf scats from interior Alaska and determined caribou and Dall sheep were the major prey consumed, accounting for 42% and 25% of the diet. Again the analysis occurred during a snowshoe hare population low. More recently Ballard et al. (1981b) completed a five year study of wolves in the Nelchina Basin of southcentral Alaska. They examined 3624 scats and found moose comprised 53% of the summer diet, snowshoe hares 14%, and beaver (Castor canadensis) 10%.

CARIBOU

Habitat Utilization

The caribou is widely distributed on arctic tundras, mountains and boreal forests of Eurasia and North America, including the Arctic Archapelago and the north coast of Greenland. Of nine living subspecies of caribou in the world, the barren-ground caribou (Rangifer tarandus granti) is the only one found in Alaska (Banfield 1961). There are at present 13 caribou herds in Alaska, including two introduced populations (Pegau 1968). In addition, there are 20 domestic reindeer herds in western Alaska (Collins pers. comm.).

Throughout the year caribou herds are almost constantly in motion. They visit some areas annually, and may utilize others only once in a decade. Even preferred areas are used for only a few weeks each year. Despite such variability, a certain periodicity and pattern are evident in both daily and seasonal movements (Hemming 1971).

Small herds may not demonstrate definite seasonal movements but instead wander locally (Banfield 1961; Skoog 1968). The north slopes of the central Alaska Mountain Range support a small herd of caribou that may be descendents of the Fortymile herd that ranged into this area during the 1930's (Skoog 1968). Hemming (1971) has identified this population as the Delta caribou herd. Animals of this population are thought to be the caribou observed on the Usibelli Coal Mine (J. Davis pers. comm.).

The Delta caribou herd ranges over an area of about 7770 sq. kms. (3000 sq. miles) on the north slopes of the Alaska Range between the Alaska Railroad on the west and the Richardson Highway on the east (Hemming 1971). In winter the herd ranges widely over the foothills of the Alaska Range between Delta Creek and the Tatlanika River and northward onto the Tanana Flats (Olson 1958; Lentfer 1965; Skoog 1968). As the calving period approaches, cows and many yearlings move into the upper portion of the Little Delta River and Delta Creek. Here the calves are born above timberline (Skoog 1968). Meanwhile bulls and other yearlings remain widely scattered through the foothills and mountains from Yanert Fork of the Nenana River to Delta Creek (for locations of the geographical areas referred to in the text see Fig. 1).

Food Habits

Throughout their range, from the boreal forest to the high arctic tundras and polar deserts of the extreme north, caribou and reindeer experience a wide variety of nutritional and climatic conditions (Staaland and Punsvik 1980). Within the major portion of their global distribution, lichens, grasses, and sedges, as well as shrubs like willow and alder, comprise the major portion of their diet (Gaare 1968; Klein 1970; Parker 1975; Thing 1980; Punsvik et al. 1980; Skogland 1980; Oosenbrug and Theberge 1980; Thompson and McCourt 1981). Within the borders of Alaska, the major diet-related studies have taken place on the Seward Peninsula (Wright 1980), the Alaskan North Slope (Kuropat and Bryant 1980; White and Trudell 1980), and interior Alaska (Skoog 1956; Boertje 1981).

The Western Arctic caribou herd on the Alaskan North Slope exhibited an intensive early season use of Lupinus arcticus. Willows were preferred over birch, but evergreen shrubs such as Ledum decumbens were not used. Of the willows, Salix pulchra was the most preferred (Kuropat and Bryant 1980). Grazing studies with reindeer on several vegetation types on the North Slope indicated forbs, deciduous shrubs (especially willow species), and lichens were the preferred food items (White and Trudell 1980).

Many species of grasses and sedges have been reported utilized by caribou during the summer. Porsild (1954) stated that nearly all grasses are eaten, and noted especially those of the genera Alopecurus, Arctagrostis, Dupontia, Festuca, Poa, and Puccinellia. In addition to these, Hadwen and Palmer (1922) mentioned Agropyron. Skoog (1968) noted the early spring use of the new shoots of grasses (mostly Festuca altaica, Calamagrostis canadensis, and Hierochloe alpina) and sedges (notably Carex bigelowii, C. membranacea, C. podacarpa, and Eriophorum vaginatum).

Boertje (1981) examined the nutritional ecology of the caribou herd in the Denali National Park and Preserve. This study is of note because of the proximity of the park to the Usibelli Coal Mine and will therefore be reviewed in detail.

To estimate actual dietary composition, Boertje modified the results of fecal analyses by using field observations of forage selected and estimated digestibility of plants identified in the feces. The early spring diet (mid-May to July) was dominanted by lichens and, to a lesser extent, overwintering berries and portions of Carex species. Intensive feeding on the new leaves of Vaccinium uliginosum, Betula nana, Arctostaphylos spp., and Salix pulchra, was observed during the last week of May and first week of June. By the second week of June only willows continued to be grazed intensively. Several species of forbs were also consumed, particularily Epilobium angustifolium and Sanguisorba stipulata. Graminoids were also grazed at times, especially the tips of Carex podocarpa.

The intake of forbs decreased from the spring to the summer (July to mid-August) diet. The decrease in use of forbs was primarily due to their decrease in availability on the summer range. Deciduous shrubs contributed about 50% to the total summer's intake. Prostrate willows, including Salix arctica, S. rotundifolia, and S. reticulata, contributed significantly to the willow component of the diet, particularly when the caribou retreated to higher elevations and wind-exposed ridgetops to escape fly harassment. Salix pulchra and S. alaxensis remained the most palatable willows throughout the summer (Boertje 1981). Skoog (1968) also found S. pulchra and S. alaxensis the most palatable willow in the diet of the Fortymile and Nelchina caribou herds in interior Alaska. Graminoids were important-- Carex podocarpa, C. bigelowii, Festuca altaica and Hierochole alpina predominated in the summer diet. Mushrooms were also highly preferred during the summer months (Boertje 1981).

Boertje (1981) found lichens dominated the autumn (mid-August to mid-October) diet whereas willows decreased in importance and graminoids (particularly Carex aquatilis) increased slightly when compared to values in spring and summer. Mushrooms and berries

(Vaccinium uliginosum and V. vitis-idaea) were important autumn forages (Boertje 1981).

MOOSE

Habitat Utilization

LeResche et al. (1974) have presented a detailed discussion of the habitats occupied by Alaskan moose. A capsulated summary of their discussion will provide a basis with which to assess the adequacy of revegetated mine spoils as moose habitat:

> The most important moose habitats in Alaska include both climax and subclimax communities. Moose are present in low densities throughout the climax taiga communities of the northern boreal forest. Climax upland birch-willow communities and lowland bog communities support greater densities of animals, as do continuously-renewed riparian seral communities and more transient post-burn communities. Upland moose habitats are very important in many areas of the state. These habitats are timberline shrub communities characterized by birch and willow, with heath and forb understories. These habitats are used most intensively in summer and autumn, but are year-round residences for moose in some areas. Lowland climax communities are many and diverse, occurring on the broad alluvial plains common south of the Brooks Range. These communities are especially important during spring and summer, and support large concentrations of moose during calving. Riparian willow communities, although seral in nature, are consistently present because of constant renewal. They are key winter ranges in much of Alaska and are the only habitat consistently occupied by moose in arctic areas (LeResche et al. 1974).

Telfer (1978) discussed the effect of snow on moose movements and habitat selection. He noted when deep snow covers much of the range, moose are forced to concentrate in areas where evergreen forest cover and topographic features provide shallower snow and pockets of warm microclimate. Hence optimum winter range provides cover and large amounts of browse interspersed in small patches. Telfer (1978) concluded that ideal moose habitat requires a variety of plant communities interspersed to form a diversity of small stands.

Food Habits

The bulk of winter moose rumen samples collected in southcentral Alaska by Chatelain (1951) consisted of mat willow, paper birch, black cottonwood (Populus trichocarpa) and aspen. Spencer and Chatelain (1953) reported data on moose food habits in southcentral Alaska based on spring browse surveys. Willows and paper birch were the preferred species in winter. Balsam poplar, highbush cranberry, red elderberry (Sambucus racemosa) and raspberry (Rubus idaeus) were less important items in the diet.

Spencer and Hakala (1964) recorded Bebb willow (Salix bebbiana), scouler willow (S. scouleriana), Barclay willow (S. barclayi), and S. arbusculoides as important willow species on the Kenai Peninsula. Hosley (1949) reported work done by L. J. Palmer on the Kenai in the 1930's which indicated tree and ground birches, willows, western mountain-ash (Sorbus scopulina), red current (Ribes triste), black current (R. laxiflorum) and serviceberry (Amelanchier alnifolia) were highly palatable to moose.

LeResche and Davis (1973) reported the food habits of three semi-tame moose on the Kenai Peninsula. Summer diets were composed of two-thirds birch leaves, and one-fourth forbs, including cloudberry (Rubus chamaemorus), round-leaf sundew (Drosera rotundifolia), fireweeds (Epilobium angustifolium, E. latifolium) and nootka lupine (Lupinus nootkatensis). Mushrooms were eaten whenever encountered and grasses, sedges and aquatics comprised about 10% of the observed diet. Winter diets varied with snow depth. When snow accumulation was less than 30 cm, sedges were consumed in great quantities; but when snow depth was over 30 cm, birch stems, mountain cranberry, willows, and alder were the main food items.

Murie (1944:183) considered willows the major summer and winter food of moose in Denali National Park. He also noted that grasses, sedges, various herbs, and submerged vegetation were consumed in summer. Cushwa and Coady (1976) determined the food habits of moose from the Kenai Peninsula and Fairbanks areas by examining rumen contents. The winter diet in the Fairbanks region was, in decreasing order of frequency, twigs of willow, birch, aspen, and alder. During the spring (April-May) twigs of willow and birch were most frequently eaten, while summer (June-August) rumen samples contained green willow leaves and unidentified grasses.

Wolff (1976) examined moose utilization of hardwood browse on the Tanana floodplain in interior Alaska. Moose consumed balsam poplar, Alaska willow (S. alaxensis), and interior willow (S. interior) on eight year old stands, and Alaska willow and New England willow (S. novae-angliae) on 15 year old stands. A similar study done in Denali National Park (Wolff and Cowling 1981) found Alaska willow and Salix arbusculoides were heaviest browsed. The importance of willow to interior Alaskan moose was further demonstrated by Milke (1969), who reported moose in the Tanana River basin demonstrated a decided preference for interior willow, Alaska willow, *Salix planifolia*, and *S. arbusculoides*. Machida (1979), in a study near Fairbanks, found Alaska willow was most preferred, *S. planifolia* was next, while Scouler willow and *S. hastata* were least preferred.

DALL SHEEP

Habitat Utilization

Nichols (1980) described Dall sheep habitat in Alaska as:

> ... typically alpine: steep, open grasslands, interspersed with broken cliffs and talus slopes on recently glaciated mountains. It usually lies almost entirely above timberline which, in Alaska, is variable in elevation but averages about 765 m (2500 ft) above sea level. Temperatures normally remain below freezing during the winter, and high winds sweep many ridges and slopes free of snow.
>
> Vegetation consists largely of sedges, bunchgrasses, low shrubs such as blueberry, crowberry, dwarf willow, mountain avens, and mosses and lichens. The lower portions of sheep habitat may have large stands of dwarf birch interspersed with larger willows and dense alder and alpine hemlock thickets. In some places where broken cliffs extned suitable habitat below timberlines, sheep utilize benches supporting stands of twisted cottonwood, aspen and occasional white spruce.

Food Habits

Little work has been done in Alaska to determine the diets of Dall sheep. Murie (1944:76-82) analyzed 75 rumen samples and noted the importance of sedges, grasses, and willows in sheep diets in Denali National Park. He mentioned bluegrass, fescue, and sedge as being the most available feed on wintering areas, and observed feeding on these species as well as bluejoint, red fescue, trisetum

(Trisetum spp.), and wheatgrass. Horsetail and bog blueberry were also found in important quantities.

Viereck (1963) observed Dall sheep in the Tonzona River and Mt. Hayes area of Alaska. The forage species taken were quantified as 'occasionally, commonly or abundantly utilized'. Most of the 47 food plants listed were summer forages and included: Epilobium latifolium, Artemisia arctica, Anemone parviflora, Poa alpina, Achillea borealis, Trisetum spicatum, Salix reticulata, Festuca altaica, and Kobresia myosuroides.

Whitten (1975) studied the habitat relationships of Dall sheep in Denali National Park. He made visual observations of feeding sheep and recorded the plant species consumed. During the summer months, Salix glauca, Salix arctica, Salix planifolia, Boykinia richardsonii, Arnica alpina, Artemisia alaskana, Dodecatheon frigidum, Saxifraga davurica, and Oxyria digyna were eaten. Winter food items were determined by examining feeding craters. Within the craters, bunchgrass (mostly alpine fescue) seemed to be the item most often grazed. Whitten did report following sheep tracks through the snow to a single Salix glauca bush in a stand of Alnus crispa. The sheep fed on stems of the willow but did not stop to feed on any of the alder. Winters (1980) reported grasses and sedges comprised the bulk of items identified in the rumens of two sheep collected near Sheep Creek in the Tanana River drainage.

