VEGETATION AND WILDLIFE STUDIES FOR THE MOUNT EMMONS PROJECT

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by:

Warren R. Keammerer, Ph.D.
Plant Ecologist

Robert E. Stoecker, Ph.D.
Animal Ecologist

Stoecker-Keammerer and Associates
Boulder, Colorado 80303
(303) 499-6695, 444-3979

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Foreword

This report presents the results of two years of vegetation and wildlife field investigations conducted for the Mount Emmons Project. Because of the relationships between vegetation types and wildlife habitat types, the two studies have been included in the same report.

The report consists of three separate documents. The first includes descriptions of the vegetation and wildlife within the project area and also includes appendix materials for the wildlife section. The second document includes appendix materials for the vegetation section. The third part consists of a packet of vegetation and wildlife habitat type maps for the project area.

VEGETATION STUDIES SUMMARY

The purpose of the vegetation studies was to collect sufficient data on the plant communities of the area for use in the preparation of an environmental report. The studies were designed to provide data for preparing a description of the existing vegetation resources and to enable evaluation of impacts and possible means for mitigating those impacts.

Vegetation studies for the Mount Emmons Project were conducted during 1978 and 1979. Field data were gathered during the 1978 and 1979 growing seasons. For the purposes of the vegetation study, the total project area was approximately 220 square miles (56,320 hectares) and extends from Allen Lane to Kebler Pass and Washington Gulch. Observations also were made in Antelope Creek and Cabin Creek.

The vegetation in the project area is composed of three basic types: forests, shrublands, and grasslands. In general, the vegetation types occur in four major elevational zones. The zones are not distinct and tend to overlap and intergrade, especially in localized areas where slope and aspect alter the general elevational trends. The alpine tundra zone includes fellfields and tundra meadows. The subalpine zone includes subalpine meadows, subalpine willow thickets, spruce-fir forests, wet sedge meadows, and sphagnum-sedge bogs. The upper montane zone includes Douglas-fir forests, lodgepole pine forests, aspen woodlands, riparian willow thickets, moist meadows, and mountain grasslands. The lower montane zone includes big sagebrush shrublands, cottonwood woodlands, ponderosa pine forests, juniper woodlands, and hay meadows-pastures. In addition to these communities, there are five other types which cross the elevational zones. These include sparsely vegetated areas, rock outcrops/talus slopes, ponds-open water, disturbed areas, and urban areas. It should be reemphasized that the concept of vegetation zones should be applied in a general way. For example, in the project area, sagebrush shrublands can occur as high as 12,000 feet (3,657 m).

Description of Project Area

Project Area

Big sagebrush shrublands are the most extensive vegetation type, and they cover more than twice as much area as the second most abundant type, spruce-fir forests. Aspen woodlands cover approximately 14 percent of the project area. These three types account for more than 65 percent of the project area.

The flora of the project area includes approximately 500 species of vascular plants. Composites and grasses account for 28.5 percent of all species. Two federally proposed endangered species were observed within the project area. *Arabis crandallii* was collected in big sagebrush shrublands on the northern end of the Almont Triangle and *Arabis oxylobula* was collected in rock crevices and steep rock outcrops in Anthracite Creek and Carbon Creek.

Each of the 23 mapped communities is briefly described below:

Fellfields. Fellfields occur on the exposed ridges and crests of the high peaks within the project area. The type is restricted and covers approximately 1,140 acres (462 hectares). Dominant species include cushion plants like dwarf clover (*Trifolium nanum*).

Alpine Meadows. The alpine meadows occur above tree limit on the high mountains of the project area. Typical stands can be seen on Mount Emmons, Mount Axtell, and Whetstone Mountain. The type is restricted and covers approximately 1,082 acres (438 hectares). Dominant species include alpine avens (*Acomastylis rossii*), alpine fescue (*Festuca brachyphylla*), and various alpine species of bluegrass (*Poa* spp.).

Subalpine Meadows. Subalpine meadows occur below tree limit and mostly above 9,000 feet (2,743 m) elevation. They occur on a variety of slopes and are usually well interspersed with the spruce-fir forests. This type covers approximately 8,104 acres (3,281 hectares). Dominant species include false

hellebore (*Veratrum tenuipetalum*), tufted hairgrass (*Deschampsia caespitosa*), and avalanche lily (*Erythronium grandiflorum*).

Engelmann Spruce-Subalpine Fir Forests. The spruce-fir forests are the most widespread vegetation type in the higher elevation [above 9,000 feet (2,743 m)] portions of the project area. They occur on all slopes and aspects and cover approximately 21,111 acres (8,547 hectares). Dominant tree species include Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). Bracted honeysuckle (*Lonicera involucrata*) and thimbleberry (*Rubus parviflorus*) are two of the most common shrubs. Heartleaf arnica (*Arnica cordifolia*), curly-leaf lousewort (*Pedicularis racemosa*) and myrtle blueberry (*Vaccinium myrtillus*) occur as common species in the herb layer.

Subalpine Willow Thickets. The subalpine willow thickets occur in wet bottomland areas above 9,000 feet (2,743 m) elevation. These thickets are usually associated with streams or meltwater runoff and are usually bordered by wet sedge meadows. This type covers approximately 919 acres (372 hectares). Major shrub species include planeleaf willow (*Salix planifolia*) and barrenground willow (*Salix brachycarpa*). The understory is similar to that encountered in the wet sedge meadow.

Wet Sedge Meadows. The wet sedge meadows occur in wet bottomland areas in the subalpine zone. This type covers approximately 504 acres (204 hectares) and is usually associated with subalpine willow thickets. Major species include species of sedge (*Carex* spp.), bluegrass species (*Poa* spp.) and western marsh marigold (*Caltha leptosepala*).

Sphagnum-Sedge Bog. Only one sphagnum-sedge bog occurs within the project area. This is the Keystone Bog. The vegetation in the bog and the area adjacent to it is composed of five distinct plant communities; dry understory lodgepole pine forests type, wet understory lodgepole pine forest type, water sedge (*Carex aquatilis*) meadow, beaked sedge (*Carex rostrata*) community, and a cottongrass-

sedge meadow. The cottongrass-sedge meadow is unusual in that a species of sundew (*Drosera rotundifolia*) occurs there. Presently, this is the only known location in Colorado where this species grows. A regional bog survey was unsuccessful in locating sundews in other bogs. The sphagnum-sedge bog covers approximately 10 acres (four hectares).

Lodgepole Pine Forests. Lodgepole pine forests occur in the higher elevation portions of the study area and are usually associated with spruce-fir forests, aspen woodlands and subalpine meadows. The type covers approximately 2,626 acres (1,063 hectares). Dominant species include lodgepole pine (*Pinus contorta*), myrtle blueberry, and heartleaf arnica.

Douglas-fir Forests. The Douglas-fir forests occur in the upper montane portions of the study area and cover approximately 3,416 acres (1,383 hectares). Some of the best developed stands occur on the west-facing slopes along the East River and also on Flat Top Mountain. The dominant species is Douglas-fir (*Pseudotsuga menziesii*). Various species of gooseberry (*Ribes* spp.) occur in the understory. Red columbine (*Aquilegia elegantula*) is commonly encountered in the herb layer.

Aspen Woodlands. Aspen woodlands occur throughout the study area and are most prevalent in the elevation zone between the coniferous forests and the big sagebrush shrublands. This is one of the common types, and it covers approximately 19,723 acres (7,985 hectares). The dominant species is quaking aspen (*Populus tremuloides*). Common understory shrub species include Wood's rose (*Rosa woodsii*) and mountain snowberry (*Symphoricarpos oreophilus*). Major herbaceous species include peavine (*Lathyrus leucanthus*), elk sedge (*Carex geyeri*), Fendler meadowrue (*Thalictrum fendleri*) and American vetch (*Vicia americana*). In some of the aspen stands tall forbs including cow parsnip (*Heracleum lanatum*) and other tall members of the Umbelliferae occur as dominants.

Riparian Willow Thickets. The riparian willow thickets occur along the major drainages in the area. This type differs from the subalpine willow thickets in that it occurs at lower elevations [below 9,000 feet (2,473 m)] and is characterized by different species of willows. Willows in this type tend to be taller. This type covers approximately 3,305 acres (1,338 hectares). Dominant species include willows (*Salix* spp.) and alder (*Alnus tenuifolia*). Prevalent herb species include Kentucky bluegrass.

Moist Meadows. Moist meadows occur in naturally irrigated areas, such as late-lying snowbank areas, in the montane zone. This type covers approximately 210 acres (85 hectares). Major species include Arizona fescue (*Festuca arizonica*), mule's ears (*Wyethia amplexicaulis*), and silvery lupine (*Lupinus argenteus*).

Mountain Grasslands. The mountain grasslands occur on upland slopes within the same general areas as the moist meadows. They tend to be somewhat drier than the moist meadow. This type covers approximately 3,433 acres (1,390 hectares). Dominant species include Thurber's fescue (*Festuca thurberi*) and fringed brome (*Bromus ciliatus*). Common forbs include peavine and showy fleabane (*Erigeron speciosus*).

Big Sagebrush Shrublands. The big sagebrush shrublands are the most extensive type within the area and they cover approximately 50,625 acres (20,496 hectares). The type occurs throughout the study area but is much more prevalent in the southern half. The sagebrush shrublands occur in areas of almost all slopes and aspects. The dominant species is overwhelmingly big sagebrush (*Artemisia tridentata*). Rothrock sagebrush (*Artemisia rothrockii*) is a common secondary dominant. Many herbaceous species occur as dominants in the herb layer. Needlegrasses (including *Stipa pinetorum* and *Stipa lettermanii*), western wheatgrass (*Agropyron smithii*) and muttongrass (*Poa fendleriana*) are commonly encountered grass species.

Cottonwood Woodlands. Cottonwood woodlands occur along the major drainages like East River and Ohio Creek. The type covers approximately 1,272 acres (515 hectares), and tends to intergrade with the riparian willow thickets. Major species include narrow-leaf cottonwood (*Populus angustifolia*), alder and in some places Colorado blue spruce (*Picea pungens*).

Ponderosa Pine Forests. The only mapped ponderosa pine forests in the study area occur on the Almont Triangle. This type is more prevalent in other parts of Colorado. Total area for this type was two acres (one hectare). The dominant species is ponderosa pine (*Pinus ponderosa*).

Juniper Woodlands. The juniper woodlands are restricted in the project area and cover approximately 17 acres (seven hectares). They occur in the southern part of the project area near Almont, and grow on dry rocky slopes. This type, in its various phases, is more prevalent in the semi-arid portions of Colorado. The dominant species is Rocky Mountain juniper (*Juniperus scopulorum*).

Hay Meadows and Pastures. The hay meadows and pastures occur within the project area directly as a result of human activity. The type is composed of irrigated fields which occur mainly along the major drainages. Extensive meadows and pastures can be seen in the Ohio Creek Valley and East River Valley. The type covers approximately 15,684 acres (6,350 hectares). Major species include European pasture grasses like red top (*Agrostis alba*) and timothy (*Phleum pratense*).

Sparsely Vegetated Areas. The sparsely vegetated areas constitute a heterogeneous group of mapped units. Areas mapped as sparsely vegetated extend from alpine areas down into the zone dominated by big sagebrush. The type includes approximately 1,391 acres (563 hectares). In the alpine, this type includes scree slopes (fine textured material) and sparsely vegetated talus slopes (coarse materials). Dominant species include *Ligularia soldanella* and various species of saxifrage (*Saxifraga* spp.). These areas have slightly more vegetation than the areas mapped as talus slopes and rock outcrops.

At lower elevations this type includes the barren rocky areas on the Almont Triangle. In these areas the only vegetation consists of scattered ponderosa pine and shrubs like antelope bitterbrush (*Purshia tridentata*) and rock spiraea (*Holodiscus dumosus*).

Rock Outcrops and Talus Slopes. The rock outcrop and talus slope type is characterized by being almost totally non-vegetated. This type covers approximately 4,782 acres (1,936 hectares). Rock brake (*Cryptogramma crispa*) is one of the few species which grows in among the rocks. Large rock glaciers and talus slopes occur on Carbon Peak and the areas around the base of Carbon Peak.