The most detailed account of Dall sheep diets within Alaska is that of Nichols and Heimer (1972). They determined the seasonal food habits of three herds located on Surprise, Crescent, and Slaughter Mountains along the Kenai River Drainage. Sedges, alpine fescue (Festuca altaica) and other grasses made up the greater portion of the summer diet on all areas. The use of sedge decreased markedly by midwinter, while the use of alpine fescue increased. Consumption of other grasses, including red fescue, alpine sweetgrass (Hierochole alpina), and Poa spp., was fairly constant throughout the year. Shrubs, mainly willows, made up a portion of the diet throughout the year, with somewhat decreased use in spring. Mosses and lichens were evident in the winter diets.

Heimer (unpub. data) determined the botanical composition of spring and winter rumen contents for two sheep populations in the Alaska Mountain Range. Grasses and sedges were the principal rumen component for the Dry Creek herd, comprising 69% and 74% of rumen contents in spring and winter respectively. The Robertson River population was similar in its consumption of grasses and sedges in winter (56%), but supplemented the summer diet of graminoids (50%) by ingesting the basal portions of oxytropes (24%).

RESULTS

Total standing biomass on the tundra control site exceeded the total biomass on the reclaimed areas (Tables 5 and 6). Salix alaxensis contributed the greatest amount of cover on both shrub areas examined, accounting for 31% of the cover on the Usibelli Mine and 25% on the B & R Mine site (Table 7). Willow accounted for 78% of the shrub density on the B & R Mine while alder accounted for 81% on the Usibelli Mine (Table 7). Total shrub density was greatest on the Usibelli Mine. Spruce was the most abundant tree on the Usibelli Mine and provided the greatest amount of cover on the coniferous cover type (Table 7).

Vertical foliage density (VFD) was greatest in the tall shrub cover type on both the Usibelli and B & R Mines (Table 8). Mean shrub ages on the revegetated areas of the Usibelli Mine were younger than shrubs on similarly aged unreclaimed sites (Tables 9 and 10).

Bird species observed and the avian habitat they were observed in are shown in Tables 11 and 12. I recorded 49 species of birds for the Usibelli Mine study area. By comparison, Tarbox et al. (1979) compiled a bird species list for the Healy area which included 51 species.

Revegetated areas exhibited a lower bird species diversity than was found on the naturally reclaimed B & R site (Table 13). Mining activities did not appear to have adversely impacted bird reproduction on adjacent land (Table 14). Territory size of two

Table 5. Plant biomass (kg/ha), cover (%), and average litter depth (cm) on the revegetated study areas, Usibelli Coal Mine, Healy, Alaska, 1981. Sample size for biomass (number of plots) and cover (number of pins) calculations are indicated in parentheses.

	Revegetated Sites					
	1972		1976		1979	
	Biomass	Cover[1]	Biomass	Cover[1]	Biomass	Cover[1]
Plant Species	(30)	(500)	(33)	(500)	(39)	(500)
Alopecurus pratensis	863.4	41	219.2	16	31.1	1
Festuca rubra	176.7	22	803.9	50	908.3	48
Calamagrostis canadensis	30.8	2	-	-	31.1	1
Epilobium spp.	7.6	1	-	-	35.8	2
Carex spp.	2.9	4	-	-	-	-
Equisetum arvense	4.6	1	-	-	-	-
Parnassia palustris	2.0	1	-	-	-	-
Bromus inermis	-	-	468.9	17	178.5	4
Phleum pratensis	-	-	20.3	1	34.3	7
Poa spp.	-	-	9.0	1	302.8	12
Litter	-	19	-	4	-	6
Bare Ground	-	4	-	5	-	14
Total	1088.1	95	1521.3	94	1521.9	95

Average (±S.D.) litter depth on each revegetated site

Site	Litter Depth
1972	1.68±2.34
1976	5.36±3.36
1979	7.09±4.32

1: total cover does not equal 100%, species exhibiting <1% were excluded from the calculations.

Table 6. Plant biomass (kg/ha) and cover (%) on the shrub tundra study site, Usibelli Coal Mine, Healy, Alaska, 1981. Sample size for biomass (number of plots) and cover (number of pins) are indicated in parentheses.

Plant Species	Biomass (25)	Cover (500)
Arctostaphylos alpina leaves	35.6	1
Betula nana stems and leaves	112.9	10
Carex bigelowii	219.1	21
Ledum decumbens stems and leaves	401.6	19
Rubus chamaemorus leaves	62.8	5
Vaccinium uliginosum leaves	489.2	18
Vaccinium vitis-idaea leaves	14.9	2
Eriophorum gracile	185.7	3
Cetraria cucullata	501.6	10
Peltigera aphthosa	88.4	1
Peltigera spp.	30.5	1
Stereocaulon spp.	3.6	1
Litter	-	5
TOTAL	2145.9	98

Note: total cover does not equal 100%, species exhibiting <1% were excluded from the calculations.

Table 7. Cover (%) and density (stems/ha) in the tall shrub cover type and coniferous cover type, Usibelli Coal Mine and tall shrub cover type on the B & R Mine, Healy, Alaska, 1981.

Plant Species	Cover	Density
USIBELLI COAL MINE		
Salix alaxensis	31	3934
Salix interior	4	850
Alnus crispa	24	20534
Picea spp.	8	712
Betula spp.	1	1
B & R MINE		
Salix alaxensis	25	9400
Salix interior	5	4800
Populus tremuloides	2	1900
Alnus crispa	2	2000

Table 8. Percent vertical foliage density (VFD) in summer (S) and winter (W) for the B & R site and the five largest cover types (in number of hectares) on the Usibelli Coal Mine, Healy, Alaska.

Distance from target (m)	Disturbed & Revegetated 1979		1976		1972		Shrub Tundra		Tall Shrub		Conifer Forest		Barren Floodplain		B & R Mine	
	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
10	13	0	38	0	25	0	11	0	73	50	63	22	2	0	75	45
20	13	0	38	0	25	0	13	0	84	84	82	84	2	0	92	89
30	25	0	38	0	33	0	14	0	92	100	84	84	2	0	100	100
40	25	0	38	0	33	0	14	0	100	100	90	95	5	0	100	100
50	31	0	63	0	38	0	14	0	100	100	100	100	5	0	100	100

Table 9. Mean ages (± standard deviation) of shrubs invading revegetated stripmine spoils on the Usibelli Coal Mine, Healy, Alaska, August, 1981.

Plant Species	Reclaimed Site	Sample Size	Age (yrs.)	Range
Alnus crispa	1972	10	3.6±2.6	2-8
Salix alaxensis		1	6.0	6
Alnus crispa	1974	5	2.8±0.6	2-4
Salix alaxensis		5	5.3±0.6	5-6
Alnus crispa	1976	1	4.0	4
Salix alaxensis		1	5.0	5
No shrubs present	1979			

Table 10. Mean ages (± standard deviation) of shrubs invading unreclaimed stripmine spoils on the Usibelli and B & R Mines, Healy, Alaska, 1981. Year of disturbance in parentheses.

Plant Species	Sample Size	Age (yrs.)	Range
USIBELLI MINE (1969)			
Salix alaxensis	10	5.2±3.1	4-11
Alnus crispa	10	8.1±1.4	3-10
B & R Mine (1971)			
Salix alaxensis	10	7.1±1.6	5-9
Alnus crispa	10	4.4±1.5	3-7

Table 11. Bird species observed on the Usibelli Coal Mine area, Healy, Alaska, 1980-1982.

Species Name/Scientific Name
Violet-green Swallow (Tachycineta thalassina)
Tree Swallow (Iridoprocne bicolor)
Bank Swallow (Riparia riparia)
Barn Swallow (Hirundo rustica)
Cliff Swallow (Petrochelidon pyrrhonota)
Gray Jay (Perisoreus canadensis)
Black-billed Magpie (Pica pica)
Rusty Blackbird (Euphagus carolinus)
Common Raven (Corvus corax)
Boreal Chickadee (Parus hudsonicus)
American Robin (Turdus migratorius)
Swainson's Thrush (Catharus ustulatus)
Orange-crowned Warbler (Vermivora celata)
Yellow Warbler (Dendroica petechia)
Common Redpoll (Carduelis flammea)
Savannah Sparrow (Passerculus sandwichensis)
White-crowned Sparrow (Zontrichia leucophrys)
Lapland Longspur (Calcarius lapponicus)
Dark-eyed Junco (Junco hyemalis)
Mallard (Anas platyrhynchos)

Table 11 (continued).

Green-winged Teal (*Anas crecca*)
Canvasback (*Aythya valisineria*)
Bufflehead (*Bucephala albeola*)
Surf Scoter (*Melanitta perspicillata*)
Red-tailed Hawk (*Buteo jamaicensis*)
Golden Eagle (*Aquila chrysaetos*)
Goshawk (*Accipiter gentilis*)
Sharp-shinned Hawk (*Accipiter striatus*)
Marsh Hawk (*Circus cyaneus*)
Merlin (*Falco columbarius*)
American Kestrel (*Falco sparverius*)
Ruffed Grouse (*Bonasa umbellus*)
Willow Ptarmigan (*Lagopus lagopus*)
Sandhill Crane (*Grus canadensis*)
Upland Sandpiper (*Bartramia longicauda*)
Lesser Yellowlegs (*Tringa flavipes*)
Solitary Sandpiper (*Tringa solitaria*)
Spotted Sandpiper (*Actitis macularia*)
Common Snipe (*Gallinago gallinago*)
Western Sandpiper (*Calidris mauri*)
Least Sandpiper (*Calidris minutilla*)
Mew Gull (*Larus canus*)
Hawk Owl (*Surnia ulula*)

Table 11 (continued).

Boreal Owl (Aegolius funereus)
Short-eared Owl (Asio flammeus)
Belted Kingfisher (Megaceryle alcyon)
Common Flicker (Colaptes auratus)
Hairy Woodpecker (Picoides villosus)
Rock Dove (Columba livia)

Table 12. Bird species and the avian habitats they were observed associated with on the Usibelli Coal Mine and B & R Mine study areas, Healy, Alaska, 1980-1982.

Shrub Tundra	Tall Shrub	Conifer Forest
Savannah Sparrow	Orange-crown Warbler	Common Redpoll
White-crowned Sparrow	Yellow Warbler	White-crowned Sparrow
Lapland Longspur	Common Redpoll	Merlin
Upland Sandpiper	White-crowned Sparrow	Ruffed Grouse
Willow Ptarmigan	Willow Ptarmigan	Hawk Owl
Short-eared Owl	Gray Jay	Boreal Chickadee
Gray Jay	Rusty Blackbird	Hairy Woodpecker
Sharp-shinned Hawk	American Robin	Boreal Owl
	Tree Sparrow	Common Flicker
	Boreal Chickadee	Gray Jay
		Dark-eyed Junco
		Sharp-shinned Hawk
		Goshawk

Disturbed & Revegetated	Disturbed & Unreclaimed
Savannah Sparrow	Short-eared Owl
White-crowned Sparrow	Savannah Sparrow
Lapland Longspur	
Short-eared Owl	

Table 12 (continued).

Water & Floodplain[1]	B & R Mine	Common[2]
Mallard	Gray Jay	Black-billed Magpie
Green-winged Teal	Ruffed Grouse	Common Raven
Canvasback	Orange-crowned Warbler	Red-tailed Hawk
Bufflehead	Yellow Warbler	Golden Eagle
Surf Scoter	Wilson's Warbler	American Kestrel
Sandhill Crane	Common Redpoll	Mew Gull
Lesser Yellowlegs	Savannah Sparrow	Marsh Hawk
Solitary Sandpiper	White-crowned Sparrow	Violet-green Swallow
Spotted Sandpiper	Tree Sparrow	Tree Swallow
Western Sandpiper	Dark-eyed Junco	Barn Swallow
Least Sandpiper		Cliff Swallow
Belted Kingfisher		American Robin
Swainson's Thrush		
Rusty Blackbird		

1: includes ephemeral water bodies.

2: birds observed on or over all cover types, includes species common to the B & R Mine site.

Table 13. Bird species diversity for six cover types on the Usibelli Coal Mine and the B & R Mine site, Healy, Alaska.

Cover Type or Site	Number of Species Observed[1]	Diversity[2] (Hm)
Shrub Tundra	8	3.00
Tall Shrubland	10	3.32
Coniferous Forest	13	3.70
Water & Floodplain	14	3.81
Disturbed & revegetated	4	2.00
Disturbed & unreclaimed	2	1.00
B & R Mine site	10	3.32

1: species number excludes birds common to all cover types.

2: Hm = species diversity under conditions of maximal equitability. Hm = $\log_2 S$, where S is the number of species in the community (Krebs 1978:456).

Table 14. Clutch size and fledging data for bird nests associated with the Usibelli Coal Mine area, Healy, Alaska, 1980-1982.

Bird Species	Number of Eggs: This Study	Number of Eggs: Gabrielson & Lincoln (1959)	Number Fledged	Egg:Fledged Ratio
Savannah Sparrow	4	3 - 6	4	1.00
Savannah Sparrow	4	3 - 6	3	0.75
White-crowned Sparrow	4	3 - 5	3	0.75
Black-billed Magpie	6	7	5	0.83
Common Raven	4	4 - 5	4	1.00
Mallard	6	8 - 12	4	0.67
Hairy Woodpecker	3	3 - 6	3	1.00
Hairy Woodpecker	3	3 - 6	3	1.00

species of nesting passerines was determined (Table 15); savannah sparrows (Passerculus sandwichensis) averaged 1.64 ha, and a white-crown sparrow (Zontrichia leucophrys) territory was 5.07 ha. Two species of gallinaceous birds, willow ptarmigan and ruffed grouse (Bonasa umbellus), were observed on the mine. Buds and twigs of willow were the dominant items in the winter diet of the willow ptarmigan (Table 16). Five species of ducks and five species of sandpipers were observed using water impoundments on the mine area. The only nesting waterfowl found associated with reclaimed land was the mallard (Anas platyrhynchos). In 1981 a nest containing six eggs was located on the 1976 revegetated area. The nest was situated in a bluejoint grass (Calamagrostis canadensis) stand, nine meters from the nearest water body. Water bodies appeared to mainly function as resting habitat for migrating waterfowl.

Table 15. Territory size of birds associated with revegetated spoils on the Usibelli Coal Mine, Healy, Alaska, 26-28 May, 1981.

Bird Species	Territory Size (ha)	Nest Site (Revegetated Area)	Percent of Territory Revegetated Land
Savannah Sparrow	0.74	1974	10
Savannah Sparrow	2.54	1972	51
White-crown Sparrow	5.07	1972	18

Twenty-six species of terrestrial mammals were observed or trapped on the Usibelli study area (Table 17). The greatest number of small mammal species observed or captured occurred on the shrub tundra cover type (Table 18). This area also exhibited the greatest diversity of small mammals (Table 19). Of those sites on which small mammals were observed or captured, the disturbed and revegetated sites exhibited the lowest species diversity.

Table 16. Winter food habits of the willow ptarmigan on the Usibelli Coal Mine, Healy, Alaska, 1981. Sample size in parentheses.

Plant Species	Percent Occurrence (N=40)
Salix spp.	95
Vaccinium uliginosum fruit	3
Unknown Forbs	2

The summer diet for caribou observed on the Usibelli Mine was very similar to the food habits reported for native ranges (see Boertje 1981 and Table 20). Lichens, willow and graminoids comprised 20, 17 and approximately 27% respectively. In the graminoid category, red fescue (*Festuca rubra*) was the major grass species identified in the diet.

Boertje (1981) determined the nutrient content of the summer (July to mid-August) dietary components of the Denali National Park

Table 17. Mammal species observed or trapped on the Usibelli Coal Mine study area, Healy, Alaska, 1980-1982.

Common Name/Scientific Name
Tundra Vole (Microtus oeconomus)
Red-backed Vole (Clethrionomys rutilus)
Masked Shrew (Sorex cinereus)
Pygmy Shrew (Sorex hoyi)
Arctic Shrew (Sorex tundrensis)
Water Shrew (Sorex palustris)
Northern Jumping Mouse (Zapus hudsonicus)
Porcupine (Erethizon dorsatum)
Least Weasel (Mustela rixosa)
Beaver (Castor canadensis)
Marten (Martes americana)
Short-tailed Weasel (Mustela erminea)
Mink (Mustela vison)
Dall Sheep (Ovis dalli)
Caribou (Rangifer tarandus)
Moose (Alces alces)
Coyote (Canis latrans)
Snowshoe Hare (Lepus americanus)
Red Squirrel (Tamiasciurus hudsonicus)
Northern Flying Squirrel (Glaucomys sabrinus)

Table 17 (continued).

Arctic Ground Squirrel (*Spermophilus parryii*)
Black Bear (*Ursus americanus*)
Grizzly Bear (*Ursus arctos*)
Red Fox (*Vulpes vulpes*)
Wolf (*Canis lupus*)
Lynx (*Lynx canadensis*)

Table 18. Small mammal species and the cover types in which they were observed or trapped on the Usibelli Coal Mine and B & R Mine study areas, Healy, Alaska, 1980-1982.

Shrub Tundra	Tall Shrub	Disturbed and Unreclaimed
Red-backed Vole	Red-backed Vole	None
Tundra Vole	Snowshoe Hare	
Masked Shrew	Masked Shrew	
Pygmy Shrew	Northern Jumping Mouse	
Arctic Shrew		
Water Shrew		
Northern Jumping Mouse		
Coniferous Forest	**B & R Mine Site**	**Disturbed and Reclaimed**
Red-backed Vole	Red-backed Vole	Tundra Vole
Red Squirrel	Tundra Vole	Masked Shrew
Northern Flying Squirrel	Masked Shrew	Arctic Ground Squirrel
Snowshoe Hare	Snowshoe Hare	
Masked Shrew	Northern Jumping Mouse	
Lynx		

Table 19. Small mammal species diversity for five cover types on the Usibelli Coal Mine, Healy, Alaska, and the B & R Mine site.

Cover Type	Number of Species Observed	Diversity[1] (Hm)
Shrub Tundra	7	2.81
Tall Shrub	4	2.00
Coniferous Forest	5	2.32
Disturbed & Revegetated	3	1.58
Disturbed & Unreclaimed	0	0
B & R Mine site	5	2.32

1: Hm = species diversity under conditions of maximal equitability. $Hm = \log_2 S$, where S is the number of species in the community (Krebs 1978:456).

caribou herd (Table 21). The nutrient content of the Denali diet (Table 21) was compared with the Usibelli data (Table 22) to determine if the diets were nutritionally similar.

The Usibelli diet exhibited similar levels of crude protein in the graminoid, deciduous shrubs, and forb categories. The mean crude protein content of lichens on the tundra adjacent to the reseeded areas was higher than levels found in Denali National Park. Maynard et al. (1979:224) indicated an acceptable ratio of calcium (Ca) to phosphorus (P) to be from 1:1 to 2:1 for farm animals other than poultry. When the proportion reaches about 10:1 problems occur. An excess of calcium interferes with the efficient assimilation of phosphorus (Maynard et al. 1979:224). The Ca:P ratios for all categories on the mine site indicated acceptable levels of both elements are present. Total nonstructural carbohydrate (TNC) levels were similar for all categories between the two studies.

Caribou were sighted most frequently on the revegetated areas, with the shrub tundra, tall shrub and coniferous forest cover types being used in decreasing order (Table 23).

Based on visual observations and pellet group data, moose utilized the tall shrub cover type more than any other area (Table 24). Of the 24 observations recorded in the tall shrub area, 10 occurred in the summer months while 14 were winter observations. The forested areas were utilized mainly in the winter months, with 73% (N=8) of the sightings occurring between September-April. The winter diet consisted mainly of willow, the summer diet was composed

Table 20. Summer food habits of caribou on the Usibelli Coal Mine, Healy, Alaska, 1981. Values are percent by dry weight composition of the diet. Sample size in parentheses.

Plant Species	Diet (N = 100)
Salix spp.	17
Festuca rubra	10
Carex spp.	2
Calamagrostis canadensis	1
Poa spp.	2
Bromus inermis	1
Medicago falcata	3
Vaccinium spp.	1
Elymus sibiricus	1
Arctostaphylos alpina	T
Parnassia palustris	T
Epilobium latifolium	T
Agropyron cristatum	T
Rubus chamaemorus	T
Equisetum arvense	T
Juncus castaneus	T
Phleum pratense	T
Achillea millefolium	T
Valeriana capitata	T

Table 20 (continued).

Moss	12
Lichen[1]	20
Unknown Graminoids	13
Unknown Forbs	10

T: indicates trace amount, <1%.

1: lichens present in the area and assumed to contribute to the diet were Cetraria cucullata, Peltigera aphthosa, Stereocaulon spp., and Peltigera spp.

Table 21. Average percent (± standard deviation) nutrient content (% relative dry weight) of summer (July to mid-August) dietary components of the Denali caribou herd, 1978-1979. Values represent means as given in Boertje (1981:271).

Plant Category	Crude Protein	P	K	Ca	Mg	TNC	Ca:P
Graminoids[1]	14.41±1.38	0.17±0.01	-	0.56±0.17	-	17.4±2.0	3.3:1
Deciduous Shrubs[2]	15.19±0.56	0.22±0.01	-	1.26	-	6.5±0.8	5.7:1
Lichens[3]	2.69±2.50	0.40±0.02	0.16	0.15	0.04	1.8±3.5	1:2.7
Forbs[4]	13.44±2.38	0.29±0.11	-	0.94±0.28	-	9.4±3.4	3.2:1
Evergreen Shrubs[5]	9.38±0.38	0.17±0.03	-	0.80	-	10.2±1.6	4.7:1

1: includes *Carex* spp., *Festuca altacia*, and *Hierochloe alpina*.

2: includes *Betula nana* and *Salix* spp.

3: includes *Cladonia alpestris*, *C. rangiferina*, *Cetraria cucullata*, *Peltigera* spp., and *Stereocaulon* spp.

4: includes *Artemisia arctica*, *Boykinia richardsonii*, *Dodecatheon frigidum*, *Epilobium latifolium*,

Table 21 (continued).

Equisetum arvense and *E. variegatum*.

5: includes *Dryas octopetala*.

Table 22. Average percent (± standard deviation) nutrient content (% relative dry weight) of the summer (July to mid-August) dietary components of caribou on the Usibelli Coal Mine, Healy, Alaska, 1981.

Plant Category	Crude Protein	P	K	Ca	Mg	TNC	Ca:P
Graminoids[1]	9.29±2.76	0.22±0.06	1.49±0.21	0.24±0.04	0.11±0.02	19.84±7.45	1:1
Deciduous Shrubs[2]	11.66±2.58	0.23±0.14	0.61±0.11	0.59±0.23	0.18±0.09	15.24±3.89	2.6:1
Forbs[3]	16.22±2.25	0.18±0.02	1.34±0.19	0.38±0.78	0.36±0.03	4.35±0.64	2.1:1
Lichens[4]	10.11±7.81	0.10±0.04	0.50±0.20	0.14±0.01	0.08±0.02	2.15±3.00	1.4:1

1: includes *Festuca rubra*, *Carex* spp., *Calamagrostis canadensis*, *Bromus inermis* and *Poa* spp.

2: includes *Salix alaxensis*, *Vaccinium uliginosum* and *V. vitis-idaea*.

3: includes *Medicago falcata*.

4: includes *Cetraria cucullata*, *Stereocaulon* spp., *Peltigera aphthosa* and *Peltigera* spp.

predominately of willow, but forbs and grasses made up to 17% of the summer diet (Table 25). Of the grasses eaten, only red fescue and bluejoint were important to the local population.

To further assess the habitat suitability of the region for moose, a count of cows and their accompanying calves was made to assess the reproductive performance of the mine population. Six calves and five cows (including one incidence of twinning) were observed from May-July 1981, resulting in a calf:cow ratio of 120:100. Haber (1977) recorded spring calf:cow ratios ranging from 58:100 to 126:100 in Denali National Park from 1966 to 1974. More recently Wolff and Cowling (1981) reported a ratio of 85:100 for the Denali moose herd. Of the six calves identified, three were killed by grizzly bears (Ursus arctos). Grizzly bear predation on moose calves has been shown to be a major source of calf mortality in central Alaska (Ballard et al. 1981a).

The overall adjusted carrying capacity of the mine area (based on S. alaxensis) was 4.7 moose-days/ha (Table 26). This was very similar to the 4.9 value reported by Wolff and Cowling (1981) for one of their sites in Denali National Park; but much less than their values of 10.8 and 10.7 on other plots. The naturally revegetated B & R Mine site exhibited an adjusted carrying capacity (9.7) of more than two times that found on the Usibelli area (Table 27).

The portion of the Usibelli Mine utilized by Dall sheep functioned primarily as a winter range (Table 28). Winter and summer diets of sheep on the mine area were composed of grasses

(Table 29). Of the ungulate species examined, sheep incorporated the greatest percent of seeded grasses into their diet. Red fescue and bluejoint were the most important items in the diet, comprising 49 and 10% of summer diets, and 40 and 15% of winter diets respectively.

A number of methods have been used in various investigations to convey an index of 'reproductive performance' of a sheep population. The most commonly used index is the ratio of lambs per 100 ewes in reproductive age. Within Alaska, Scott et al. (1950) reported a ratio of 70% for sheep populations on the Kenai Peninsula, while Nichols and Smith (1971) reported 55% in the Dry Creek area. Based on six months ewe:lamb counts, the Usibelli population had a ewe:lamb ratio of 53%-- what Hoefs and Cowan (1979) would classify as 'average' in reproductive performance.