Ponds and Open Water. Ponds, lakes and reservoirs occur throughout the project area. This type covers approximately 212 acres (86 hectares). Water lily (*Nuphar polysepalum*) occurs rarely in subalpine ponds. Pondweed species (*Potamogeton* spp.) were noted in some of the shallow ponds in Alkali Basin.

Disturbed Areas. The disturbed area type was used for mapping a variety of major disruptions in the vegetation. This type includes gravel pits, existing tailing disposal sites, old coal mine areas, large ranchyards, the Roaring Judy Trout Hatchery and the Crested Butte airport. Disturbed areas cover approximately 373 acres (151 hectares). The disturbed areas are essentially non-vegetated.

Urban Areas. The urban area type was used to map lands that included the towns of Crested Butte and Almont. The total area of this type is approximately 583 acres (236 hectares). The vegetation in these areas consist of lawns, flower gardens, and ornamental tree and shrub plantings.

Mine Area

The vegetation of the Red Lady Basin, Keystone Mine and Coal Creek area is characteristically upper montane, subalpine and alpine in nature. The lower elevations are characterized by a mosaic of aspen woodlands, subalpine meadows, and spruce-fir forests. Just northeast of Red Lady Basin (in Coon Basin) extensive stands of lodgepole pine occur. At higher elevations the woodland-meadow

mosaic gives way to expanses of sparsely vegetated, rocky areas. Alpine meadows and fellfields occur above tree limit on Mount Emmons.

Mill/Tailing Pond

Alkali Basin. The vegetation in Alkali Basin is composed of three major vegetation types. Big sagebrush shrublands occupy 50 to 75 percent of the Basin, and occur on all slopes and aspects. The big sagebrush shrublands form the matrix in which the other vegetation types grow. Aspen woodlands are the second most abundant type and they occupy 10 to 20 percent of the Basin. The woodlands are much more abundant on the south (north-facing) side of the valley. Isolated aspen stands occur on the south-facing side of the valley. The third major vegetation type in Alkali Basin is the irrigated pasture type located on the valley floor. It accounts for less than five percent of the total. In addition to these major types, numerous minor types occur. Riparian willow thickets occur along Alkali Creek, in the ephemeral drainages at the head of the Basin, and along the drainages from Red Mountain. Moist meadows occur around the upper rim of the Basin in the areas where snowbanks persist into early summer. Mountain grasslands occur as scattered stands on exposed ridges. A limited number of sparsely vegetated areas occur on the south-facing flank of Red Mountain. Stands of Douglas-fir forest occur on the upper north-facing slope of Flat Top Mountain. At the base of the Basin isolated stands of juniper occur on the south-facing slopes. These minor vegetation types were not all sampled, but were examined relative to species composition and general botanical characteristics.

Alternate Mill/Tailing Pond Sites

Antelope Creek. The vegetation of Antelope Creek is similar to that in Alkali Basin with the exception that sagebrush is more abundant and the aspen woodlands tend to be less prevalent. Riparian shrub thickets occur along Antelope Creek.

Cabin Creek. The vegetation in Cabin Creek is also similar to that in Alkali Basin. Big sagebrush shrublands cover most of the area with riparian willow thickets occurring along Cabin Creek. Cottonwood woodlands occur to a limited extent in the upper portion of the valley. In the lower part of the valley, black sage (*Artemisia nova*) occurs as a secondary dominant with big sagebrush.

Anthracite Creek-Kebler Pass Area. The vegetation in the Anthracite Creek-Kebler Pass area is composed primarily of spruce-fir forests, aspen woodlands and subalpine meadows. Spruce-fir is the dominant vegetation in the area immediately around Kebler Pass and at elevations above 9,500 feet (2,895 m) in Anthracite Creek. In the main part of the creek valley and the areas around Horse Ranch Park, aspen woodlands are the prevalent type. The subalpine meadows form the matrix in which the aspen woodlands occur. The wet streamsides and the areas surrounding the numerous beaver ponds are characterized by riparian willow thickets.

Washington Gulch. The vegetation in Washington Gulch is composed primarily of spruce-fir forests, aspen woodlands, and subalpine meadows. In addition to these major types, mountain grasslands, wet sedge meadows and subalpine willow thickets also occur. The spruce-fir forests occur mostly at the upper end of the Gulch with the aspen woodlands and meadows forming a mosaic in the middle portions of the valley. The willow thickets and wet sedge meadows occur on the valley floor.

Ancillary Facilities

Mount Axtell - Alkali Basin Corridor. The corridor between Mount Axtell and Carbon Creek and the area above Alkali Basin is a mosaic of aspen woodlands, big sagebrush shrublands and a limited amount of lodgepole pine forest. Aspen is the most abundant type and is more prevalent at the Carbon Creek end of the

Corridor. At the Alkali end, big sagebrush is more prevalent.

Sensitive Areas.

Sensitive areas are those which are highly susceptible to external disturbing influences. It would be possible to develop a sensitivity rating for all the communities within the project area, since to a degree all communities are susceptible to disturbance. The sensitive areas addressed in this section are those which have slow regeneration potential or are those with high scientific value.

The alpine tundra areas (2,221 acres) are sensitive in that the tundra communities require long time periods to become re-established.

The other sensitive area is the Keystone Bog (nine acres). The vegetation in the bog is unusual in Colorado because of its botanical components. At this time the most unusual component of the bog is the sundew.

WILDLIFE STUDIES SUMMARY

The report on wildlife presents the results of a two-year baseline investigation of terrestrial wildlife in the Mount Emmons Project area. Field work was conducted from May 1978 to May 1980, and included studies of large mammals, small and medium-sized mammals, birds, reptiles and amphibians.

The project area includes approximately 570km^2 (220 mi^2) (Plate 5, sheets 1 and 2). Observations were also made at Anthracite Creek, Antelope Creek, and Carbon Creek. Within these areas, four major wildlife habitats were recognized: alpine and subalpine, montane forests, big sagebrush shrubland, and agricultural land.

Alpine and subalpine habitats are generally above 3,200m (10,500 ft). The characteristic wildlife species of the alpine include the white-tailed ptarmigan, white-crowned sparrow, water pipit, and gray-crowned rosy finch. Subalpine areas, as occur in Red Lady Basin on Mount Emmons, are the upper distributional limits of the red-backed vole and long-tailed vole. These rodents provide an important food source for long-tailed weasels and coyotes, two common predators within the project area. The pika is the most characteristic wildlife species of the subtype talus. Pikas were observed at the top of Mount Emmons (3,657m; 12,000 ft) and as low as (2,682m; 8,800 ft) elevation in mid-Alkali Basin.

Montane forests consist of spruce-fir forests, lodgepole pine forests, aspen woodlands, meadows, montane riparian habitats, and other subtypes generally within the elevational range of 2,740 to 3,200m (9,000 to 10,000 ft). Characteristic wildlife include the blue grouse, snowshoe hare, Nuttall's cottontail, and beaver. The chickaree or red squirrel is most common in spruce-fir forest. Warbling vireos and nesting tree swallows typically occur

in aspen woodlands. Differences between spruce-fir and lodgepole pine forests relate mainly to wildlife abundance: fewer rodents were captured in lodgepole pine forests than in spruce-fir forests; birds common to both forest types, the ruby-crowned kinglet, mountain chickadee, and red crossbill, were more numerous in spruce-fir forests.

Big sagebrush shrubland typically separates the montane forests from the agricultural hay meadows of the major valleys. Characteristic bird species include the sage grouse, Brewer's sparrow, green-tailed towhee, sage thrasher, and vesper sparrow. Few mammals are characteristic of sagebrush areas, although white-tailed jackrabbits and meadow voles were found only in this habitat type.

Agricultural land consists of hay meadows, pastures, and riparian areas of the major valley floors. The riparian areas are of considerable importance to wildlife, since they provide cover, water, and an abundance of food. Songbird diversity was highest in the riparian habitat of lower Carbon Creek near its confluence with Ohio Creek. Ducks and other waterbirds, while not abundant anywhere within the project area, were most often observed in riparian habitats below 2,560m (8,400 ft). Characteristic wildlife of the riparian includes the red-winged blackbird, belted kingfisher, mallard, and in some areas, the raccoon, and striped skunk. Species characteristic of open hay meadows and pastures include the common snipe, brown-headed cowbird, black-billed magpie, and raven.

Large mammal studies consisted primarily of aerial counts of elk and mule deer on summer and winter ranges, evaluations of winter range use based on pellet-group counts and big sagebrush utilization, and studies of winter mortality.

The winter range habitats investigated included the south-facing slopes of Flat Top, Alkali Basin, the Almont Triangle, and the sagebrush habitat in Antelope Creek. The highest elk and mule deer pellet-group densities for 1979-80 occurred on the southern part of the Almont Triangle, where pellet-group density estimates of 381 per hectare (154/A) and 186 per hectare (75/A) were obtained for elk and mule deer respectively.

Big sagebrush utilization by big game was very low at the two locations sampled: 5 and 0.8 percent for the south-facing slopes of Flat Top; and 3 and 5 percent for the Almont Triangle, for the two winter periods respectively.

Winter distributions of elk and mule deer within the project area were similar and were strongly influenced by snow depth and the locations of unprotected haystacks.

Deer mortality during the first winter of baseline investigation, 1978-79, was severe due to the deep snowfall and cold temperatures that occurred in January. The deer population in late February 1979 was estimated to contain only 2.7 percent fawns, although high mortality had also occurred among all age classes. Most of winter deer mortality occurred south of the project area near highway 50.

Quantitative studies of breeding bird diversitits were conducted at 19 locations representing 8 habitats during 1979. Thirty-three locations were studied during both years of baseline investigations (Plate 5, sheets 1 and 2). Bird diversities were highest for riparian habitats and aspen habitats. The number of birds identified in the project area totaled 120 species. Six have not been reported for the area previously: the cattle egret, American avocet, mockingbird, gray-cheeked thrush, LeCont's sparrow, and lark bunting.

Fourteen species of raptorial birds were identified. Red-tailed hawks were the most common species encountered.

Three species of grouse were identified: the white-tailed ptarmigan, blue grouse, and sage grouse. Ptarmigan nest in the alpine of Mount Emmons. Blue grouse were observed in all habitat subtypes of the montane. Sage grouse were only observed in the sagebrush habitat of the Almont Triangle, Flat Top, Alkali Basin, and west of Alkali Basin toward Ohio Creek. Six strutting grounds, all in close proximity, were identified near Ohio Creek (Plate 5, sheet 2).

Quantitative studies of small mammals were conducted at 13 locations representing 8 habitats during 1979. Eighteen locations were studied during both years of baseline investigation (Plate 5, sheets 1 and 2). Abundance of deer mice and voles was highest in the aspen habitat of Carbon Creek. Diversity of small mammals was highest in the riparian habitat of Coal Creek where 9 species were identified. Thirty-three species of mammals were identified within the project area.

Threatened or endangered species identified within the project area include the bald eagle, a federally listed endangered species, and the greater sandhill crane, a state endangered subspecies. Two or three bald eagles were repeatedly observed from November through February in the cottonwood grove north of Almont. This area has long been known as wintering habitat for bald eagles. Two flocks of greater sandhill cranes were observed during the spring migration of 1979, and a group of nine sandhill cranes was observed feeding in an agricultural meadow of Ohio Creek during April 1980.

Four sensitive areas were identified: 1) the south-facing slope of Flat Top, 2) the Almont Triangle, 3) the cottonwood grove north of Almont, and 4) the sage grouse strutting grounds near Ohio Creek (Plate 5, sheet 2).

A sensitive area was defined as any local area of special significance to wildlife. The south-facing slope of Flat Top is important winter range for elk and mule deer. The Almont Triangle, between the Taylor and East Rivers, is important winter range for elk, mule deer, and bighorn sheep. The cottonwood grove north of Almont is wintering habitat for the endangered bald eagle. The sage grouse strutting grounds near Ohio Creek are major breeding grounds for the sage grouse of Alkali Basin and vicinity.

SECTION 1

VEGETATION STUDIES

Prepared by: Warren R. Keammerer
Deborah B. Keammerer
Steven J. Peterson

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INTRODUCTION

The vegetation studies for the Mount Emmons Project were conducted during the 1978 and 1979 growing seasons. Initial field work began in May 1978 with most of the data collection occurring in June and July. Studies in 1979 followed a similar schedule. The purpose of the study was to collect sufficient data on the plant communities of the area for use in the preparation of an environmental report. The studies were designed to provide data for preparing a description of the existing vegetation resources and to enable evaluation of impacts and possible means for mitigating those impacts.

Intensive studies were conducted in areas of anticipated project development. Specifically, these were proposed tailing disposal sites, mill sites, ore transportation corridors, and mine sites. Vegetation data were collected in and around Alkali Basin, Red Lady Basin and the areas surrounding the Keystone Mine; the corridor connecting Mount Axtell with Alkali Basin; and staging areas in the Carbon Creek drainage. Also, general observations on the vegetation were made in Antelope Creek Valley and Cabin Creek Valley. In 1978, studies were conducted in Anthracite Creek Valley and Washington Gulch because at that time these areas were being considered as possible tailing disposal sites. These areas were later eliminated from consideration as potential alternatives. The vegetation data collected from these areas are included in this report, since the information is appropriate for use in describing the vegetation of the total study area. In each of the study areas, emphasis was placed on the major vegetation types.

Most of the summarized data from the sampled areas is presented in the appendix. Summaries of the stand data have been included as tables to augment the text. Each of the mapped vegetation types is described for the entire

study area on the basis of the data which were collected during the last two years. Additionally, areas of anticipated impact are described in general terms relative to the vegetation they support.

METHODS

Vegetation Mapping

The vegetation maps of the study area were prepared using a combination of aerial photographic interpretation and field checking. In an area as large as the Mount Emmons Project study area, aerial photographs played an important role in the preparation of vegetation maps. Since many portions of the study area were accessible only on foot, the aerial photographs provided an excellent means of evaluating the vegetation in inaccessible areas. In areas which were accessible, the aerial photographs were used in the field in order to determine relationships between color and texture on the photographs and actual on-the-ground vegetation components. Using the photographs in this manner, vegetation-aerial photograph relationships were extrapolated into areas which were not accessible. In addition to the on-the-ground checking, fixed wing aircraft and helicopter flights were used to check areas with difficult access.

The final vegetation map was prepared at a scale of 1:24,000 (1 inch = 2,000 feet) and in general covers an area bounded by Allen Lane on the south, Ohio Creek on the west, the Slate River on the east and Kebler Pass and Washington Gulch on the north.

The scheme for classification of the vegetation was based on Langenheim (1962). It was necessary to modify the system in order to include lower elevation types [those below 8,500 feet (2,591 m)].

Once the map was prepared, the areal extent of each of the mapped types was determined using a polar planimeter. Because of the complexity of the

vegetation in certain places, some of the areas on the map are portrayed as mixed types. For areal extent determination purposes, the mixed types were included with the type which was most prevalent. These determinations were made on the basis of aerial photographic interpretation.

In addition to the map of the entire area, separate maps were prepared for Cabin Creek and Antelope Creek. These maps were prepared at a scale of 1:12,000 (1 inch = 1,000 feet).

A vegetation map was also prepared for the Access Drift study area near the Keystone Mine. The map was prepared at a scale of 1:2,400 (1 inch = 200 feet) and was completed in 1978.

Floristic Studies

During all aspects of the field work, a list of all observed vascular plants was kept. This list formed the basis for the preparation of the annotated flora. Collections were made for known species, and these were later identified in the laboratory. Specific determinations of difficult species were made by Dr. W. A. Weber at the University of Colorado Museum.

Special attention was placed on searching likely habitats for proposed endangered or threatened species. Based on available information on endangered or threatened species in Colorado (USDI 1978), a list of species which could occur within the area was prepared. Information in the USDI (1978) publication was used to determine what kinds of habitats supported the endangered species. These kinds of habitats were searched.

Quantitative Sampling Program

The purpose of the quantitative sampling program was to obtain data on species composition, cover, frequency and density for the types portrayed on the vegetation map. The data collected as part of this program will be useful not only for the current characterization of the vegetation types, but will

also be useful in the future for comparison of reclaimed areas with original pre-mining conditions.

The primary criterion for sampling stand selection was that the site to be sampled was located in or near to an area which would likely be affected by development. For example, the sagebrush shrublands in Alkali Basin were sampled to a much greater extent than were the sagebrush shrublands on the south side of Flat Top Mountain, even though both were within the defined study area. A second criterion for stand selection was that areas which had been significantly altered by disturbances were not sampled. Areas in meadows which were obviously trampled and overgrazed were not sampled. A third criterion was related to size of the stand to be sampled. Sampled areas were at least five acres (two hectares) in areal extent.

Each of the selected study sites was sampled once. Sampling of the types continued through the growing season. In this way it was possible to account for seasonal changes within a given type, but not for individual stands.

Three basic vegetation types occur within the study area: forests, shrublands, and meadows. The sampling program was designed such that data for trees, shrubs and herbaceous species was collected using methods appropriate for different life forms. Trees were sampled using either the quarter method (Cottam and Curtis 1956) or a quadrat method. Shrubs were sampled using Lindsey's (1955) line-strip method, and herbs were sampled using a quadrat method. The numbers and sizes of quadrats, transects and quarter method points used to sample the different stands and vegetation types are presented in Table I-1.

In forested stands trees were sampled to obtain estimates of density, basal area, diameter at breast height, and frequency. Mean values for density, basal area and diameter were determined in the laboratory. All individuals greater than 2 inches (5.1 cm) in diameter at breast height were considered to be trees.

In those communities where they occurred, shrubs were sampled to obtain estimates of cover, density, and frequency by species. In the laboratory mean values were obtained for these parameters. Density data were recorded and summarized on the basis of height classes for shrubs and tree saplings.

For herbaceous species, cover and presence were estimated and recorded in each of the circular quadrats. Total cover by all species, cover by litter, cover by lichens, cover by mosses, cover by rock, and percent bare soil was also estimated. In the laboratory, mean values were calculated for these parameters.

Individual summaries for trees, shrubs and herbs were prepared for each of the sampled stands. For the vegetation types which were sampled with more than one stand, the stand summaries have been included in the Vegetation Appendix. Summaries based on the most prevalent species in these types have been included in the body of the report. For vegetation types which were sampled with only one stand, the stand summaries have been included in the body of the text rather than the Vegetation Appendix.

In order to rank the species in the sampled communities, an importance value was calculated. Importance is used in plant ecological studies as a means for ranking species (Curtis 1959). Importance value is a synthetic index which is used to combine frequency, density and cover data. For trees, importance value was calculated as the sum of relative frequency (percent of total plots or points of occurrence), relative density (percent of total individuals counted), and relative basal area (percent of total basal area), and had a theoretical range from 0 to 300. For shrubs, importance value was calculated by adding relative frequency, relative density and relative cover (percent of total cover), and ranged from 0 to 300. For species in the herb layer, importance value was determined as the sum of relative frequency

and relative cover and ranged from 0 to 200. Species in each of the strata were ranked on the basis of importance value. The species with the highest importance value was given a rank of one. To the extent that the importance of species can be measured in terms of the above paramenters, this method can be used to identify community dominants and evaluate the roles of community components.

Productivity Studies

Productivity studies were conducted to estimate the biomass production of the major plant communities. Productivity data will be useful in evaluating the success of future revegetation programs and in evaluating impacts relative to the loss of plant communities as a result of mine and mill developments.

The productivity studies were conducted in 1978 and 1979 using a harvest method. Circular quadrats of known area (Table I-1) were clipped in big sagebrush shrublands, aspen woodlands, moist meadows, hayfields-pastures, spruce-fir forests, and subalpine meadows. Sites were clipped in late July. Not all types were clipped each year. In 1978 all of the clipped sites were located in the Alkali Basin area. In 1979 sites were clipped in the Alkali Basin areas and in Red Lady Basin near the Keystone Mine (Table I-1). Clipped samples were separated on the basis of species for grasses, semi-shrubs and shrubs. All forbs were grouped as a combined fraction, except in the aspen woodlands. Since forbs constitute a major component in the understory of the aspen woodlands, major forb species were separated from less important ones. Samples were collected in paper bags and air dried. In the laboratory all samples were oven dried at approximately 105°C for 24 hours. Mean values for each of fractions at each of the sampling locations were calculated.

Bog Studies

One of the most interesting results from the first year of field work was

Table I-1. Summary of sample sizes and numbers for all stands included in the vegetation studies. Refer to Plate 1 for stand locations.

Stand Name	Herbaceous Layer Size (m^2)	Herbaceous Layer Number	Shrub Transects Size	Shrub Transects Number	Tree Quarter Method Number of Points	Tree Quadrats Size (m^2)	Tree Quadrats Number	Clipped Quadrats Size (m^2)	Clipped Quadrats Number
Big Sagebrush Shrubland									
ALK-SB-1	1.0	15	2x15	15				1.0	5
ALK-SB-2	1.0	15	2x15	15				1.0	5
ALK-SB-3	1.0	15	2x15	15				1.0	5
ALK-SB-4	1.0	15	2x15	15				1.0	5
ALK-SB-5	1.0	15	2x15	15				1.0	5
ALK-SB-6	1.0	15	2x15	15				1.0	5
ALK-SB-7	1.0	15	2x15	15				1.0	5
ALK-SB-8	1.0	15	2x15	15				1.0	5
ALK-SB-9	1.0	15	2x15	15				1.0	5
SB-MS-1	1.0	20	4x10	16				1.0	10
SB-MS-2	1.0	20	4x10	16				1.0	10
SB-MS-4	1.0	20	4x10	16				1.0	10
SB-MS-6	1.0	20	4x10	16				1.0	10
SB-MS-7	1.0	20	4x10	16				1.0	10
SB-AS-1	1.0	15	2x15	15					
SB-AS-2	1.0	15	2x15	15					
SB-AS-3	1.0	15	2x15	15					
SB-AS-4	1.0	15	2x15	15					
SB-AS-6	1.0	15	2x15	15					
SB-AS-7	1.0	15	2x15	15					
SB-AS-11	1.0	15	2x15	15					
Aspen Woodlands									
ALK-AW-1	1.0	15	2x15	10	20			0.5	5
ALK-AW-2	1.0	15	2x15	10	20			0.5	5
WAS-AW-4	1.0	15	2x15	10	20				
ANT-AW-3	1.0	15	2x15	10	20				
ANT-AW-5	1.0	15	2x15	10	20				
ANT-AW-6	1.0	15	2x15	10	20				

Table I-1. (contd.) Summary of sample sizes and numbers for all stands included in the vegetation studies.

Stand Name	Herbaceous Layer Size (m^2)	Herbaceous Layer Number	Shrub Transects Size	Shrub Transects Number	Tree Quarter Method Number of Points	Tree Quadrats Size (m^2)	Tree Quadrats Number	Clipped Quadrats Size (m^2)	Clipped Quadrats Number
Aspen Woodlands (cont'd)									
DA-AW-7	1.0	15	2x15	10		30	10		
AW-MS-3	1.0	20	4x10	16		40	16	0.5	10
AW-MS-5	1.0	20	4x10	16		40	16	0.5	10
AW-MS-8	1.0	20	4x10	16		40	16		
AW-AS-5	1.0	15	2x15	15					
AW-AS-8	1.0	15	2x15	15	20				
AW-AS-12	1.0	15	2x15	15	20				
Spruce-Fir Forests									
KP-SF-1	1.0	15	2x15	10	20				
ANT-SF-2	1.0	15	2x15	10	20				
WAS-SF-3	1.0	15	2x15	10	20				
DA-SF-4	1.0	10	2x15	10		30	10		
SF-MS-10	1.0	20	4x10	16		40	16	1.0	10
SF-AS-10	1.0	15	2x15	15	20				
Lodgepole Pine Forests									
DA-LP-1	1.0	10	2x15	10		30	10		
LP-AS-9	1.0	15	2x15	15					
Moist Meadow									
ALK-M-1	1.0	15						0.25	5
Mountain Grasslands									
ANT-M-4	1.0	15							
WAS-M-6	1.0	15							
Wet Sedge Meadow									
WAS-M-7	1.0	15							

Table I-1. (contd.) Summary of sample sizes and numbers of all stands included in the vegetation studies.