Snowshoe hares used the tall shrub cover type more than any other habitat examined. Hare density in the shrub zone was 10 hares/ha in winter and 18/ha in summer (Table 30). Shrubs comprised the major portion of the summer diet (69%), while spruce made up 51% of the winter diet (Table 31).

Eighty-six percent of arctic ground squirrel diets consisted of red fescue and bluejoint (Table 32). In an attempt to determine if the squirrels were exhibiting a preference for red fescue or simply using what was most available, feeding trials were conducted. Six arctic ground squirrels were live-trapped on the study area and housed in 50 X 50 X 38 cm laboratory cages (Wahmann Mfg. Co.,

Table 23. Caribou numbers and cover type use on the Usibelli Coal Mine, Healy, Alaska, 1980-82.

Date	Total Number of Caribou Observed	Number of Observations	Number per Observations
1-15 May	20	1	20
16-31 May	7	2	3.5
1-15 June	23	6	3.8
16-30 June	27	8	3.4
1-15 July	34	8	4.3
16-31 July	52	12	4.3
1-15 August	14	5	2.8
16-31 August	5	2	2.5
1-15 September	0	0	0
15-31 September	0	0	0

Cover Type	Percent of Observations per Cover Type
Coniferous Forest	2/44 = 5%
Shrub Tundra	12/44 = 27
Revegetated	18/44 = 41
Tall Shrub	4/44 = 9
Unreclaimed	8/44 = 18

Table 24. Moose numbers and cover type use on the Usibelli Coal Mine, Healy, Alaska, 1980-82.

Month	Total Number of Moose Observed	Number of Observations	Number per Observation
Jan.	2	2	1
Feb.	2	2	1
March	1	1	1
April	2	2	1
May	15	11	1.4
June	10	8	1.3
July	16	7	2.3
August	5	5	1
Sept.	2	2	1
Oct.	2	2	1
Nov.	3	3	1
Dec.	4	4	1

Cover Type	Percent of Observations per Cover Type
Coniferous Forest	11/49 = 22%
Shrub Tundra	4/49 = 8
Revegetated	10/49 = 20
Tall Shrub	24/49 = 49

Table 25. Food habits of moose on the Usibelli Coal Mine, Healy, Alaska, 1981. Sample size in parentheses. Values are percent dry weight of diet.

Plant Species	Winter (60)	Summer (20)
Salix spp.	84	64
Vaccinium uliginosum	-	4
Festuca rubra	-	10
Calamagrostis canadensis	-	3
Medicago falcata	-	T
Melilotus spp.	-	T
Bromus inermis	-	T
Carex spp.	-	T
Juncus castaneus	-	T
Lichen/Moss	2	1
Unknown Forbs	2	7
Unknown Graminoids	-	5
Unknown Shrubs	12	7

T: indicates trace amount, $<1\%$.

Baltimore, Maryland) for one week (6-12 July 1982). The squirrels were offered 50 g of fresh cut *Festuca rubra*, *Calamagrostis canadensis*, *Alopecurus pratensis* and *Bromus inermis* daily. Water and rolled oats were supplied *ad lib*. All squirrels lost an average of 11 g at the end of the seven day period. There was no significant difference in the amounts of *Festuca*, *Calamagrostis* and *Alopecurus* species consumed ($P > 0.05$, paired t-test), but all three species were eaten in significantly greater quantities than *Bromus inermis* ($P < 0.05$). This lack of preference for Brome was also noted by Batzli and Sobaski (1980).

Because of the limited home range of arctic ground squirrels (3.2-4.3 ha, Batzli and Sobaski 1980), feeding areas can easily be determined. Knowing where the food is consumed makes it possible to use data from the fecal analysis technique and calculate preference indices. Of the standing biomass available on the ground squirrel colony site (684 kg/ha), red fescue accounted for 60% of the available forage, bluejoint comprised 35%. Preference values were calculated for red fescue and bluejoint by dividing the percent of the food item in the diet by the percent of the item available as forage (Reichman 1975). Each species had a value of less than one, indicating the squirrels were consuming the plants as they were encountered in the habitat and not selecting for one plant over another. Thus the lack of preference exhibited in the caged trial was also reflected in the field diet.

Ground squirrels were apparently limited in their distribution by soil texture and permafrost depth. Burrows were constructed in loamy soils lacking permafrost. Mean placental scar count per female was 6.8±2.4. Squirrel density was 4-5 per hectare.

Observations were made of squirrel burrowing attempts on the 1976 and 1979 reclaimed sites. In previous years ground squirrels had traveled from the Hydraulic Pit to the office and shop area of the mine. These squirrels were live-trapped and set free near the 1976 and 1979 study areas. The animals have survived by burrowing into the road embankment along Gold Run Road. Seven observations were made of these individuals attempting to excavate a burrow on the reclaimed areas. All attempts were abandoned. No active ground squirrel burrow was ever found on any revegetated area except the 1972 site.

One hundred thirty-three scats were collected for carnivore diet analysis. Using the criteria established for scat classification (Table 4), 96 scats were identified as red fox, coyote, or wolf in origin, 37 scats could not be classified and were excluded from the analysis. During the summer months 36% of red fox, 32% of coyote, and 38% of wolf diets were composed of snowshoe hare. The hare retained its importance in winter diet for coyotes and foxes, but wolves consumed mainly Dall sheep (Tables 33 and 34).

Red foxes and coyotes were consistent in their selection of the tall shrub cover type. In winter, wolves mainly utilized the revegetated areas frequented by Dall sheep, during summer wolves were rarely observed on the mine.

Table 26. Production of woody browse on the Usibelli Coal Mine, Healy, Alaska, 1981.

Species	Mean diameter at point of browsing (mm)	Weight per twig (g)	Twigs per stem	Forage available per stem (g)	Stems per hectare	Browse available per hectare (kg/ha)
Salix alaxensis	5.02	1.95	4.1	8.0	3934	31.47
S. interior	4.73	2.11	4.0	6.5	850	5.53
Alnus crispa	4.93	2.80	4.5	12.6	20534	258.73

Species	Browsing intensity (percent of plant browsed	Browse consumed (kg/ha)	Adjusted Carrying Capacity[1] (moose-days/ha)
S. alaxensis	88	27.69	4.72
S. interior	86	4.75	0.83
A. crispa	7	18.11	38.81

1: adjusted carrying capacity = $\frac{\text{75\% of browse available}}{\text{5 kg/moose/day}}$ (Wolff and Zasada 1979)

Table 27. Production of woody browse on the B & R Mine site, Healy, Alaska, 1981.

Species	Mean diameter at point of browsing (mm)	Weight per twig (g)	Twigs per stem	Forage available per stem (g)	Stems per hectare	Browse available per hectare (kg/ha)
Salix alaxensis	4.81	2.11	4.5	6.9	9400	64.86
S. interior	4.50	2.00	4.2	6.0	4800	28.80
Alnus crispa	5.10	2.42	5.3	14.1	2000	28.20

Species	Browsing intensity (percent of plant browsed)	Browse consumed (kg/ha)	Adjusted Carrying Capacity[1] (moose-days/ha)
S. alaxensis	82	53.19	9.73
S. interior	80	23.04	4.32
A. crispa	2	0.56	4.23

1: adjusted carrying capacity = $\frac{\text{75\% of browse available}}{\text{5 kg/moose/day}}$ (Wolff and Zasada 1979)

Ten species of raptors were identified on the mine site. Of the species noted, six were observed hunting over reclaimed areas. Microtines, hares, ground squirrels, shrews, and insects were the major items consumed (Tables 35 and 36).

The tundra vole (Microtus oeconomus) was the only microtine that occupied reclaimed mine spoils (Table 37). Density of the vole on seeded areas was greater than occurred on native habitat (9.1 vs 2.1/ha). Tundra voles consumed mainly graminoids, the plants comprising 75% of the diet on revegetated areas and 70% on undisturbed shrub tundra (Tables 38 and 39). The mean number of placental scars per female on seeded areas was 6.6 ± 1.7. The average number of embryos per female equaled 5.8 ± 1.3. There was no significant difference ($P > 0.05$, unpaired t-test) between the mean number of placental scars for voles on reclaimed sites and tundra voles from natural habitats (Table 40). The mean number of embryos per female was significantly larger ($P < 0.05$) at the St. Lawrence and Benedeleben locations (Table 40).

Red-backed voles (Clethrionomys rutilus) were found on undisturbed areas (density = 4.2/ha), but were absent from reclaimed sites. Red-backed voles consumed mainly berries (Table 39), food items missing on the revegetated areas.

Table 28. Dall sheep numbers and seasonal use of the revegetated Hydraulic Pit area, Usibelli Coal Mine, Healy, Alaska, 1980-82[1].

Date	Total number of Sheep Observed	Number of Observations	Number per Observation
1-15 May	27	3	9
16-31 May	46	5	9.2
1-15 June	2	1	2
16-30 June	1	1	1
1-15 July	14	3	4.7
16-31 July	15	6	2.5
1-15 August	4	2	2
16-31 August	6	3	2
19-26 September	52	2	26
17-24 October	100	2	50
21-30 November	104	2	52
7-12 December	104	2	52
29 January	20	1	20
7-26 February	50	2	25
8-15 March	40	2	20
9-21 April	40	2	20

1: data for Sept-April is from 1981, summer data is from May-August, 1980-82.

Table 29. Food habits of Dall sheep utilizing the revegetated Hydraulic Pit area, Usibelli Coal Mine, Healy, Alaska. Values are percent dry weight of the diet. Sample size in parentheses.

Plant Species	Summer Diet May-August, 1981-82 (13)	Winter Diet Sept.-April, 1981 (160)
Festuca rubra	49	40
Calamagrostis canadensis	10	15
Melilotus spp.	T	5
Vaccinium spp.	T	1
Chenopodium album	-	1
Rubus chamaemorus	2	1
Salix spp.	3	3
Medicago falcata	T	T
Brassica campestris	2	T
Descurainia sophioides	-	T
Pedicularis capitata	2	-
Lepidium densiflorum	-	T
Arctagrostis latifolia	T	T
Parnassia palustris	-	T
Valeriana capitata	T	-
Artemisia tilesii	-	T
Betula glandulosa	-	T

Table 29 (continued).

Moss/Lichen	18	8
Unknown Forbs	11	23
Unknown Graminoids	2	2

T: indicates trace amount, $< 1\%$.

DISCUSSION

The major animal groups or species found in the study areas are discussed separately in the following sections. Items emphasized will be: (1) habitat utilization, and (2) food habits.

The concept of habitat is a rather broad-based, all encompassing one. Habitat is defined as the range of environments in which a species occurs (Krebs 1978:227). Using direct observations and various 'signs', the habitats used by the various wildife species on the Usibelli Mine study area were delineated-- with emphasis on those parts of their environments most likely affected by stripmining and revegetation practices.

Food habits express a fundamental relationship between animals and their environment. The feeding habits and plants used by herbivores should be determined in order to better understand the interspecific, intraspecific, and environmental relationships of the species (Peek 1974). The diet information obtained for specific mammal species observed on the Usibelli Mine is reviewed and compared to food habit data available for each species on its native range. This was done to determine the adequacy of reclaimed areas as foraging habitat.

BIRDS

PASSERINE BIRDS

Habitat Utilization

Based on the number of avian species that were observed to occupy the various cover types, the disturbed and unrevegetated cover

Table 30. Density estimates (hares/ha) of snowshoe hares on the Usibelli Coal Mine, Healy, Alaska, 1981.

Cover Type	DENSITY Winter	Summer
Tall Shrub	10	18
Conifer Forest	6	12
Revegetated	0	0

type was least diverse; the revegetated sites were next in their lack of diversity. The naturally revegetated site (B & R Mine) was similar to the tundra control site and equal to the tall shrub cover type in bird species diversity (Table 13).

Two species on the Usibelli Mine, white-crown sparrow and savannah sparrow, utilized portions of seeded areas as part of their territory. The average territory size of savannah sparrows (1.64 ha) was a larger value than reported for other localities (eg. 0.17 ha in Nova Scotia (Welsh 1975) and 0.69 ha in Wisconsin (Wiens 1969:38)). A single white-crown sparrow was found which included seeded land in its territory (5.07 ha). The concept of territory used here follows the criteria used by Wiens (1969:20):

> Territories of individual pairs of birds were adopted as the areal units for habitat analysis on the assumption that the features of a territory reflect the habitat preference of the owner, within the range of conditions and circumstances available to it.

No territory sizes for the two species in Alaska are available, but the large dimensions may be interpreted as implying one of three things: 1) Alaskan passerines need larger territories than conspecifics further south; 2) passerines utilizing portions of reclaimed mine spoils need larger areas than under natural conditions to satisfy their habitat needs; or 3) there is a lack of competition.

Surface mining activities have been postulated to affect avian populations on sites adjacent to active stripmines (Allaire 1978a). Some species have been shown to have lower reproductive success on mined areas than in natural habitats (Wray et al. 1982). To ascertain if the bird species in the vicinity of the Usibelli Mine were impacted, nests, eggs and fledglings were counted (Table 14). Compared with clutch size information presented by Gabrielson and Lincoln (1959), it does not appear the mined areas have adversely affected the reproductive performance of the local bird fauna.

Current reclamation practices initially create habitats that are not useful to the majority of passerine birds found in interior Alaska. The lack of an overstory for nest sites and nesting cover make the reclaimed areas unattractive to many bird species. To make a reclaimed mine site more functional as bird habitat, careful planning to ensure the redevelopment of a natural complex of vegetation should be undertaken (Karr 1980; Schaïd et al. 1983). The establishment of vegetation-related requirements (ie. food resources, nest sites, song perches) has been found to create adequate year-round habitat (Anderson and Ohmart 1980) and result in greater avian use and diversity (Terrel and French 1975).

Table 31. Food habits of snowshoe hares on the Usibelli Coal Mine, Healy, Alaska. Values are percent dry weight of diet. Sample size in parentheses.

Plant Species	Winter (42)	Summer (29)
Salix spp.	22	42
Alnus crispa	6	3
Betula spp.	1	T
Picea spp.	51	12
Festuca rubra	-	2
Calamagrostis canadensis	-	T
Unknown Graminoids	T	4
Unknown Forbs	2	10
Unknown Shrubs	16	24
Vaccinium uliginosum	T	T

T: indicates trace amount, $<1\%$.

Food Habits

No diet analysis was performed for the passerine bird species using the Usibelli Mine area.

WATERFOWL

Habitat Utilization

Water bodies on the mine appeared to function mainly as resting habitat for ducks. Sightings of all ducks (except the mallard) were concentrated in the early spring or late fall-- times of the year when waterfowl were migrating.

The only nesting waterfowl found associated with reclaimed land was the mallard. Mallards use many types of nest cover; in an abandoned crop field Dubbert (1969) found wheatgrass (Agropyron spp.), sweet clover (Melilotus spp.), and alfalfa (Medicago sativa) to be utilized. More than any other duck, mallards have been able to utilize agricultural fields for feeding (for a review of food habits in natural and cultivated situations see Bellrose 1980:243). The wide utilization of many types of nest cover and plasticity in foods consumed have made the mallard the most common duck associated with stripmines (Riley 1954, 1960).

I believe the species reported to nest in the Healy area by Tarbox et al. (1979) (excluding the mallard) did not use ponds on the mine because of the absence of preferred foods. Green-winged teal feed on seeds of moist soil plants deposited in previous years (Bellrose 1980:226; Hughes and Young 1982), wigeons prefer the stems and leafy parts of aquatic plants (Bellrose 1980:206), while

Table 32. Food habits of arctic ground squirrels on the Usibelli Coal Mine, Healy, Alaska, 1981. Values are percent dry weight of the diet. Sample size in parentheses.

Plant Species	Diet (100)
Festuca rubra	55
Calamagrostis canadensis	31
Bromus inermis	2
Valeriana capitata	1
Alopecurus pratensis	T
Salix spp.	T
Unknown Forbs	2
Unknown Graminoids	8

T: indicates trace amount, $<1\%$.

buffleheads mainly consume aquatic insects (Erskine 1972); none of these food items were observed in the water bodies created as a result of mining activities.

Sandpipers on the mine were not observed at permanent water bodies (ie. settling ponds) but frequented the ephemeral water bodies created by rain filling depressions and sinkholes. The fluctuating water levels in these 'ponds' created small areas of mud flats and decaying vegetation, which in association with the insects populating the adjacent seeded areas, created ideal feeding habitat. No sandpiper nests were located on the reclaimed areas.

Present surface mining techniques and the associated reclamation procedures appear beneficial in a limited way for waterfowl. Water bodies are created which function as resting sites for migrating ducks and feeding areas for sandpipers.

Food Habits

No diet analysis was performed for the waterfowl occurring on the mine area.

GALLINACEOUS BIRDS

Habitat Utilization

Game birds have been found to readily utilize stripmines as year-round habitat (eg. bobwhite quail (*Colinus virginianus*) in Illinois (Vohs et al. 1962) and ruffed grouse in West Virginia (Kimmel and Samuel 1978)). Only the willow ptarmigan and ruffed grouse were observed on the Usibelli Mine. Spruce grouse (*Canachites canadensis*) were reported nesting in the Healy area by Tarbox et al. (1979) but none were sighted on the mine.

Table 33. Summary of food remains in red fox, coyote, and wolf scats collected during the summer (May-August) of 1981 and 1982, Usibelli Coal Mine, Healy, Alaska. N equals the number of food items identified. The total number of scats examined per species is indicated in parentheses.

	RED FOX (22)		COYOTE (37)		WOLF (14)	
Food Item	N	Percent Occurrence	N	Percent Occurrence	N	Percent Occurrence
Tundra Vole	3	10.0	5	9.1	2	11.1
Redback Vole	1	3.3	-	-	-	-
Snowshoe Hare	11	36.6	18	32.7	7	38.8
Arctic Ground Squirrel	2	6.6	4	7.3	5	27.7
Dall Sheep	4	13.3	5	9.1	1	5.5
Unknown Birds	-	-	3	5.5	-	-
Unknown Mammals	9	30.0	14	25.4	2	11.1
Vegetation	-	-	6	10.9	1	5.5
TOTAL	30		55		18	

Table 33 (continued).

Mean number of items per scat:

Red Fox	1.23 ± 0.53
Coyote	1.35 ± 0.54
Wolf	1.29 ± 0.47

Table 34. Summary of food remains in red fox, coyote, and wolf scats collected during the winter (Sept.-April) of 1981 and 1982, Usibelli Coal Mine, Healy, Alaska. N equals the number of food items identified. The total number of scats examined per species is indicated in parentheses.

	RED FOX (7)		COYOTE (4)		WOLF (12)	
Food Item	N	Percent Occurrence	N	Percent Occurrence	N	Percent Occurrence
Snowshoe Hare	3	33.3	1	25.0	-	-
Red Squirrel	1	11.1	-	-	-	-
Dall Sheep	2	22.2	1	25.0	12	100.0
Unknown Birds	-	-	1	25.0	-	-
Ptarmigan	1	11.1	-	-	-	-
Unknown Mammals	2	22.2	1	25.0	-	-
TOTAL	9		4		12	

Mean number of items per scat:

Red Fox 1.29 ± 0.47 Coyote 1.00 Wolf 1.00

The willow ptarmigan was the only game bird repeatedly observed associated with a disturbed area. The major portion of sightings (68% of observations) were made during the winter months. Birds were never observed on revegetated areas but were frequently sighted in areas where natural invasion of shrubs had occurred. Visual sightings and the frequency of droppings found in the tall shrub cover type indicated this was preferred winter habitat. A revegetated road through an aspen stand was the only site on which ruffed grouse were observed. All sightings occurred in summer and were of single birds foraging.

Food Habits

Willow made up 95% of the diet of willow ptarmigan on the Usibelli Mine, bog blueberry fruits 3%, and unknown forbs 2%, no grasses were evident (Table 16). The diets of ruffed grouse in the area were not determined but based on reported dietary data (McGowan 1973), reclaimed sites may serve as auxillary feeding areas.

The loss of aspen and willow, and lack of consideration for shrub re-establishment, make current reclamation procedures of little value to game birds.

RAPTORS

Habitat Utilization

Raptors have been reported to use stripmines as nesting sites and hunting areas (Birkenholz 1958; Allaire et al. 1982). Ten species of raptors were observed on the Usibelli Mine; no birds nested on the revegetated areas but all species used the regions for hunting.

The majority of sightings (80%) of short-eared owls were in or over reclaimed areas. The revegetated areas and their short statured vegetation are similar to the undisturbed habitats utilized by short-eared owls in Alaska (Gabrielson and Lincoln 1959:542-545).

Red-tailed hawks were observed over all cover types on the study area. Single birds were observed a total of 17 times during the summers of 1981 and 1982. Pairs of birds were sighted on three occasions (once in 1981, twice in 1982). These paired sightings occurred when an arctic ground squirrel had been captured by one bird and an in-flight food exchange took place with the second hawk. Based on the route taken by the bird which received the squirrel, and assuming a nesting density of one pair per 61.6 sq kms (24 sq miles) (Lowe 1978), I estimated the study area was used by one pair of hawks which nested in the Dora Creek drainage. I made two attempts (June 1981 and 1982) to locate the nest but was unsuccessful.

Hawk owls were observed on the mine area five times. Two sightings were of an individual hunting on a reclaimed area; three birds were observed perched on top of dead snags along the Gold Run Road.

During the summers of 1980-82, a single golden eagle was observed on the study area. The bird was still in immature plumage, exhibiting whitish feathers below and near the elbow of the wing (Gabrielson and Lincoln 1959:266). Despite the juvenile appearence the bird was observed performing courtship maneuvers on 10 April 1981. No second eagle was ever observed, all 31 sightings were of a solitary bird. The bird was cosmopolitan in the cover types it was sighted over, but based on observed and documented food habits, areas inhabitated by ground squirrels must be considered important feeding sites for eagles.

A pair of kestrels were observed on the mine area during the summers of 1981 and 1982. It was believed the birds were a mated pair, having been observed perched together in the same or adjacent trees in early spring (Bent 1961b:107). The birds were sighted over all cover types but appeared to prefer (78%, N=32 observations) the open habitat of revegetated areas, gravel bars, and open tundra.

Observations of the male carrying food items and earlier sightings of the male female together suggested a nest was located in the Gagnon Creek drainage. Unlike most hawks and falcons, which either make true nests in trees or lay their eggs on open ledges or bare cliffs, the kestrel hides its eggs in deep hollows, either a natural cavity in a tree or in a hole excavated by a woodpecker (Bent 1961b:108). Attempts were made to locate the nest but all were unsuccessful. The pair was successful during the 1981 season because two immature birds were observed in the company of the adults.

Marsh hawk preference for meadow-inhabiting birds and small mammals (Beebe 1974), and its propensity to nest in grassy habitat explain its high use (85% of observations) of the revegetated sites on the Usibelli Mine.

Two accipiters, the goshawk (Accipiter gentilis) and sharp-shinned hawk (Accipiter striatus), were sighted on the mine area. The goshawk frequented the Poker Flats Road and Poker Lake regions (Fig. 2). A pair of sharp-shinned hawks nested in the Sanderson Creek drainage during the summers of 1981 and 1982. The birds were often sighted flying along the drainage but in 1981 single hawks were observed on four occasions over the 1976 revegetated study site. In every instance the bird was chasing or harassing a short-eared owl.

Food Habits

A single short-eared owl spent the 1981 summer season on the Usibelli Mine. By observing the owl when it was perched, I was able to locate eight castings, 75% of which contained tundra voles (Table 35). The predominance of tundra voles in the diet is consistent with the observed hunting behavior of the bird. The only microtine captured on the revegetated areas was the tundra vole and the majority (80%) of short-eared owl sightings were on or over reclaimed areas.

Red-tailed hawks were observed with prey items on four occasions (Table 35). On three occasions a hawk was observed to capture an arctic ground squirrel at the Hydraulic Pit colony. A flying red-tailed hawk with a snowshoe hare in its talons was observed on one occasion over the Gold Run Road. Based on these limited observations red-tailed hawks in the Usibelli area seem to prey on ground squirrels to a greater extent than hawks observed by Lowe (1978).

Two observations of hawk owls capturing food items were made in 1981. The birds were approached to a point where an identification of the prey could be made. In both cases the food items were voles (Table 35). Based on the fact the voles were captured on the 1972 reclaimed site, and that after three summers of trapping only Microtus oeconomus were ever found in the area, I believe the prey items captured were tundra voles.

The golden eagle on the Usibelli Mine exhibited prey selection very similar to that reported for golden eagles in Denali National Park (Murie 1944:225). The eagle preyed mainly on arctic ground squirrels, but was also observed carrying a snowshoe hare and gallinaceous-type bird (assumed to be a willow ptarmigan) (Table 35).

On 11 June 1981, while watching a male kestrel, I observed the bird land in an aspen tree, sit for approximately 15 min and then regurgitate a food pellet. After the bird flew I checked under the tree and found eight pellets-- all of which conformed in size and shape to the still moist pellet deposited minutes earlier. I checked under the tree twice a month until September-- recovering a total of 36 pellets. Food items in these pellets were identified and ascribed to kestrels feeding in the mine area (Table 36). This represents the only documented diet analysis reported for kestrels in Alaska. Young and Blome (1975) determined the food habits of kestrels in northern Ontario, Canada. Invertebrates comprised 76% of the diet, birds 20% and mammals 2%. Arthropods and small

Table 35. Food items observed in the diets of raptors associated with the revegetated portions of the Usibelli Coal Mine, Healy, Alaska.

Bird Species	Prey Species Captured	Number of Observations
Short-eared Owl	Red-backed Vole	2
	Tundra Vole	6
Red-tailed Hawk	Arctic Ground Squirrel	3
	Snowshoe Hare	1
Hawk Owl	Tundra Vole	2
Golden Eagle	Arctic Ground Squirrel	3
	Snowshoe Hare	1
	Unknown Bird	1

Table 36. Prey items found in 36 American Kestrel pellets collected on the Usibelli Coal Mine, Healy, Alaska, 1981.