Stand Name	Herbaceous Layer Size (m^2)	Herbaceous Layer Number	Shrub Transects Size	Shrub Transects Number	Tree Quarter Method Number of Points	Tree Quadrats Size (m^2)	Tree Quadrats Number	Clipped Quadrats Size (m^2)	Clipped Quadrats Number
Subalpine Meadow									
ANT-M-5	1.0	15							
DA-M-8	1.0								
M-MS-9	1.0	20						0.25	10
M-AS-12	1.0	15							
Alpine Meadows									
MTE-T-1	1.0	15							
T-MS-11	1.0	20							
Fell Field									
MTE-FF-1	1.0	15							
Hay Meadow/Pasture									
ALK-M-2	1.0	15						0.25	5
ALK-M-3	1.0	15						0.25	5
Keystone Bog									
KB-1	1.0	10	2x15	10		45	10		
KB-2	0.1	10	2x15	10		45	10		
KB-3	0.1	15							
KB-4	0.1	15							
KB-5	0.1	15							
Abandoned Road Right-Of-Ways									
RC-AS-13	1.0	15							
RC-AS-14	1.0	15							
RC-AS-15	1.0	15							

the recognition of the botanical significance of the acid bog near the Keystone Mine. The bog, referred to as the Keystone Bog throughout this report, contains the only known population of round-leaved sundew (*Drosera rotundifolia*) in Colorado. Because of the bog's significance, studies were conducted which were designed to describe the vegetation within the bog and also to survey other bogs in the region to determine if other sundew populations could be located. The methods used for sampling the bog were similar to those used in other areas. Quadrat sizes and numbers for the Keystone Bog study sites are presented in Table I-1.

On a regional basis, bogs were examined qualitatively on foot. These bogs exhibited physical features similar to those of the Keystone Bog. Most were associated with mining areas, and their specific locations were obtained from Charles Robinson, a geologist, who has kept a record of limonitic bog locations in Colorado.

Successional Studies

The purpose of the successional studies was to determine which species are most likely to colonize disturbed areas. The data from these studies will help in the selection of revegetation seed mixes.

Sampling for the successional studies was conducted along the abandoned right-of-way adjacent to the existing Kebler Pass road. Three sites were sampled to determine species composition and to identify dominant species in these areas. The same methods were used as in the other plant communities. Quadrat sizes and numbers are listed in Table I-1.

RESULTS AND DISCUSSION

Vegetation Mapping

Four vegetation maps were prepared for the project area. Plate 1 (Sheets

1 and 2) presents the vegetation of the main study area, mapped at a scale of 1:24,000 (1 inch = 2,000 feet). Plate 1, sheet 1 covers the northern part of the study area, and Plate 1, sheet 2 covers the southern part. Twenty-three mapping units were used to depict the vegetation within the study area. These units along with the area they occupy and their percent of the total area are presented in Table I-2.

The vegetation map of Antelope Creek is presented as Plate 2, and the vegetation map of Cabin Creek is presented as Plate 3.

The detailed vegetation map of the area adjacent to the Keystone Mine including the proposed access drift area is presented as Plate 4.

Flora of the Mount Emmons Project Study Area

Description of the Flora. The vascular flora of the Mount Emmons Project study area is composed of 68 families, 260 genera and 494 species (Table I-3). This high degree of species diversity relates to the broad elevation range of the study area which extends from approximately 7,700 feet (2,347 m) near Gunnison to over 12,000 feet (3,657 m) on Mount Emmons. Within this elevational range, four general vegetation zones can be seen. It is not possible to place rigid elevational limits on these zones, since local influences such as slope, exposure and substrate cause the zones to overlap. Within the study area the four zones occur as follows: big sagebrush [7,700 - 8,500 feet (2,347 - 2,591 m)], aspen [8,500 - 9,500 feet (2,591 - 2,895 m)], spruce-fir [9,500 - 11,500 feet (2,895-3,505 m)], and alpine tundra [areas above 11,500 feet (3,505 m)]. The variety of habitats within these zones makes it possible for so many species to occur within the study area.

In terms of the number of species, the flora is dominated by two plant families: Compositae (aster family) and Gramineae (grass family). These two families account for more than 28 percent of the total flora. Six other

Table I-2. Planimetric analysis for the units portrayed on the vegetation map (Plate 1).

Type	No. of Acres	No. of Hectares	% of Total Area
1 Moist Meadows	209	85	0.15
2 Mountain Grasslands	3,433	1,390	2.44
3 Wet Sedge Meadows	504	204	0.36
4 Sphagnum-Sedge Bog	9	4	0.01
5 Subalpine Meadows	8,105	3,281	5.77
6 Alpine Meadows	1,081	438	0.77
7 Alpine Fellfields	1,140	462	0.81
8 Sparsely Vegetated Areas	1,390	563	0.99
9 Big Sagebrush Shrublands	50,626	20,496	36.03
10 Subalpine Willow Thicket	920	372	0.65
11 Cottonwood Woodlands	1,273	515	0.91
12 Ponderosa Pine Woodlands	3	1	<0.01
13 Lodgepole Pine Forests	2,624	1,063	1.87
14 Douglas-fir Forests	3,416	1,383	2.43
15 Aspen Woodlands	19,723	7,985	14.04
16 Engelmann Spruce-Subalpine Fir Forests	21,110	8,547	15.02
17 Hay Meadow-Pasture	15,685	6,350	11.16
18 Disturbed Areas	372	151	0.27
19 Urban Areas	584	236	0.42
20 Rock Outcrops/Talus	4,781	1,935	3.40
23 Riparian Willow Thicket	3,304	1,338	2.35
25 Juniper Woodlands	18	7	0.01
Ponds, Lakes, and Reservoirs	214	87	0.15
TOTAL	140,524*	56,893	100.00%

* 220 square miles

Table I-3. Number of genera, number of species and percent of flora for plant families encountered in the Mount Emmons Project study area.

	No. of Genera	No. of Species	% of Flora
ARTHROPHYTA			
Equisetaceae	1	2	0.40
MICROPHYLLOPHYTA			
Selaginellaceae	1	1	0.20
PTEROPHYTA			
Polypodiaceae	4	4	0.81
CONIFEROPHYTA			
Cupressaceae	1	3	0.61
Pinaceae	4	7	1.42
ANTHOPHYTA			
Monocotyledoneae			
Cyperaceae	4	19	3.85
Gramineae	24	63	12.75
Iridaceae	1	1	0.20
Juncaceae	2	7	1.42
Lemnaceae	1	1	0.20
Liliaceae	10	13	2.63
Orchidaceae	5	7	1.42
Dicotyledoneae			
Aceraceae	1	1	0.20
Amaranthaceae	1	1	0.20
Anacardiaceae	1	1	0.20
Berberidaceae	1	1	0.20
Betulaceae	2	2	0.40
Boraginaceae	6	10	2.02
Cactaceae	2	2	0.40
Campanulaceae	1	3	0.61
Caprifoliaceae	3	3	0.61
Caryophyllaceae	7	14	2.83
Celastraceae	1	1	0.20
Chenopodiaceae	4	5	1.01
Compositae	37	78	15.79
Cornaceae	1	1	0.20
Crassulaceae	3	3	0.61
Cruciferae	16	30	6.07
Droseraceae	1	1	0.20
Elaeagnaceae	1	1	0.20
Ericaceae	6	10	2.02

Table I-3. (contd.) Number of genera, number of species and percent of flora for plant families encountered in the Mount Emmon Project study area.

	No. of Genera	No. of Species	% of Flora
Euphorbiaceae	1	1	0.20
Fagaceae	1	1	0.20
Fumariaceae	1	2	0.40
Gentianaceae	3	3	0.61
Geraniaceae	1	1	0.20
Grossulariaceae	1	4	0.81
Hippuridaceae	1	1	0.20
Hydrophyllaceae	2	3	0.61
Labiatae	2	2	0.40
Leguminosae	8	21	4.25
Linaceae	1	1	0.20
Loasaceae	1	1	0.20
Malvaceae	2	3	0.61
Moraceae	1	1	0.20
Nyctaginaceae	1	1	0.20
Nymphaeaceae	1	1	0.20
Onagraceae	3	5	1.01
Orobanchaceae	1	2	0.40
Plantaginaceae	1	2	0.40
Polemoniaceae	5	9	1.82
Polygonaceae	5	13	2.63
Portulacaceae	2	3	0.61
Primulaceae	2	2	0.40
Ranunculaceae	11	20	4.05
Rhamnaceae	1	1	0.20
Rosaceae	15	26	5.26
Rubiaceae	1	3	0.61
Salicaceae	2	6	1.21
Santalaceae	1	1	0.20
Saxifragaceae	3	11	2.23
Scrophulariaceae	10	24	4.85
Solanaceae	1	1	0.20
Umbelliferae	11	13	2.63
Urticaceae	1	1	0.20
Valerianaceae	1	3	0.61
Verbenaceae	1	1	0.20
Violaceae	1	4	0.81
TOTAL	260	494	99.9

families (Cruciferae, Rosaceae, Scrophulariaceae, Leguminosae, Ranunculaceae, and Cyperaceae) account for another 28 percent of the species. Forty-three families are represented by only one, two or three species and collectively account for approximately 15 percent of the flora.

Barrel (1969) lists 1,062 species in his flora of the Gunnison Basin. While his flora may be incomplete, it does provide insight into total species diversity on a regional basis. His flora covers a much larger area than the Mount Emmons project study area; however, nearly all of the study area occurs within the area covered by his flora. It is interesting to note that approximately half the species he reports were observed in the Mount Emmons Project study area. A complete list of the species observed in the study area is presented in Appendix Table I-121.

Endangered and Threatened Species

Special attention was given to those species which are considered to be threatened or endangered according to the Smithsonian Institution (Ayensu and De Filipps 1978) and the U. S. Department of the Interior (1978). It should be emphasized that these species are proposed for listing as threatened and endangered. Final legislative action has not yet occurred. Because of their rarity and the concern for their continued existence in the habitats where they grow, they are presented here with information regarding their occurrence in the Mount Emmons Project study area.

During the course of field studies, habitats most likely to support proposed threatened or endangered species were searched. Also, taxonomic groups like rockcress (*Arabis* spp.) and milkvetch (*Astragalus* spp.) which were difficult to identify were collected so that accurate identifications could be made. The species included in this section are those which are known to occur in the Gunnison area. Only two of the species were enocuntered in this study (*Arabis crandallii* and *Arabis oxylobula*).

Endangered Species

Arabis gunnisoniana Rollins. This species of rockcress was known from the Gunnison area and occurred along the Gunnison River in areas that are now inundated by Blue Mesa Reservoir. Previously known populations have not been relocated and the species is currently listed as probably extinct. It grows in dry sagebrush communities and is similar to several other species of rockcress. Taxonomically, it is part of a group of closely related species included in the *Arabis demissa* complex (USDI 1978). The appropriate habitat for this species occurs primarily in the low elevations [below 8,400 feet (2,560 m)] of the study area which are dominated by big sagebrush shrublands. The best habitat occurs on the south side of Flat Top Mountain. One specimen of *Arabis* was collected in this area, and was keyed to *A. demissa*. In general appearance it closely resembled *A. gunnisoniana* (determination was made by W. A. Weber, University of Colorado Museum). It is possible that *A. gunnisoniana* could occur in the study area; however, it was not observed

Arabis crandallii Robinson. This species of rockcress is listed by Ayensu and De Filipps (1978) and is not included in the U. S. Department of Interior list (1978). In general appearance it resembles *A. gunnisoniana*. *A. crandallii* was collected on the Almont Triangle near one of the sagebrush sampling sites (SB-AS-1). It occurs only to a limited extent in that area. (Identification was verified by W. A. Weber).