Prey Items	Percent Frequency of Occurrence
SMALL MAMMALS	
Masked Shrew (*Sorex cinereus*)	19
Arctic Shrew (*Sorex tundrensis*)	3
Microtus spp.	56
BIRDS	36
ARTHROPODS	
Arachnida	61
Pentatomidae	47
Carabidae	81
Curculionidae	8
Chrysomelidae	8
Formicidae	8
Insect Larva	58
TOTAL	
Small Mammals	75
Birds	36
Arthropods	86

mammals appear to compose the major items in the diet of kestrels on the mine (Table 36).

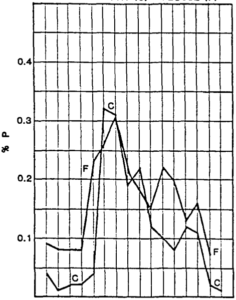
No diet information was collected for the marsh hawk although on three occasions a female marsh hawk was sighted as she dove to the ground in what I interpreted as an attempt to capture a prey item. All of these sightings were in reclaimed areas, which make me believe tundra voles are consumed by marsh hawks inhabiting the mine area.

No diet information was obtained for the accipiters living in the area.

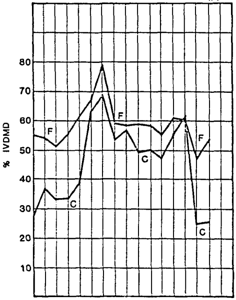
The affect of current stripmine reclamation techniques on interior Alaskan raptors will significantly depend on the size of the disturbed area. Short-eared owls and marsh hawks, because of their preference for open terrain, and documented diet preference for microtines, derive the greatest benefit from current reclamation methods. The major problem in the raptor-mine reclamation relationship for the other raptor species observed is the loss of nesting habitat. Coal extraction methods presently employed by the Usibelli Mine result in the disturbance of small areas of land at any one time. There are always areas of forest adjacent to, or in close proximity to, a reclaimed area. These stands of variously aged trees provide the nesting habitat required by owls, falcons, hawks, accipiters, and eagles. Surface mining and reclamation activities that would remove the forest and create large expanses of treeless grasslands would be very detrimental for most Alaskan raptors.

Figure 5. Year-round nutrient content of *Calamagrostis canadensis* (C) and *Festuca rubra* (F) on the Usibelli Coal Mine, Inc., Healy, Alaska, 1980-81. Plotted values represent 5 pooled samples/ sampling date/species. (P = phosphorus, Ca = calcium, IVDMD = *in vitro* dry matter disappearence).

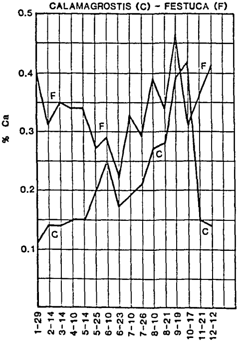
SEASONAL NUTRIENT CYCLE
CALAMAGROSTIS (C) - FESCUE (F)



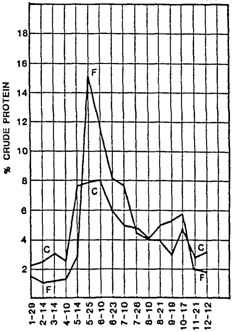
SEASONAL NUTRIENT CYCLE
CALAMAGROSTIS (C) - FESTUCA (F)



SEASONAL NUTRIENT CYCLE
CALAMAGROSTIS (C) - FESTUCA (F)



SEASONAL NUTRIENT CYCLE
CALAMAGROSTIS (C) - FESTUCA (F)



SNOWSHOE HARES

Habitat Utilization

Density estimates (Table 30) indicate the tall shrub cover type is the preferred year-round snowshoe hare habitat on the Usibelli Mine. This area would qualify as a 'refuge' according to Wolff's criteria, and hence must be considered important hare habitat. Wolff (1980) characterized a refuge (his designated Area III) as having a vertical foliage dnesity (VFD) of approximately 75%, and a tree and shrub density of 22,027 stems/ha. The tall shrub cover type on the Usibelli and B & R study areas had VFD's over 73%, and shrub densities of 25,318 stems/ha (Table 26) and 16,200 stems/ha (Table 27) respectively.

If the tall shrub cover type qualifies as optimum snowshoe habitat the revegetated areas must be considered as poor hare habitat. There are no tree or shrub communities established on even the oldest reclaimed area-- and the VFD values never approach 75% (Table 8).

Food Habits

Winter diets of hares on the mine were composed of 51% spruce and 45% shrubs (mainly willow). Summer diets consisted of 69% shrubs, 12% forbs and 6% graminoids (Table 31). Grass has been reported to be a major food item in the summer diet of hares in Maine (Severaid 1942), Newfoundland (Dodds 1960), and Ontario (de Vos 1964), but in interior Alaska it made up less than one percent of the diet of any hare (Wolff 1978). The density and frequency of occurrence of a particular plant species in a given habitat has been suggested as an important factor affecting the composition of hare diets (Dodds 1960; Telfer 1972). This may account for the greater consumption of grasses by hares on the Usibelli Mine; the revegetated areas providing larger acreages of grassland than were available in other Alaskan studies (eg. Wolff 1978). Many other factors have been found to affect forage selection and consumption by snowshoe hares. Such items as snow depth (Klein 1977), plant secondary chemicals (Bryant and Kuropat 1980), hare density (Wolff 1980) and forage nutrient levels (Sinclair et al. 1982) will all affect the food habits of local snowshoe populations. Hence dietary comparisons of hare populations from different geographical areas should be made with caution.

The purpose of examining the diet of hares on the mine area was to determine which major plant category (trees, shrubs, forbs, grass) was of greatest dietary importance, and to relate how current reclamation practices affect this plant category and indirectly impact the snowshoe hare. The categories of major dietary importance were spruce trees and shrubs. Sinclair et al. (1982), using a captive colony of snowshoes, determined 11% crude protein to be the threshold diet quality, below which hares begin to lose weight. Year-round nutrient data for grasses (Fig. 5) when compared to shrubs (Figs. 6 and 7) indicates shrubs come closest to providing the necessary 11% crude protein.

Based on forage nutrient levels, dietary data, and habitat use,

Figure 6. Year-round nutrient content of Salix alaxensis and Alnus crispa leaves (L) and current years stem growth (S) on the Usibelli Coal Mine, Inc., Healy, Alaska, 1980-81. Plotted values represent 5 pooled samples/sampling date/species. (P = phosphorus, Ca = calcium).

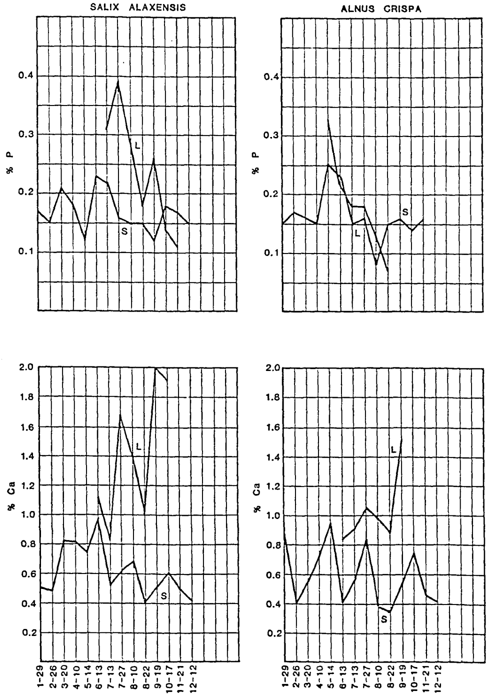
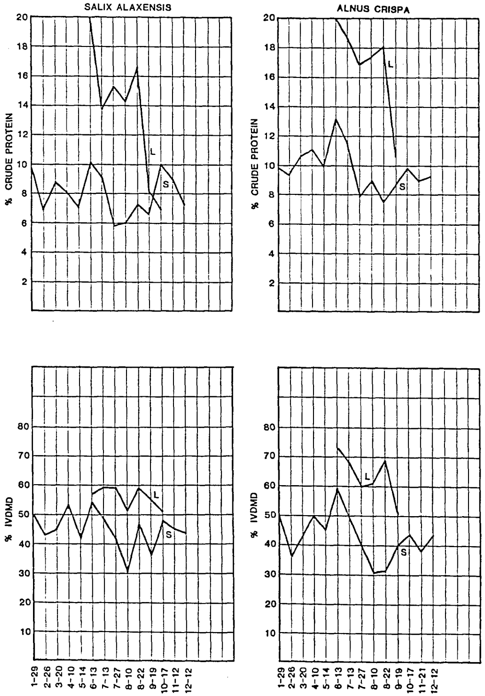

SALIX ALAXENSIS
ALNUS CRISPA
% P
0.4
0.3
0.2
0.1
L
S
% Ca
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
1-29
2-26
3-20
4-10
5-14
6-13
7-13
7-27
8-10
8-22
9-19
10-17
11-21
12-12

Figure 7. Year-round nutrient content of *Salix alaxensis* and *Alnus crispa* leaves (L) and current years stem growth (S) on the Usibelli Coal Mine, Inc., Healy, Alaska, 1980-81. Plotted values represent 5 pooled samples/sampling date/species. (IVDMD = *in vitro* dry matter disappearence).


SALIX ALAXENSIS
ALNUS CRISPA
% CRUDE PROTEIN
% IVDMD
L
S
20
18
16
14
12
10
8
6
4
2
80
70
60
50
40
30
20
10
1-29
2-26
3-20
4-10
5-14
6-13
7-13
7-27
8-10
8-22
9-19
10-17
11-12
11-21
12-12

the long term loss of coniferous forests and tall shrubs due to mining, and the lack of woody vegetation in present reclamation procedures, will greatly reduce and possibly eliminate the snowshoe hare population on large-scale surface mines.

ARCTIC GROUND SQUIRRELS

Habitat Utilization

Surface mining and subsequent reclamation can drastically alter the physical and chemical character of soil (Indorante et al. 1981). It was the change in physical properties of the soil that apparently limited ground squirrel expansion on the mine area. Melchior (1961) examined the physical properties of soil removed by arctic ground squirrels and found the material to be loamy in texture, exhibiting a low clay content. The only locality on the reclaimed areas that exhibited loamy textured soil was the 1972 revegetated site (Table 41). The largest concentration of squirrels on the mine was located in this area, particularily in the Hydraulic Pit area (Fig. 2).

The Hydraulic Pit colony exhibited a population level and reproductive performance similar to colonies on native range. Green (1977) reported densities of 5-6 squirrels per hectare in favorable habitat near Kluane Lake, Yukon Territory, Canada, and Carl (1971) found 6-8 animals per hectare near Cape Thompson, Alaska. The arctic ground squirrel colony on the Hydraulic Pit exhibited a density of 4-5/ha.

Reproductive data concerning arctic ground squirrels are scarce.

Carl (1962) reported a mean placental scar count per female of 7.56±1.67 (N=9) and an average of 7.25±1.16 embryos per female (N=8). The Usibelli colony exhibited a mean placental scar count of 6.8±2.4 per female (N=14). There was no significant difference ($P > 0.05$, unpaired t-test) between the Usibelli and Cape Thompson reproduction data.

Ground squirrels have not populated the adjacent tundra areas on the mine because of the high permafrost level. Batzli and Sobaski (1980) noted ground squirrel burrows in northern Alaska were concentrated in areas where the soil thawed deeply (> 80 cm) by mid-summer. In the Usibelli area the permafrost has melted to an average depth of 48±4 cm by mid-summer -- too shallow for ground squirrel burrows that reach depths greater than 0.5 m (Batzli and Sobaski 1980).

Food Habits

Arctic ground squirrels on the mine exhibited a lack of dietary preference for any particular plant species. This characterizes the squirrel as a generalist, an organism that utilizes several food categories (eg. plant species) with considerable frequency (Morse 1971). Schoener (1971) considered when the dietary generalist strategy is optimal and concluded:

> ... an animal can be said to be more generalized than a second if it is omnivorous, eating both animal and plant food...

Arctic ground squirrels are renown for their use of animal matter in addition to vegetation (Geist 1933; Cade 1951; Mayer 1953b;

Batzli and Sobaski 1980). By employing the generalist strategy, the arctic ground squirrel has quickly exploited and benefited from the grassland food resource resulting from current mine reclamation techniques.

SMALL MAMMALS

Habitat Utilization

On the Usibelli Mine only one small mammal, the tundra vole, was captured on all reclaimed sites. The grass habitat created as a result of reclamation activities are analogous to the tundra voles' preferred natural habitat (West 1982). No red-backed voles were captured on revegetated sites.

Table 37. Small mammal species captured on each revegetated study plot, Usibelli Coal Mine, Healy, Alaska, 1980-82.

Trap Site	Species Captured
1972	Tundra Vole
1976	Tundra Vole
	Masked Shrew
1979	Tundra Vole
	Masked Shrew

Based on comparisons of density and reproductive values, and determined diet, revegetated stripmine spoils are ideal habitat for tundra voles. Current reclamation techniques must therefore be considered extremely beneficial for the tundra vole.

I believe red-backed voles were absent from the revegetated sites for dietary reasons. The diet of _C. rutilus_ exhibited a strong preference for fleshy fruits (Table 39), but in years of poor fruit production they rely heavily on fungi (Dyke 1971), food items lacking in the monotypic grass stands that characterize reclaimed mine spoils. Current stripmine reclamation techniques do not promote the development of fruit (berry) producing plants or fungi, and hence must be considered very detrimental for red-backed voles.

Food Habits

Tundra voles on the mine concentrated on graminoids, the plants comprising 75% of the diets on revegetated areas (Table 38) and 70% on undisturbed shrub tundra (Table 39). Red fescue, meadow foxtail, and bluejoint were the grasses of greatest dietary importance on the mine spoils-- cottongrass was important on the tundra control site.

No northern red-backed voles were ever captured on a revegetated mine spoil. The voles were also absent from the barren floodplain cover type-- but were present in all other areas. Stomach contents of red-backed voles captured on the tundra control site (Table 39) revealed bog blueberry fruits were the major food item consumed

Masked shrews (_Sorex cinereus_) were captured on all revegetated

Table 38. Summer food habits of tundra voles on revegetated mine spoils, Usibelli Coal Mine, Healy, Alaska, 1980-82. Values are percent dry weight of diet. Sample size in parentheses.

Plant Species	Diet (211)
Festuca rubra	37
Alopecurus pratensis	17
Calamagrostis canadensis	17
Medicago falcata	4
Carex spp.	1
Phleum pratense	1
Valeriana capitata	T
Parnassia palustris	T
Bromus inermis	1
Brassica campestris	T
Moss	19
Unknown Forbs	T
Unknown Graminoids	1

T: indicates trace amount, $<1\%$.

Table 39. Summer food habits of red-backed and tundra voles on alpine tundra, Usibelli Coal Mine, Healy, Alaska, 1980-82. Values are percent dry weight of diet. Sample size in parentheses.

Plant Species	Red-back Vole (17)	Tundra Vole (24)
Vaccinium uliginosum fruits	70	19
Vaccinium vitis-idaea fruits	3	-
Rubus chamaemorus	5	-
Carex spp.	2	6
Eriophorum gracile	-	60
Moss/Lichens	16	10
Unknown Graminoids	1	4
Unknown Forbs	3	1

Table 40. Reproductive data for tundra voles in Alaska. Locations are assigned according to the United States Geological Survey 1:250,000 topographic quadrangle map for the area in which the voles were collected. Sample size in parentheses.

Location	Mean (±S.D.) number of Placental Scars	Mean (±S.D.) number of Embryos	Source of Data
St. Lawrence	6.0±1.4 (2)	8.3±1.3 (9)	Univ. Alaska Museum, Fairbanks
Arctic	6.3±3.5 (3)	-	" " " "
Survey Pass	-	5.9±1.8 (7)	" " " "
Point Hope	6.0±1.6 (10)	6.4±1.4 (16)	" " " "
Bendeleben	-	7.7±0.8 (6)	" " " "
Healy	6.6±1.7 (14)	5.8±1.3 (16)	This Study

areas except the 1972 site. Shrews are insectivores, feeding on insects that populate the litter and debris found beneath vegetation (Quay 1951; Whitaker and Maser 1976; Terry 1978). The 1972 site exhibited the shallowest litter depth ($P < 0.05$, unpaired t-test) of all areas examined (Table 5). This lack of ground litter may account for the shrews absence. The scarcity of insect habitat would result in little food being available, and hence make the site unattractive as shrew habitat.

CARNIVORES

Habitat Utilization

The wolf, red fox, and coyote are very mobile animals, utilizing a number of habitats and cover types in their daily activities. Within the Usibelli study area, red foxes were observed more often in the shrub and forested cover types (N=8) than in any other types (N=3). Foxes incorporated man-made structures as denning sites, utilizing an abandoned truck and a stored dump-truck bed.

Coyotes (when excluding sightings on roads), as with foxes, were mainly observed (N=10) in the shrub cover type; but use of the revegetated areas was also evident (N=3). Hunting activities were observed on the reclaimed areas while all sightings made in the shrub cover type were of animals in transit. Additionally, the only den located was in a man-made structure (a culvert).

Wolves were transient in the area, mainly utilizing the region when Dall sheep were present. Wolves did not appear to prefer any particular region of the mine-- being observed in all cover types. The presence of wolves during the winter probably had little effect on the local fox population, the two canids reportedly being tolerant of one another (Murie 1944:220). However, wolves may have been responsible for coyotes leaving the region during the winter (Fuller and Keith 1981; Carbyn 1982).

Food Habits

Red foxes on the mine consumed mainly snowshoe hares and Dall sheep during the summer and winter months (Tables 33 and 34). The occurrence of sheep in the diet is probably the result of scavenging on animals killed by wolves. The high incidence of snowshoe hares in the seasonal diet of foxes, as well as coyotes and wolves, corresponds with the availability of the hares in the Usibelli area. Signs of debarking and heavy browse damage, densities of 18/ha in summer and 10/ha in winter, plus the reports of local trappers, indicated the snowshoe hare population in the Healy region was high and hence readily available as prey to local predators.

Taking into account the size of the individual prey, lagomorphs can be considered a main food of red foxes (Johnson 1970), and in cases where they occur in high densities, they must be considered the most important food (Jensen and Sequeira 1978; Jones and Theberge 1982). But in areas where lagomorphs are scarce, rodents, especially voles, are the preferred food of foxes (MacDonald 1977). Reseeding disturbed areas at Usibelli with graminoids resulted in a greater density of voles than are normally found on undisturbed tundra. Hence the red fox, on dietary considerations alone, is not too adversely affected by present stripmine reclamation methods.

Coyotes associated with the mine consumed more snowshoe hares than any other food item identified (Tables 33 and 34). Wolves associated with the mine and revegetated areas consumed snowshoe hares and arctic ground squirrels during the summer but concentrated solely on Dall sheep during the winter months. The presence of wolves on the mine was more pronounced in the winter than summer. Summer observations (N=3) were of individuals apparently passing through the area. Winter sightings (N=10) were of a pack of six animals on the Gold Run Road and in the Hydraulic Pit area. During the winter months Dall sheep congregate on the Hydraulic Pit region and associated 1972 revegetated site, thus making it possible for wolves to concentrate their hunting effort in one locality. Six kills of Dall sheep by wolves were documented on the Hydraulic Pit area between 1981 and 1982.

Because of the relatively small size of the areas revegetated on the Usibelli Mine, current reclamation procedures do not appear detrimental to the local red fox, coyote and wolf populations. The availability of adjacent and interspersed timber and shrublands, and associated snowshoe hare populations, provide the necessary habitat and food to maintain the carnivores. However, current practices may not be sufficient if areas disturbed by mining result in the over-all elimination of shrub habitat and creation of large expanses of seeded grassland and loss of valuable snowshoe hare habitat.

CARIBOU

Habitat Utilization

Forty-four separate sightings of caribou on the Usibelli Mine were recorded from May through August, 1980-82. In 41% of the sightings, caribou were on a revegetated area; of these sightings, 8 (44%) were of animals grazing on the seeded grasses. The next most frequented cover type was the shrub tundra (27%), with the forest and tall shrub types being the least used (Table 23). These observations should not be construed as implying daily habitat selection by the animals-- if the caribou were observed through the course of a day their presence was recorded, if no animals were observed, no attempt was made to find them (this was attempted twice but proved to be too time consuming).

The number of animals seen per observation was normally four (Table 23). Because of the small number observed at any one time, the sighted animals should be considered as a 'band' rather than a 'herd'. Miller et al. (1975) suggested the basic caribou social unit, usually less than ten animals, is the winter 'band' or group-- although these observations are summer sightings I shall employ Miller's terminology. It was not possible to confirm that the same individuals returned to the mine area each year. Davis et al. (1982) reported caribou are not assumed to be faithful to particular seasonal ranges, or if fidelity exists, it occurs only for the entire herd and not for bands of the herd.

Unreclaimed haul roads associated with the revegetated sites were an important habitat component of caribou on the mine area. Caribou were observed running out of the various cover types and onto a road, apparently to take advantage of the wind and thus avoid biting insects. Roads have been shown to be beneficial for caribou; functioning as terrain on which to escape insect harassment (Hanson 1981) and as travel routes (Roby 1978; Tracy 1977; Horejsi 1981). Whether a roadway represents an obstruction or benefit for caribou may be dependent upon the mode of construction. Roads elevated substantially above the surrounding terrain have been postulated to present a physical and visual barrier to caribou (Klein 1980). Caribou on the Usibelli Mine exhibited no fear or avoidance of the roads in the mine area.

In addition to roads, a section of unreclaimed land on the mine was used as insect avoidance habitat. The area was a mixture of coal and rock (the disturbed and unreclaimed cover type) that had not been covered by topsoil. The color of the surface was black--resulting in the surface temperatures being 3 to 5 C higher than on adjacent reclaimed areas. In Finland, Helle and Aspi (1983) found that updrafts created by solar heating of nonvegetated surfaces decreased dispersal of carbon dioxide and thus reduced insect harassament. Thus these black, unreclaimed areas may not be aesthetically pleasing but may be useful to caribou.

The reclaimed study plots all received caribou use, but the 1976 and 1979 sites (located on a ridge) were frequented the most. The proximity of these seeded areas to open expanses of native alpine tundra range, and the location of the reseeded sites on a wind-swept ridge, resulted in the revegetated plots being physiognomically very similar to the caribou's native summer habitat (Boertje 1981).

Caution should be exercised in applying the above observations and reactions to all caribou. The revegetated areas were not on caribou wintering or calving areas, or in major migration corridors. Disturbance or obstructions within these sensitive areas have proven to be detrimental in the past (Klein 1980; Hanson 1981). Therefore the only conclusions that can be safely made concerning caribou and revegetated stripmine spoils are: 1) the animals did not purposely avoid the reclaimed areas and, 2) caribou can and will utilize some of the seeded plants as food.

Food Habits

The caribou present on the Usibelli Mine consumed mainly willow, lichens and graminoids (Table 20). The mine area frequented by the caribou was a wind-swept ridge (elev. 732 m). This habitat and the consumption of willow agree with the food habits of the Denali National Park herd in similar habitat and during the same season (Boertje 1981). Graminoids composed a much larger portion of the Usibelli diets than in the Denali herd. In general, the relative availability of palatable food species is thought to determine the diet of caribou on a particular range (Skoog 1968; Bergerud 1977). The small 'grasslands' created as a result of revegetating mine spoils have made available a summer range of highly nutritious and digestible forages (Fig. 5). The high incidence of grasses (30%) in the diet indicates the Usibelli caribou are taking advantage of the reseeded areas and incorporating the seeded plants into their diets.

The high occurrence of mosses (10%) found in the Denali diet was considered by Boertje (1981) to have been ingested incidental to the selection of other forages. Mosses are easily overestimated when using the microhistological technique because they fragment more than other plants; even tiny sized moss particles are easy to identify. Dearden et al. (1975) reported high numbers of moss fragments can cause the underestimation of other forages, especially lichens. They performed digestion trials with reindeer, cattle (Bos spp.) and bison (Bison bison), and found mosses were completely indigestible-- and were assumed to be of insignificant nutritional importance. Recently the consumption of moss has been postulated to function more as an adaptation to cold than as an important food item (Prins 1981).

Boertje (1981) determined the nutrient content of the summer dietary components of the Denali caribou herd (Table 21). The nutrient content of the Usibelli diet (Table 22) was found to be similar to the Denali diet in crude protein levels and total nonstructural carbohydrates. Based on this comparison of nutritional levels the Usibelli range (incorporating the revegetated portions) meets the nutritional needs of caribou in the summer. Of the plants presently used for reclamation, red fescue was the species of greatest nutritional and dietary importance.

MOOSE

Habitat Utilization

Visual observations indicated moose utilized the tall shrub cover type more than any other area (Table 24). Of the 24 (49%) observations recorded in the tall shrub area, ten (42%) occurred in the summer months (May-August) while 14 (58%) were winter observations, indicating the year-round importance of the tall shrub zone as moose habitat. The forested areas were utilized mainly in the winter months, with 73% (N=8) of the sightings occurring between September-April. This winter use of forested areas coincides with the observations of McNicol and Gilbert (1980), Chamberlin (1972), Des Meules (1964), and Doerr (1983), all of whom noted the movement of moose from open to moderate canopy cover as snow depth and wind increased.

The year-round importance of the tall shrub cover type and winter use of forested areas at Usibelli indicates the importance of having a mosaic of cover types available to support a moose population. Revegetated stripmine spoils did not serve as barriers to moose movements nor did the seeded grasses contribute significantly to the diet. The stripmine conditions that appeared important to moose on the Usibelli Mine were abandoned roads, unreclaimed slopes, and unreclaimed (not seeded) road embankments.