Arabis oxylobula Greene. This rockcress species is also part of the *A. demissa* complex. Previously, the species had been reported from Garfield County near Glenwood Springs. In this study, it was encountered in the Anthracite Creek and Carbon Creek drainages. It grows almost exclusively on vertical rock outcrops and occurs on small ledges and in crevices. The species was first collected by Osterhout in 1899 and 1902 (USDI 1978) and was not collected

again until 1978. All other collections of this species have come from the Glenwood Springs area.

Astragalus microcymbus Barneby. This species of milkvetch is known from low elevation [less than 7,700 feet (2,347 m)] sagebrush communities in the vicinity of Gunnison and also from the drainage of South Beaver Creek (Barrel 1969). The known localities are southwest of the Mount Emmons Project study area. This species was not encountered in this study.

Senecio porteri Greene. *Senecio porteri* is an alpine species that occurs in meadows and fellfields. It is known from one site in the Gunnison Basin (Barrel 1969) and also from the Wallowa Mountains in Oregon. Appropriate habitats in the alpine were searched, but no individuals were observed. It is possible that the species could occur in the alpine on Mount Emmons, Mount Axtell or Whetstone Mountain. The areas on Mount Emmons were carefully searched and no individuals of the species were seen.

Stellaria irrigua Bunge. *Stellaria irrigua* is a small herbaceous species which occur on loose alpine scree slopes. It usually occurs with *Ligularia soldanella*. In the Gunnison Basin it has been reported from Mount Belleview (Barrel 1969). The alpine areas on Mount Emmons were carefully searched, especially in the local areas where *Ligularia soldanella* grows. No individuals of *Stellaria irrigua* were found. Because of its diminutive size, it could have been overlooked.

Threatened Species

Sullivantia purpusii (Brand) Rosendahl. *Sullivantia purpusii* occurs on wet rock ledges around seeps and waterfalls. It is known from several locations in the Gunnison Basin (Barrel 1969), but was not observed within the Mount Emmons Project study area. Seeps and waterfalls in the Carbon Creek and Coal Creek drainages and in the Red Lady Basin were checked, but the species was not located.

Descriptions of Plant Communities and Other Mapped Units

The descriptions of communities which follow are presented primarily along an elevational gradient starting with the alpine tundra communities and working downward. The concept of elevational zonation has been widely used in describing mountain vegetation (Marr 1967, Langenheim 1962, and Barrell 1969). These researchers emphasize that vegetation zones appear in only a general sense and much overlap and intergradation can be seen between zones. For the purpose of the following descriptions four major zones were considered. The alpine tundra zone includes fellfields and tundra meadows. The subalpine zone includes meadows, subalpine willow thickets, spruce-fir forests, wet sedge meadows, and sphagnum-sedge bogs. The upper montane zone includes Douglas-fir forests, lodgepole pine forests, aspen woodlands, riparian willow thickets, moist meadows, and mountain grasslands. The lower montane includes big sagebrush shrublands, cottonwood woodlands, ponderosa pine forests, juniper woodlands and hay meadows-pastures. In addition to these communities there are five other mapping units which cross the elevational zones. These include sparsely vegetated areas, rock outcrops/talus slopes, ponds-open water, disturbed areas, and urban areas. It should be reemphasized that the concept of vegetation zones should be applied in only a general way. As Langenheim (1962) points out, sagebrush shrublands can occur as high as 12,000 feet (3,656 m) in the Crested Butte area.

Fellfields (Type 7). Fellfields occur on windswept alpine ridges such as those found on Mount Emmons, Mount Axtell and Whetstone Mountain. Habitats such as these are restricted within the study area and consequently fellfields are not common. Fellfields occupy approximately 1,140 acres (462 hectares); 0.81 percent of the study area.

Cushion plants are one of the most common life forms of plants encountered in the fellfield communities (Figure I-1). In the sampled fellfield stand on

Figure I-1. Alpine fellfield community on upper slopes of Mount Emmons.

Mount Emmons, dwarf clover (*Trifolium nanum*) was the number one ranking species (Table I-4). Other components include common alpine species like fleabane (*Erigeron pinnatisectus*) and alpine avens (*Acomastylis rossii*). Total herb cover was approximately 22 percent, while cover by rock was 63 percent. These communities occur in one of the most extreme environments within the study area. In winter these areas are mostly blown free of snow, and during the short growing season, are subject to intense ultraviolet radiation. Many of the plants grow in rock crevices or in the lee of the rocks (Figure I-1).

Alpine Meadows (Type 6). Alpine meadows occur in habitats similar to fell-fields except that the substrate tends to be less rocky and the sites tend to hold a limited amount of snow in winter. Some of the best developed tundra meadows in the study area occur on Scarp Ridge just northwest of Gunsight Pass. Dominant species in this type include alpine avens, sheep fescue (*Festuca brachyphylla*) and whiproot clover (*Trifolium dasyphyllum*). These three species had the highest mean importance value based on data collected from alpine areas on Mount Emmons (Table I-5). Tundra meadows also occur on Mount Axtell (Figure I-2). In these meadows, old-man-of-the-mountain (*Hymenoxis grandiflora*) occurs as a common species. On both Mount Emmons and Mount Axtell, krummholz tree islands occur in the tundra meadows. These twisted and wind sculpted trees form a link between the tundra and subalpine forests. The herbaceous species which grow underneath the individual krummholz islands are characteristic of the spruce-fir forests rather than the tundra. Krummholz was not mapped as a plant community type, since the isolated tree islands were not large enough to include on the vegetation map. Ecologically, the krummholz demonstrates the plasticity of the subalpine tree species relative to their ability to adapt to and withstand the rigorous alpine environment (Marr 1977).

The alpine meadows are restricted within the study area and occupy 1,081 acres (437 hectares); 0.77 percent of the area.

Figure I-2. Alpine tundra meadow community on Mount Axtell. The conspicuous flowers are old-man-of-the-mountain (*Hymenoxis grandiflora*).

Table I-4. Summary statistics for herb layer species in Mount Emmons stand MTE-FF-1 (fellfield)

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
PERENNIAL GRASSES AND SEDGES							
Agropyron scribneri	0.2	0.68	0-2	13	2.01	2.69	15
Carex haydeniana	0.3	1.02	0-4	7	1.08	2.10	17
Festuca brachyphylla	2.4	8.19	0-7	80	12.38	20.57	4
Poa sp.	1.4	4.78	0-6	73	11.30	16.08	5
Trisetum spicatum	0.3	1.02	0-3	33	5.11	6.13	8
Sub-Total	4.6						
FORBS							
Acomastylis rossii	5.9	20.14	0-28	27	4.18	24.32	3
Allium sp.	<0.1	<0.01	0-<1	7	1.08	1.08	19
Androsace septentrionalis	<0.1	<0.01	0-<1	33	5.11	5.11	9
Claytonia megarhiza	0.1	0.34	0-1	13	2.01	2.35	16
Draba stenoloba	0.9	3.07	0-7	53	8.20	11.27	7
Erigeron pinnatisectus	3.3	11.26	0-12	87	13.47	24.73	2
Erysimum asperum	<0.1	<0.01	0-<1	13	2.01	2.01	18
Hymenoxys grandiflora	0.3	1.02	0-3	20	3.10	4.12	12
Ligularia soldanella	0.3	1.02	0-4	13	2.01	3.03	14
Polemonium viscosum	0.7	2.39	0-10	7	1.08	3.47	13
Sedum lanceolatum	0.2	0.68	0-2	27	4.18	4.86	10
Selaginella densa	1.0	3.41	0-15	7	1.08	4.49	11
Smelowskia calycina	1.5	5.12	0-5	60	9.29	14.41	6
Trifolium nanum	10.5	35.84	0-30	73	11.30	47.14	1
Sub-Total	24.7						

Based on data from 15 1.0m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1978 data.

Table I-4.(contd.) Summary statistics for herb layer species in Mount Emmons stand MTE-FF-1.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
Sum of Species Cover	29.30		1-85				
Total Cover in Herb Layer	21.53		1-45				
Litter Cover	20.53		0-45				
Bare Soil	15.73		0-50				
Rock Cover	63.40		30-100				

Number of Species per Square Meter	Mean	Range
Herb Species	6.47	1-11
Shrub Species	0.00	----
Total Species	6.47	1-11

Additional Herbaceous Species: *Arabis demissa? (oxylobula), Besseya alpina, Campanula uniflora, Carex chalciolepsis, Haplopappus pygmaeus, Lloydia serotina, Minuartia obtusiloba, Minuartia rubella, Paronychia pulvinata, Saxifraga cernuua, Saxifraga flagellaris, Silene acaulis, Senecio saxosus, Trifolium dasyphyllum*

Table I- 5. Summary of mean cover, percent frequency, and importance values for the top ten ranked species for the 1978 alpine meadow study site MTE-T-1 and the 1979 alpine meadow study site TM-MS-11.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Agropyron scribneri	1.50	0-3.0	36.50	0-73.0	5.08	A-10.15	50.00
Calamagrostis purpurescens	2.90	0-5.8	42.50	0-85.0	7.63	A-15.25	50.00
Carex brevipes	1.95	0-3.9	56.50	13.0-100.0	6.72	1.06-12.37	100.00
Festuca brachyphylla	3.15	1.3-5.0	94.00	93.0-95.0	10.88	7.17-14.58	100.00
Poa fendleriana	1.15	0-2.3	30.00	0-60.0	4.06	A-8.12	50.00
Trisetum spicatum	1.95	0-3.9	46.50	0-93.0	6.52	A-13.04	50.00
FORBS							
Achillea lanulosa	1.45	0-2.9	46.50	0-93.0	5.82	A-11.64	50.00
Acomastyllis rossii	19.60	10.5-28.7	93.50	87.0-100.0	36.14	24.94-47.33	100.00
Artemisia scopulorum	1.95	0.1-3.8	48.50	7.0-90.0	6.20	0.71-11.68	100.00
Erigeron pinnatisectus	0.80	0.3-1.3	48.50	7.0-90.0	3.96	0.99-6.92	100.00
Erysimum asperum	0.55	0-1.1	40.00	0-80.0	4.03	A-8.05	50.00
Polemonium viscosum	2.15	0-4.3	43.50	0-87.0	6.56	A-13.11	50.00
Potentilla diversifolia	2.20	0-4.4	47.50	0-95.0	6.54	A-13.07	50.00
Potentilla rubricaulis	1.55	0-3.1	40.00	0-80.0	4.93	A-9.85	50.00
Sedum lanceolatum	0.75	<0.1-1.5	44.00	15.0-73.0	4.39	0.74-8.03	100.00
Silene acaulis	1.50	0-3.0	47.50	0-95.0	5.20	A-10.40	50.00
Trifolium dasyphyllum	4.35	3.8-4.9	90.00	80.0-100.0	13.06	11.84-14.27	100.00

A = absent

Subalpine Meadows (Type 5). The subalpine meadows occur at elevations below tree limit and usually above 9,500 feet (2,895 m) elevation. At higher elevations [above 11,000 feet (3,353 m)] they grade into alpine meadows and at lower elevations [below 9,500 feet (2,895 m)] they grade into mountain grasslands or moist meadows. In addition to occurring as rather broad open areas, subalpine meadows also occur intermixed with spruce-fir forests (Figure I-3). In some of those areas, the forests are more abundant and the meadows occur as clearings in the forests. In other areas the meadows are much more prevalent and the forests occur as isolated patches within the meadow matrix. Subalpine meadows are widely distributed and occupy approximately 8,104 acres (3,281 hectares); 5.77 percent of the study area.

Four subalpine meadows were sampled (Table I-6). Eleven of the 25 major species occurred in only one stand, illustrating the site variability within this type. At higher elevations meadows occurring on benches or relatively flat sites tend to be dominated by tufted hairgrass (*Deschampsia caespitosa*). Mean cover for this species ranged from zero to 20.3 percent in the subalpine meadows. Other important species include western yarrow (*Achillea lanulosa*), fringed brome (*Bromus ciliatus*), and peavine (*Lathyrus leucanthus*). Meadows dominated by false hellebore (*Veratrum tenuipetalum*) are also included in this type, but none of these areas were sampled. Other tall forb meadows containing mountain coneflower (*Rudbeckia montana*), cow parsnip (*Heracleum lanatum*), fern-leaf lomatium (*Lomatium dissectum*), elderberry (*Sambucus microbotrys*), and lovage (*Ligusticum porteri*) are also included in this type.

Mean production was 1,648 lbs/acre (185 g/m^2) in the sampled stand in Red Lady Basin. Approximately 70 percent of the total was attributable to perennial grasses and sedges (Table I-7). The most productive species was tufted hairgrass with a mean value of 570 lbs/acre (64 g/m^2).

Figure I-3. Engelmann spruce-subalpine fir forests with interspersed subalpine meadows.

Table I-6. Summary of mean cover, percent frequency, and importance values for the top ten ranked species in each of the subalpine meadow 1978 study sites ANT-M-5, DA-M-8 and 1979 study sites M-MS-9 and M-AS-12.

Species	Mean Cover (%)	Range of Cover Values (%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Bromus ciliatus	3.30	0-11.9	45.00	0-100.0	7.05	A-18.98	50.00
Calamagrostis canadensis	0.53	0-2.1	18.33	0-73.3	1.94	A-7.76	25.00
Carex brevipes	0.63	0-2.5	16.25	0-65.0	2.80	A-11.20	25.00
Carex geyeri	1.00	0-3.7	20.75	0-50.0	3.30	A-10.91	50.00
Carex sp.	0.50	0-2.0	18.33	0-73.3	1.90	A-7.58	25.00
Deschampsia caespitosa	5.08	0-20.3	25.00	0-100.0	12.36	A-49.44	25.00
Festuca arizonica	3.58	0-10.3	42.50	0-100.0	9.91	A-24.99	50.00
Festuca thurberi	1.40	0-5.6	10.00	0-40.0	3.36	A-13.43	25.00
Juncus parryi	1.03	0-4.1	13.75	0-55.0	3.34	A-13.36	25.00
Phleum alpinum	0.20	0-0.8	13.75	0-55.0	1.73	A-6.91	25.00
Stipa columbiana	1.05	0-4.2	21.68	0-86.7	3.13	A-12.50	25.00
FORBS							
Achillea lanulosa	3.70	0-7.9	59.25	0-87.0	10.11	A-13.82	75.00
Artemsia dracunculus	0.83	0-3.3	7.50	0-30.0	2.12	A-8.47	25.00
Claytonia lanceolata	0.38	0-1.5	25.43	0-55.0	2.75	A-8.28	75.00
Dugaldia hoopesii	1.48	0-3.3	30.00	0-60.0	3.96	A-9.42	50.00
Epilobium angustifolium	0.60	0-2.1	15.75	0-50.0	2.29	A-8.05	50.00
Erigeron speciosus	0.73	0-2.9	15.00	0-60.0	2.59	A-10.34	25.00
Erythronium grandiflorum	1.00	0-3.3	41.58	0-100.0	5.00	A-16.17	75.00
Fragaria ovalis	2.90	0-9.9	35.08	0-87.0	5.50	A-16.01	50.00
Galium bifolium	0.48	0-1.9	29.25	0-87.0	2.46	A-7.25	50.00
Galium boreale	1.08	0-3.8	26.68	0-66.7	2.72	A-6.54	50.00
Heuchera parviflora	0.70	0-2.8	20.00	0-80.0	2.37	A-9.46	25.00
Lathyrus leucanthus	3.68	0-14.1	37.50	0-100.0	6.69	A-21.39	50.00
Polygonum sawatchense	0.90	0-1.6	79.50	45.0-100.0	7.05	4.57-9.40	100.00
Senecio crassulus	1.28	0-2.7	29.58	0-73.3	4.50	A-9.65	50.00

A = absent

Table I-6. (contd.) Summary of top ten species in the subalpine meadow community 1978.

Species	Mean Cover (%)	Range of Cover Values (%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Importance Values	Range of Importance Values	Presence (%)
Taraxacum officinale	2.25	0-5.0	54.50	0-100.0	6.56	A-12.78	75.00
Thlaspi montanum	0.63	0-1.7	46.68	10.0-86.7	3.97	0.97-7.65	100.00
Viola nuttallii	0.83	0-1.5	37.50	0-80.0	3.76	A-6.40	75.00
WOODY SPECIES							
Pachystima myrsinites	4.10	0-16.4	17.50	0-70.0	8.82	A-35.26	25.00
Vaccinium caespitosum	0.55	0-2.2	8.75	0-35.0	1.93	A-7.71	25.00
Vaccinium myrtillus	1.40	0-4.0	5.83	0-13.3	2.94	A-7.99	50.00

Table I-7. Mean production for Red Lady Basin stand M-MS-9.

Species	Mean ± S.D. n = 10	Range
GRASSES AND SEDGES		
Bromus ciliatus	7.816	0- 32.196
Calamagrostis purpurescens	4.220	0- 13.200
Carex sp.	16.084	0-112.684
Carex spp.	14.521	0- 57.012
Deschampsia caespitosa	63.996	22.856-185.464
Festuca brachyphylla	0.280	0- 2.808
Juncus parryi	10.972	0- 43.688
Phleum alpinum	0.816	0- 4.796
Phleum commutatum	1.024	0- 10.236
Poa spp.	9.208	0- 33.468
Sub-Total	128.937 ± 73.448	56.576-319.272
FORBS	38.696 ± 35.236	2.056-109.028
WOODY SPECIES		
Vaccinium caespitosum	17.380 ± 37.168	0-100.128
TOTAL PRODUCTION	185.013 ± 57.760	141.380-328.532

S. D. equals the standard deviation. Values in grams/m^2. n = sample size. 1979 data.

Engelmann Spruce-Subalpine Fir Forests (Type 16). The Engelmann spruce-subalpine fir forests are widespread within the study area. They cover approximately 21,109 acres (8,546 hectares); 15.02 percent of the total area. The spruce-fir type covers extensive areas between 9,500 (2,895 m) and 11,500 feet (3,505 m). The two dominant species are Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) which occur at mean densities of 306 and 165 trees per acre (756 and 408 trees per hectare) respectively. While the subalpine fir are more numerous, the spruce tend to be larger. Mean diameter at breast height in the six sample spruce-fir stands ranged from 4.5 to 8.7 inches (11.4 to 22.0 cm) for subalpine fir and 7.0 to 17.5 inches (17.8 to 44.5 cm) for Engelmann spruce. These were the only two tree species encountered in these forests.

The spruce-fir forest canopy restricts light to the extent that shrubs and herbs are limited in the understory. The major woody components are saplings of fir and spruce (Table I-8). These components consistently had the highest mean cover and importance values. Thimbleberry (*Rubus parviflorus*) and bracted honeysuckle (*Lonicera involucrata*), while not always abundant in the understory, are typical shrub species of the spruce-fir forests.

The two most common species in the herb layer were low growing shrubs. Myrtle blueberry (*Vaccinium myrtillus*) and mountain lover (*Pachystima myrsinites*) occurred in all the sampled spruce-fir stands and had mean importance values of 40.7 and 20.8 respectively (Table I-9). Elk sedge (*Carex geyeri*) was the most common graminoid species, however its mean cover was only 1.4 percent. Heart-leaf arnica (*Arnica cordifolia*) and curled lousewort (*Pedicularis racemosa*) were two of the more important forb species. While rarely encountered in the sample plots, various orchid species characteristically occur in the spruce-fir forests. Fairy Slipper (*Calypso bulbosa*), rattlesnake plantain (*Goodyera oblongifolia*),

Table I-8. Summary of cover, percent frequency, density and importance values for the top five ranked shrub species in each of the spruce-fir woodland community study sites.

Species	Mean Cover (%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Density (No./ha)	Range of Density Values
Abies lasiocarpa	4.47	1.3-16.3	82.30	43.8-100.0	3320	1067-4141
Juniperus communis	<0.01	0-<0.1	1.05	0-6.3	3	0-16
Lonicera involucrata	0.07	0-0.2	30.05	0-70.0	430	0-1500
Picea engelmannii	0.97	0.5-1.7	54.02	40.0-73.3	658	216-1667
Ribes cereum	<0.01	0-<0.1	1.05	0-6.3	3	0-16
Ribes lacustre	0.25	0-1.3	10.00	0-40.0	382	0-1731
Ribes montigenum	0.15	0-0.6	18.33	0-80.0	156	0-766
Rosa woodsii	0.15	0-0.9	10.55	0-50.0	200	0-1067
Rubus parviflorus	0.78	0-4.7	10.00	0-60.0	1433	0-8600
Sambucus racemosa	0.05	0-0.3	1.67	0-10.0	17	0-100

Species	Mean Importance Values	Range of Importance Values	Presence (%)
Abies lasiocarpa	150.48	62.99-233.06	100.00
Juniperus communis	1.11	A-6.64	16.67
Lonicera involucrata	19.95	A-33.53	83.33
Picea engelmannii	61.66	19.66-79.93	100.00
Ribes cereum	1.11	A-6.64	16.67
Ribes lacustre	18.30	A-91.13	33.33
Ribes montigenum	13.77	A-62.92	50.00
Rosa woodsii	6.65	A-33.56	33.33
Rubus parviflorus	23.31	A-139.84	16.67
Sambucus racemosa	2.15	A-12.89	16.67

1978 study sites, KP-SF-1, ANT-SF-2, WAS-SF-3, DA-SF-4, and 1979 study sites SF-AS-10, SF-MS-10. A = absent.

Table I-9. Summary of mean cover, percent frequency, and importance values for the top ten ranked species in each of the spruce-fir community study sites.

Species	Mean Cover (%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Bromus porteri	<0.01	0-<0.1	15.62	0-40.0	2.50	A- 5.13	66.70
Bromus sp.	0.18	0-1.1	11.17	0-67.0	1.15	A- 6.90	16.67
Carex geyeri	1.43	0.2-4.5	57.67	33.0-100.0	16.53	2.89-45.11	100.00
FORBS							
Arnica cordifolia	1.50	0-2.9	48.12	0-87.0	11.09	A-21.28	83.30
Arnica longifolia	0.10	0-0.6	5.00	0-30.0	0.99	A- 5.91	16.67
Artemisia dracunculus	0.02	0-0.1	3.33	0-20.0	0.67	A- 4.00	16.67
Aster engelmannii	0.53	0-3.1	14.17	0-80.0	2.02	A-10.86	33.33
Cerastium sp.	0.08	0-0.5	6.67	0-40.0	1.10	A- 6.61	16.67
Cicuta douglasii	0.53	0-3.2	6.67	0-40.0	1.31	A- 7.85	16.67
Dugaldia hoopesii	0.17	0-0.8	13.33	0-50.0	2.53	A- 9.01	33.33
Epilobium angustifolium	0.28	0-1.3	12.17	0-40.0	1.80	A- 5.74	33.33
Epilobium sp.	0.05	0-0.3	3.33	0-20.0	0.89	A- 5.32	16.67
Erythronium grandiflorum	0.17	0-0.6	11.67	0-30.0	2.26	A- 7.63	50.00
Fragaria ovalis	0.88	0-2.5	29.50	0-50.0	6.56	A-15.37	83.30
Galium boreale	0.42	0-2.5	11.00	0-53.0	1.68	A- 7.85	33.30
Gaultheria humifusa	0.10	0-0.6	3.33	0-20.0	1.60	A- 9.61	16.67
Lathyrus leucanthus	0.53	0-2.1	13.33	0-40.0	3.33	A-13.72	33.33
Ligusticum porteri	0.82	0-4.9	13.33	0-80.0	4.96	A-29.75	16.67
Lupinus argenteus	0.17	0-1.0	6.67	0-40.0	1.48	A- 8.88	16.67
Osmorhiza obtusa	0.28	0-1.1	24.45	0-53.0	3.41	A- 8.67	83.33
Pedicularis racemosa	2.28	0-8.7	38.33	0-70.0	11.57	A-20.50	66.67
Pyrola secunda	0.33	0-1.6	10.12	0-40.0	3.88	A-14.88	66.67
Thlaspi montanum	0.08	0-0.5	6.67	0-40.0	1.10	A- 6.61	16.67
Vicia americana	0.25	0-1.0	6.67	0-20.0	1.60	A- 6.56	33.33

1978 study sites, KP-SF-1, ANT-SF-2, WAS-SF-3, DA-SF-4 and 1979 study sites SF-MS-10 and SF-AS-10. A = absent.