Road-building activities on stripmines result in the deposition of soil over the vegetation within 30-50 m of the road. This accumulation of surface soil offers a site on which natural revegetation can occur. On the Usibelli Mine, willows (especially Salix alaxensis) invade these newly disturbed areas first-- with alder apparently dominanting the willow later in the successional continuum (Tables 9 and 10). This same plant trend was also evident on abandoned roads that were naturally revegetated.

Ahlen (1975), while working in Scandinavia, noted road-building for forestry purposes resulted in a specific roadside vegetation, where early successional plant species colonized the exposed soil. He observed Salix was often abundant and constituted an important cervid browse. Moose and red deer (Cervus elaphus) followed the roads long distances, browsing on roadside vegetation. The same use of roads for travel and roadside vegetation for food was observed for the Usibelli moose. Thus it was the roadside vegetation, creek bottoms and the availability of a forested area in the winter, that were important habitat for moose on the Usibelli Coal Mine.

Food Habits

Food habits of moose associated with the Usibelli Mine generally parallel dietary data reported for interior Alaskan moose-- willow is heavily utilized (Table 25).

Under the best conditions woody browse contains less than 10% crude protein, 1-7% crude fat, 40-60% carbohydrates (NFE), and 20-40% cellulose (crude fiber) (Houston 1968; Milke 1969). Salix alaxensis leaves contain over 10% crude protein and thus could easily meet the summer protein needs (Fig. 7). Gasaway and Coady

(1974) reported winter crude protein levels of 6% for Kenai and interior Alaska browse consumed by moose. Additionally, moose exhibit a reduced food intake in late winter (Gasaway and Coady 1974); thus having 7-10% winter crude protein levels and approximate 45% digestibility (IVDMD) qualifies S. alaxensis as a usable year-round forage species on the Usibelli Mine.

Although known to feed primarily on woody vegetation, moose also consume grasses. In Sweden, Cederlund et al. (1980) detected small amounts of grasses, particularly Deschampsia flexuosa, in the rumen during all months except January and June. Houston (1968) noted Wyoming moose ate significant quantities of grasses in spring and summer. Cushwa and Coady's (1976) observations were similar for interior Alaskan moose. Usibelli moose consumed grasses during the spring and summer months, periods of highest crude protein and digestibility (Fig. 5).

Table 41. Pooled soil textural data (10 samples per study site) for revegetated sites on the Usibelli Coal Mine, Healy, Alaska.

	PERCENT				
Study Site	Sand	Silt	Clay	Rock	Textural Classification
1972	41	37	22	27	loam
1976	29	29	42	38	clay
1979	29	27	44	39	clay

DALL SHEEP

Habitat Utilization

The Dall sheep that grazed the revegetated mine spoils on the Usibelli Coal Mine are a separate entity from the surrounding Denali National Park herds. In 1975, Alaska Department of Fish and Game biologists live-trapped and collared (with numbered collars) a group of sheep on a section of the reseeded mine. Subsequent helicopter surveys and hunter returns verified the Usibelli sheep were a distinct herd, occupying a summer range near Sugar Loaf Mountain (Fig. 2), with the Usibelli Mine and its reclaimed areas falling on the edge of their apparent winter range (W. Heimer pers. comm.)

The attractiveness of the reclaimed areas as sheep winter range was observed during this study. Wild sheep normally migrate to high elevation ranges in summer (Murie 1944:70-75; Hoefs and Cowan 1979), and winter at lower altitudes (Murie 1944:70-75).

Dall sheep at Usibelli exhibited similar habits. They left the mine in the valley during spring and summer; returning in the autumn and winter to graze on the reclaimed areas near the Hydraulic Pit and on adjacent native range (Table 28).

In their study of Dall sheep in the Yukon Territory, Canada, Hoefs and Cowan (1979) observed that the intensity with which winter ranges are used depended on the proximity of the area to escape terrain. Almost all the low elevation winter ranges they examined had escape terrain nearby (exceptions were mineral licks or large open areas where approaching predators could be easily detected). They also noted the importance of preferred 'bedding' sites, areas along canyons or on elevated spots which allowed surveillance of the surrounding area. The Hydraulic Pit area conforms to Hoef's and Cowan's description of a desirable winter range. The flat revegetated areas are adjacent to steep walled terrain that are readily used by the sheep to escape predators. Additionally, the presence of narrow bench-like areas provide ideal bedding sites which the sheep use with great predictibility. The presence of these bedding sites with their view of the surrounding area further characterize the Hydraulic Pit as being similar to natural winter range.

The proximity of the wintering area to human activity and its consequential deterring affect on predators (eg. wolves); vertical topography for bedding sites and escape routes; and the tendency for the area to be kept snowfree by wind, have all served to enhance the attractiveness of the mine site to the local sheep population.

Food Habits

Grasses composed the winter diet of Dall sheep on the Usibelli Coal Mine (Table 29). This consumption of grasses parallels reported winter use of graminoids on the Kenai Peninsula (Nichols and Heimer 1972) and in interior Alaska (Murie 1944:76-82; Whitten 1975).

Field studies relating nutritional content of forages and diets for Dall sheep are scarce. Heimer (unpub. data) chemically analyzed the washed rumen contents of two sheep populations. The sites were representative of a 'low quality' (Dry Creek) and 'high quality' (Robertson River) Dall sheep population. The Dry Creek spring (April) samples (N=13) averaged 9.2% crude protein, 77.4% NDF, and 48.5% ADF. Winter (November) rumens (N=9) contained 6.3% crude protein, 79% NDF, and 48.5% ADF. The 'high quality' range spring samples (N=12) contained 9.6% crude protein, 78% NDF, and 45% ADF. Festuca rubra and Calamagrostis canadensis comprised over 50% of the identifiable items in sheep diets on the mine area. Samples of F. rubra and C. canadensis collected on the sheep range in the summer contained average (±SD) crude protein, NDF, and ADF levels of 5.9±1.8, 59.2±4.6, 32.4±3.5, and 7.4±4.2, 63.5±7.2, and 36.0±5.4 percent, respectively. Winter samples of red fescue contained 3.1±0.9, 61.9±9.3, and 40.5±6.5% crude protein, NDF, and ADF. Bluejoint contained 2.5±1.9, 76.3±10.7, and 49.9±9.2 percent, respectively. When compared with Heimer's rumen content data, the fescue and bluejoint at Usibelli ranked lower in crude protein than native range.

In an attempt to further determine if the nutritional levels of revegetated mine spoils are sufficient to meet the needs of Dall sheep, the nutrient content of the Usibelli sheep diets were compared with the recommended nutrient levels for maintenance in domestic sheep (Ovis spp.) (Table 42). The reseeded areas, principally the Hydraulic Pit, functioned primarily as winter range (Table 28); therefore, the nutrient content of the winter diet was examined to determine if the available forage supplied a 'maintenance' diet. Red fescue and bluejoint comprised 55% of the winter diet. Neither species provided the 8.9% crude protein recommended for domestic sheep or the suggested phosphorus levels (Fig. 5). Red fescue supplied sufficient levels of calcium but bluejoint remained deficient. On the unproven assumption that dietary requirements of Dall sheep are similar to those of domestic sheep, it appears the seeded grasses used in revegetating the Usibelli Mine are insufficient to meet the maintenance needs of wintering Dall sheep.

Table 42. Recommended nutrient content of domestic sheep diets.[1]

Sex	Body Weight	Crude Protein	Ca	P	Body weight of adult Dall sheep[2]
Ewes	80 kg	8.9%	0.25%	0.24%	70 - 90 kg
Rams	100	8.9	0.30	0.17	45 - 56

1: values from National Research Council (1975).

2: values from Whitaker (1980).

Like other wild ungulates which experience seasonal changes in forage quality, Dall sheep annually undergo major fluctuations in energy retention and, based on observed weight loss, are in negative energy balance during winter. Nichols and Heimer (1972) recorded winter weight loss for adult ewe Dall sheep on the Kenai Peninsula as approximately 10.5 kg over 165 days, or an average of 0.06 kg/day. Although Dall sheep utilize essentially all visible fat reserves before spring (Heimer 1973), they still must consume forage of a high enough crude protein content to keep the rumen microbes functioning. Exhausted fat reserves and a decimated microflora result in death for wintering Dall sheep. Oh et al. (1968) reported 4.3% protein levels in domestic sheep forage limited ruminal fermentation. Red fescue and bluejoint exhibit protein levels in excess of 4.3% during all months except the winter period, December through April (Fig. 5). Based on plant nutrient data, if Dall sheep on the Usibelli Coal Mine foraged solely on revegetated grasses they would have difficulty maintaining rumen function.

Sheep foraged on the reseeded Hydraulic Pit area for varying lengths of time. Bands were identified by noting distinctive individuals-- such characteristics as the length of broken horns or body scars aided identification. Groups of sheep were observed foraging on the seeded area for 2-5 days and then sighted 3-15 kms away feeding in windblown areas. Well used trails leading from the Hydraulic Pit to cratered sites near Healy Creek and along the ridge between Cripple and Dora Creeks were additional evidence of foraging outside the reclaimed areas. This supplemental feeding on native plants may provide the additional protein necessary to maintain rumen activity.

Of the graminoids used for revegetation purposes, red fescue and bluejoint were the species most readily consumed by Dall sheep. However, the importance of having access to sources of protein other than seeded graminoids must not be underestimated.

SUMMARY

The impact of stripmine activities and reclamation on wildlife species in interior Alaska will depend on the magnitude of the areas disturbed. Small-scale disturbances, as exemplified by the Usibelli Coal Mine, are not that detrimental to the local animal populations. The ready access to surrounding, undisturbed native habitat greatly mediated any negative affects caused by the disturbed areas. The Usibelli Mine at present must be considered the premiere Alaskan example of how surface mining, reclamation, and wildlife can be integrated together in a manner beneficial for both man and animal. But if future stripmining operations are to be large-scale undertakings, involving the disturbance of hundreds of hectares of land; then reclamation procedures currently being used in interior Alaska will be of little value to most wildlife.

The loss of a naturally complex, multi-layered vegetation community and its replacement with a monotypic community of graminoids will be detrimental to almost all animal species native to Alaska. Small mammals, that specifically consume grasses, and raptorial birds that concentrate on these small herbivores will greatly benefit from current revegetation practices. However large ungulates such as caribou and moose will lose valuable feeding habitat. Dall sheep may derive some benefit from the seeded grasses, but without nearby escape terrain and access to native range, sheep use of large seeded areas is doubtful.

Avian species will be adversely affected through the loss of feeding and nesting habitat. Other species will be eliminated from, or confined to, small areas because of the loss of critical seasonal food resources (eg. red-backed voles) or changes in soil structure and texture (eg. arctic ground squirrels). Small areas disturbed by surface mining and allowed to naturally revegetate were found to support small mammal and bird communities more diverse than seeded areas. The implication is that, in surface mined areas not subject to serious erosion problems, topsoil should be replaced and the site allowed to revegetate via natural plant succession.

Current reclamation and mining procedures should be altered to promote a more diverse vegetation or to insure that a sufficient amount of native vegetation will remain intact in a stripmined area. If such changes are not implemented, large scale coal mining and concomitant reclamation activities within Alaska will have serious detrimental effects on native wildlife populations.

MANAGEMENT RECOMMENDATIONS

Based on this study, I suggest the following recommendations so that current mine reclamation techniques will better meet the needs of local wildlife species.

1) promote a diversity of vegetation on areas that are mined and reclaimed, especially if the disturbed areas are large. The greatest drawback of current reclamation techniques in Alaska is the resulting formation of monotypic grass stands. These areas are of very little value to the majority of wildlife species that inhabit interior Alaska because of the lack of food and/or niche diversity. If buffer zones consisting of shrub or forested habitat were left undisturbed, the usefulness of the surrounding reclaimed areas would be enhanced. These buffer sites would provide critical native vegetation for food, security cover, and reproductive habitat for many wildlife species. Such areas could serve as source areas from which small mammals could repopulate reclaimed areas when the sites become suitable habitat. The buffer zone vegetation would also serve as seed banks from which native plant species could invade reclaimed areas; thereby promoting revegetation of the region by native plants.

2) place uprooted trees and brush in windrows or piles adjacent to undisturbed areas. These brush piles would provide the cover and habitat needed by small mammals and hares, and provide perches and nest sites vital to birds.

3) if seed sources or cuttings are available, native plants

are recommended for reclaiming disturbed areas.

4) of the species currently used for mine reclamation, red fescue and bluejoint appear to be the most beneficial to wildlife and should be incorporated into seed mixtures applied to interior Alaskan stripmine spoils.

5) in areas where soil erosion problems are not pressing, seeding rates should be low so as to produce grass stands with openings into which native shrubs, trees and forbs can readily invade.

The above recommendations could be implemented under the current state and federal regulations governing stripmine reclamation. The amount and type of buffer areas left would vary according to the size (number of hectares) and cover types disturbed by surface mining.

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