Table I-9. (contd.) Summary of top ten species in spruce-fir community 1978 and 1979.

Species	Mean Cover (%)	Range of Cover Values (%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Importance Values	Range of Importance Values	Presence (%)
WOODY SPECIES							
Abies lasiocarpa	2.30	0-13.5	43.88	0-93.0	15.59	A-60.0	83.33
Pachystima myrsinites	2.02	0.1-6.0	39.88	10.0-73.3	20.81	1.54-66.90	100.00
Ribes montigenum	0.08	0-0.5	1.12	0- 6.7	0.95	A- 5.72	16.67
Rubus parviflorus	0.87	0-5.2	6.67	0-40.0	1.80	A-10.79	16.67
Vaccinium myrtillus	9.57	1.5-21.6	67.88	30.0-90.0	40.69	24.79-72.22	100.00

species of coralroot (*Corallorhiza trifida* and *Corallorhiza maculata*), bog orchids (*Habenaria obtusata* and *Habenaria hyperborea*) and twayblade (*Listera cordata*) were all observed growing in the understory of spruce-fir forests.

Production estimates for spruce-fir forests are based on a single site in Red Lady Basin. Total production was approximately 151 lbs/acre (17 g/m^2) (Table I-10). Forbs accounted for 42 percent of the production and myrtle blueberry accounted for 54 percent of the total.

Logging and fire have both contributed to the ecology of the spruce-fir forests. Sampled stands in Washington Gulch and on Kebler Pass both showed signs of past logging. Large areas in Splains Gulch have been logged recently. Fires in the spruce-fir forests have helped create the complex mosaics involving subalpine meadows, spruce-fir forests, aspen woodlands, and lodgepole pine forests which are so common within the study area.

Subalpine Willow Thickets (Type 10). The subalpine willow thickets are characterized by low growing willows. They mostly occur above 9,000 feet (2,473 m) and extend upward into wet areas in the tundra meadows. This type covers approximately 920 acres (372 hectares); 0.65 percent of the study area. The willow thickets occur on wet hillsides and moist bottomlands with *Salix planifolia* and *Salix brachycarpa* occurring as dominant species. This type is usually bordered by wet sedge meadows or subalpine meadows. The herbaceous species in this type are usually those which are characteristic of the neighboring meadows. Western marsh marigold (*Caltha leptosepala*) is usually a common species. Some of the best developed subalpine willow thickets within the study area occur in Washington Gulch.

Wet Sedge Meadows (Type 3). Wet sedge meadows occur primarily in bottomlands along streams in the subalpine zone. In some instances they are associated with beaver ponds. They occupy approximately 504 acres (204 hectares); 0.36 percent

Table I-10. Mean production for Red Lady Basin stand SF-MS-10.

Species	Mean ± S.D. n = 10	Range
GRASSES AND SEDGES		
Calamagrostis sp.	0.025	0- 0.151
Carex geyeri (?)	0.177	0- 1.111
Carex sp.	0.465	0- 1.323
Unknown Grass	0.002	0- 0.019
Sub-Total	0.669 ± 0.469	0- 1.474
FORBS	7.131 ± 5.906	0.868- 16.379
WOODY SPECIES		
Vaccinium caespitosum	0.545	0- 5.453
Vaccinium myrtillus	8.629	0- 23.390
Sub-Total	9.175 ± 9.157	0- 25.592
TOTAL PRODUCTION	16.975 ± 12.031	4.029- 36.535

S. D. equals the standard deviation. Values in grams/m^2. n = sample size. 1979 data.

of the study area. The major species are sedges (*Carex* spp.). In a sampled stand of this type in Washington Gulch, a sedge species (*Carex* sp.) was the number one ranking species and had a mean cover of 56 percent. Other major species included Kentucky bluegrass (*Poa pratensis*) and common dandelion (*Taraxacum officinale*) (Table I-11). These meadows tend to be very lush and because of overlapping cover, the sum of individual species cover is in excess of 100 percent. At higher elevations, this type is closely associated with subalpine willow thickets.

Sphagnum-Sedge Bog (Type 4). The sphagnum-sedge bog type is unusual and is represented by one site in the entire study area. It cover approximately nine acres (four hectares); 0.01 percent of the area. The ground layer is almost completely covered by a species of sphagnum moss. Because of its botanical significance, this bog was studied in detail. Results of these studies are presented in a later section.

Lodgepole Pine Forests (Type 13). The lodgepole pine forests are not as abundant as the spruce-fir forests. They occur primarily on dry slopes and cover approximately 2,625 acres (1,063 hectares); 1.87 percent of the total study area. One of the largest stands in the area occurs in Coon Basin just northeast of Red Lady Basin. Two lodgepole pine forest stands were sampled. One was located below Ohio Pass in the Carbon Creek drainage and the second was immediately west of the Keystone Mine. The major tree species was lodgepole pine (*Pinus contorta*) which occurred at a mean density of 679 trees per acre (1,677 trees per hectare). Mean diameter ranged from 6.7 to 7.4 inches (17.1 to 18.9 cm). Other tree species which occur in the lodgepole pine forests include subalpine fir, Engelmann spruce and aspen. Subalpine fir was most prevalent and had a mean density of 81 trees per acre (200 trees per hectare). Langenheim (1962) discusses the lodgepole pine in

Table I-11. Summary statistics for herb layer species in Washington Gulch stand WAS-M-7.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
PERENNIAL GRASSES AND SEDGES							
Carex sp.	55.7	34.90	10-90	100	11.03	45.93	1
Deschampsia caespitosa	0.6	0.38	0-5	13	1.43	1.81	18
Phleum commutatum	2.7	1.69	0-15	33	3.64	5.33	12
Poa pratensis	38.7	24.25	10-75	100	11.03	35.28	2
Poa sp.	1.7	1.07	0-5	60	6.62	7.69	7
Sub-Total	99.4						
FORBS							
Achillea lanulosa	4.6	2.88	0-40	33	3.64	6.52	8
Bistorta bistortoides	2.7	1.74	0-18	33	3.64	5.38	11
Caltha leptosepala	4.7	2.94	0-50	20	2.21	5.15	13
Epilobium angustifolium	4.5	2.82	0-20	87	9.59	12.41	5
Erigeron sp.	0.3	0.19	0-4	7	0.77	0.96	19
Galium bifolium	<0.1	<0.01	0-<1	7	0.77	0.77	23
Geum macrophyllum	0.9	0.56	0-4	47	5.18	5.74	9
Polygonum sawatchense	0.1	0.06	0-1	7	0.77	0.83	20
Potentilla gracilis	3.3	2.07	0-30	20	2.21	4.28	14
Potentilla sp.	0.1	0.06	0-2	7	0.77	0.83	20
Ranunculus alismaefolius	7.3	4.57	0-20	73	8.05	12.62	4
Saxifraga oregona	3.0	1.88	0-45	7	0.77	2.65	16
Senecio dimorphophyllus	0.7	0.44	0-10	13	1.43	1.87	17
Stellaria sp.	0.7	0.44	0-5	33	3.64	4.08	15
Taraxacum officinale	11.9	7.46	0-80	80	8.82	16.28	3
Trifolium repens	12.4	7.77	0-65	27	2.98	10.75	6

Based on data from 15 1.0m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1978 data.

Table I-11. (contd.) Summary statistics for herb layer species in Washington Gulch stand WAS-M-7.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
FORBS							
Veronica peregrina	0.1	0.06	0-1	20	2.21	2.27	17
Unknown Cruciferae	0.7	0.44	0-4	33	3.64	4.08	14
Unknown Umbelliferae	0.1	0.06	0-2	7	0.77	0.83	20
Unknown Forb	2.1	1.32	0-15	40	4.41	5.73	10
Sub-Total	60.2						
Sum of Species Cover	159.60		119-260				
Total Cover in Herb Layer	97.80		95-100				
Litter Cover	100.00		100-100				

Table I-11. (contd.) Summary statistics for herb layer species in Washington Gulch stand WAS-M-7.

Number of Species per Square Meter	Mean	Range
Herb Species	9.00	4-14
Shrub Species	0.00	-----
Total Species	9.00	4-14

Additional Herbaceous Species: *Antennaria rosea, Aster sp., Bromus ciliatus, Cardamine cordifolia, Carex retrorsa, Castilleja sulphurea, Collomia linearis, Delphinium nelsonii, Dodecatheon pulchellum, Equisetum arvense, Festuca thurberi, Fragaria ovalis, Geum triflorum, Juncus arcticus, Pedicularis groenlandica, Rumex acetosella, Rumex sp., Veratrum californicum*

Additional Woody Species: *Pentaphylloides floribunda*

the Crested Butte area in conjunction with the burn replacement community types. The presence of spruce and fir trees in the lodgepole pine forests suggest that it may be successional. The lodgepole pine forests tend to occur on dry sites and are prone to fires. The stand next to the Keystone Mine burned in October 1979. The understory in the lodgepole pine forest is usually sparse. The most prevalent components in the shrub and sapling layer are saplings of the canopy components (Table I-12). In the sampled stands, saplings of subalpine fir had the highest mean cover, density and importance value.

The herb layer in the lodgepole pine forests is limited. Total cover is usually less than five percent. The most prevalent understory species was myrtle blueberry which had a mean cover of one percent. Pine needle litter forms a nearly continuous cover in these forests. Species composition (Table I-13) is similar to that found in the spruce-fir forests, however fewer species were encountered.

Douglas-fir Forests (Type 14). The Douglas-fir forests are widespread in the study area but are mostly outside the areas of anticipated impacts. This type is slightly more abundant than the lodgepole pine forests and covers 3,416 acres (1,383 hectares); 2.43 percent of the study area. The major species is Douglas-fir (*Pseudotsuga menziesii*). These forests occur on slopes above the East River and also occur on Flat Top Mountain above Alkali Basin. The understory in these forests is sparse. Common understory components include mountain lover, kinnikinnik (*Arctostaphylos uva-ursi*), elderberry, and red columbine (*Aquilegia elegantula*).

Aspen Woodlands (Type 15). Aspen woodlands are one of the most common vegetation types in the study area. In general they are a buffer between the higher elevation coniferous forests and the lower elevation big sagebrush

Table I-12. Summary of cover, percent frequency, density and importance values for the top five ranked shrub species in the lodgepole woodland community study sites.

Species	Mean Cover (%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Density (No./ha)	Range of Density Values
Abies lasiocarpa	3.05	0-6.1	30.00	0-60.0	800	0-1600
Lonicera involucrata	<0.01	0-<0.1	16.65	0-33.3	111	0-222
Picea engelmannii	0.10	0-0.2	15.00	0-30.0	133	0-266
Pinus contorta	0.45	0-0.9	10.00	0-20.0	67	0-133
Populus tremuloides	0.05	<0.1-0.1	35.00	0-60.0	50	0-66
Rosa woodsii	0.05	0-0.1	13.39	0-26.7	667	0-1333
Shepherdia canadensis	<0.01	0-<0.1	10.00	0-20.0	34	0-67
Symphoricarpos oreophilus	<0.01	0-<0.1	6.65	0-13.3	22	0-44

Species	Mean Importance Value	Range of Importance Values	Presence (%)
Abies lasiocarpa	110.91	A-221.82	50.0
Lonicera involucrata	14.13	A-28.25	50.0
Picea engelmannii	17.83	A-35.65	50.0
Pinus contorta	16.30	A-32.59	50.0
Populus tremuloides	28.84	9.93-47.75	100.0
Rosa woodsii	38.40	A-76.79	50.0
Shepherdia canadensis	13.84	A-13.84	50.0
Symphoricarpos oreophilus	4.60	A-9.20	50.0

1978 study site DA-LP-1 and 1979 study site LP-AS-9. A = absent.

Table I-13. Summary of mean cover, percent frequency, and importance value for the top ten ranked species for the lodgepole forest study sites.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Carex sp.	0.15	0-0.3	5.00	0-10.0	25.00	A-50.00	50.00
Calamagrostis scopulorum	<0.01	0-<C.1	10.00	0-20.0	12.50	A-25.00	50.00
FORBS							
Arenaria macrophyllum	0.05	0-0.1	6.65	0-13.3	3.19	A-6.37	50.00
Arnica cordifolia	0.40	0-0.8	16.65	0-33.3	13.83	A-27.65	50.00
Dugaldia hoopesii	0.40	0-0.8	30.00	0-60.0	18.08	A-36.16	50.00
Epilobium angustifolium	0.05	0-0.1	23.35	0-46.7	8.52	A-17.03	50.00
Pyrola secunda	<0.01	0-<0.1	10.00	0-20.0	3.19	A-6.38	50.00
Senecio serra	0.15	0-0.3	6.65	0-13.3	5.31	A-10.62	50.00
WOODY SPECIES							
Abies lasiocarpa	<0.01	0-<0.1	5.00	0-10.0	6.25	A-12.50	50.00
Pachystima myrsinites	0.25	0-0.5	6.65	0-13.3	7.44	A-14.88	50.00
Pinus contorta	0.05	0-0.1	5.00	0-10.0	12.50	A-25.00	50.00
Rosa woodsii	0.15	0-0.3	10.00	0-20.0	6.38	A-12.76	50.00
Vaccinium myrtillus	0.90	0.4-1.4	35.00	30.0-40.0	65.03	42.55-82.50	100.00

1978 study site DA-LP-1 and 1979 study site LP-AS-9. A = absent.

shrublands. The aspen woodlands cover approximately 19,723 acres (7,985 hectares); 14.04 percent of the total area. The one unifying characteristic of the aspen woodlands is the dominance by quaking aspen (*Populus tremuloides*). Mean density in the 11 sampled stands was 618 trees per acre (1,527 trees per hectare). Density is quite variable and ranged from 1,040 trees per acre (2,570 trees per hectare) in the densest stand to 248 trees per acre (613 trees per hectare) in the least dense stand. In general, the trees are smaller in the denser stands and larger in the less dense stands. The stand with 248 trees per acre occured in Anthracite Creek Valley, and contained the largest aspen trees measured in the study area. The stands in Anthracite Creek tend to have larger trees than the aspen stands in Alkali. Mean diameter for aspen ranged from 4.7 to 7.6 inches (12.0 to 19.3 cm). The only other tree species that was encountered in the aspen woodlands was subalpine fir which had a mean density of two trees per acre (four trees per hectare).

The shrub layer in the aspen can be quite diverse (Table I-14). Aspen saplings were the only shrub layer component that occurred in all the sampled stands. Wood's rose (*Rosa woodsii*) had the highest mean cover (4.2 percent) and mean density [5,182 individuals per acre (12,800 individuals per hectare)]. Mountain snowberry (*Symphoricarpos oreophilus*) was the only other shrub species that occurred in substantial numbers [1,060 individuals per acre (2,619 individuals per hectare)].

The herb layer in the aspen woodlands is characterized by numerous species (Table I-15). The three major herbaceous species were peavine, elk sedge, and Fendler meadowrue (*Thalictrum fendleri*). Of these three only Fendler meadowrue occurred in all the sampled stands. In terms of herbaceous understory, two distinct types of aspen woodlands occur within the study area. The aspen stands in Anthracite Creek and Washington Gulch are characterized by dense, tall forb

Table I-14. Summary of cover, percent frequency, density and importance values for the top five ranked shrub species in each of the aspen woodland community study sites.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Density (No./ha)	Range of Density Values
Abies lasiocarpa	0.02	0-0.3	9.72	0-20.0	40	0-133
Alnus tenuifolia	0.12	0-1.5	0.77	0-10.0	31	0-400
Amelanchier alnifolia	0.85	0-4.3	18.72	0-53.3	1455	0-3022
Lonicera involucrata	0.02	0-0.2	6.35	0-40.0	38	0-300
Picea engelmannii	0.02	0-0.3	1.80	0-10.0	6	0-33
Populus tremuloides	3.02	<0.1-9.7	82.47	50.0-100.0	1546	200-3700
Prunus virginiana	<0.01	0-<0.1	6.25	0-81.3	47	0-609
Ribes lacustre	0.01	0-0.1	3.08	0-20.0	26	0-167
Ribes montigenum	0.05	0-0.3	3.72	0-25.0	103	0-641
Ribes sp.	0.01	0-0.1	1.54	0-10.0	15	0-133
Rosa woodsii	4.19	0-19.5	43.75	0-100.0	12803	0-24567
Sambucus microbotrys ssp. *pubens*	0.22	0-0.7	9.68	0-40.0	312	0-1222
Sambucus racemosa	0.04	0-0.5	1.54	0-20.0	18	0-233
Symphoricarpos oreophilus	1.46	0-10.0	35.39	0-93.3	2619	0-20422

1978 study sites ALK-AW-1, ALK-AW-2, ANT-AW-3, ANT-AW-5, ANT-AW-6, WAS-AW-4, DA-AW-7, and 1979 study sites AW-AS-5, AW-AS-12, AW-MS-3, AW-MS-5, AW-AS-8, and AW-MS-8. A = absent.

Table I-14. (contd.) Summary of top five ranked shrub species in the aspen woodland community 1978 and 1979.

Species	Mean Importance Value	Range of Importance Values	Presence (%)
Abies lasiocarpa	8.69	A-37.64	69.23
Alnus tenuifolia	2.95	A-38.35	7.69
Amelanchier alnifolia	24.82	A-79.88	53.85
Lonicera involucrata	2.63	A-15.64	23.08
Picea engelmannii	2.55	A-29.25	23.08
Populus tremuloides	105.65	35.87-233.83	100.00
Prunus virginiana	1.72	A-22.30	7.69
Ribes lacustre	2.59	A-16.73	23.08
Ribes montigenum	1.87	A-10.29	23.08
Ribes sp.	3.82	A-46.03	15.38
Rosa woodsii	84.49	A-200.82	76.92
Sambucus microbotrys ssp. *pubens*	20.68	A-131.03	53.85
Sambucus racemosa	1.29	A-16.75	7.69
Symphoricarpos oreophilus	34.94	A-126.44	61.54

Table I-15. Summary of mean cover, percent frequency, and importance values for the top ten ranked species in each of the aspen woodland community study sites.

Species	Mean Cover (%)	Range of Cover Values (%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Bromus ciliatus	0.18	0-1.3	13.23	0-65.0	1.39	A-7.83	25.00
Bromus porteri	1.39	0-6.0	34.48	0-100.0	4.33	A-15.88	38.46
Carex geyeri	5.29	0-9.2	62.98	0-100.0	11.95	A-26.21	92.31
Elymus cinereus	0.35	0-3.9	9.75	0-66.7	1.23	A-11.15	15.38
Elymus sp.	0.68	0-4.3	16.46	0-87.0	2.08	A-13.68	23.08
FORBS							
Achillea lanulosa	1.35	0-7.5	31.07	0-93.0	4.69	A-16.09	76.92
Arenaria macrophylla	1.25	0-6.7	22.82	0-100.0	2.69	A-13.08	53.85
Arnica cordifolia	0.83	0-6.4	5.64	0-53.0	1.51	A-11.35	23.08
Aster sp.	0.52	0-4.3	8.69	0-73.3	1.30	A-9.88	15.38
Cicuta douglasii	1.26	0-16.3	8.77	0-100.0	1.38	A-16.98	23.08
Cirsium undulatum	0.61	0-3.4	14.23	0-70.0	2.16	A-12.76	38.46
Delphinium barbeyi	3.83	0-27.8	18.54	0-100.0	4.24	A-28.71	30.77
Dugaldia hoopesii	1.05	0-12.0	7.23	0-67.0	1.46	A-14.34	23.08
Erigeron speciosus	0.97	0-7.1	12.82	0-60.0	2.75	A-19.05	38.46
Erythronium grandiflorum	1.08	0-11.1	14.38	0-100.0	1.58	A-13.27	15.38
Fragaria ovalis	1.38	0-5.7	19.54	0-95.0	3.75	A-14.45	69.23
Galium bifolium	0.65	0-2.5	37.56	0-93.0	3.54	A-8.12	69.23
Galium boreale	1.44	0-3.8	57.48	0-100.0	6.37	A-15.36	76.92
Geranium richardsonii	2.25	0-12.8	34.00	0-100.0	4.41	A-18.87	53.85
Heracleum lanatum	5.14	0-27.7	20.59	0-87.0	5.43	A-27.71	38.46
Hydrophyllum capitatum	0.85	0-10.1	11.85	0-87.0	1.65	A-15.46	23.08
Hydrophyllum fendleri	2.56	0-18.7	19.44	0-100.0	3.21	A-21.63	30.77
Lathyrus leucanthus	10.42	0-26.7	63.12	0-100.0	20.60	A-65.65	84.62

1978 study sites ALK-AW-1, ALK-AW-2, ANT-AW-3, ANT-AW-5, ANT-AW-6, WAS-AW-4, DA-AW-7, and 1979 study sites AW-MS-3, AW-MS-5, AW-MS-8, AW-AS-5, AW-AS-8, and AW-AS-12. A = absent.

Table I-15. (contd.) Summary of top ten species in the aspen woodland community 1978 and 1979.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
Ligusticum porteri	4.67	0-18.6	33.28	0-93.3	7.79	A-33.07	53.85
Lomatium dissectum	0.42	0-5.2	9.77	0-93.0	1.42	A-15.61	23.08
Lupinus argenteus	1.18	0-12.6	15.75	0-100.0	3.11	A-28.27	46.15
Mertensia ciliata	0.54	0-6.7	8.69	0-100.0	1.01	A-12.29	15.38
Mertensia viridis	0.92	0-6.6	9.23	0-60.0	1.24	A-9.11	15.38
Osmorhiza obtusa	0.96	0-5.2	17.46	0-73.0	2.04	A-9.97	30.77
Pedicularis bracteosa	0.61	0-7.9	3.62	0-47.0	0.96	A-12.50	7.69
Senecio serra	0.28	0-3.7	3.85	0-50.0	0.88	A-11.45	7.69
Silene menziesii	0.34	0-4.4	5.64	0-73.3	0.84	A-10.95	7.69
Smilacina stellata	0.87	0-6.8	16.44	0-73.0	2.36	A-11.44	61.54
Taraxacum officinale	0.75	0-2.6	29.05	0-70.0	3.56	A-12.98	84.62
Thalictrum fendleri	5.28	0-13.7	55.36	0-86.7	10.74	A-18.09	100.00
Thlaspi montanum	0.81	0-4.1	26.42	0-90.0	2.91	A-15.50	53.85
Valeriana acutiloba	1.37	0-10.3	12.31	0-80.0	1.76	A-11.63	30.77
Vicia americana	2.76	0-8.5	57.15	0-95.0	8.40	A-20.42	76.92
Viola adunca	0.93	0-6.4	14.85	0-100.0	1.82	A-12.99	23.08
Viola nuttallii	1.04	0-6.1	26.66	0-93.3	3.02	A-16.44	38.46
WOODY SPECIES							
Pachystima myrsinites	0.45	0-3.1	8.18	0-53.0	1.20	A-7.73	23.08
Rosa woodsii	2.77	0-13.1	32.18	0-80.0	6.56	A-20.89	53.85
Symphoricarpos oreophilus	0.72	0-4.6	9.28	0-33.3	1.60	A-8.20	46.15

understories. In Alkali Basin the understory is characterized by low forbs [most notably peavine and American vetch (*Vicia americana*)], grasses and sedges. In this case, it appears that these differences may be related to the grazing history in these areas. The areas in Alkali Basin appear to have received a greater degree of grazing pressure than those in Anthracite Creek.

The aspen woodlands in the northern part of the study area and those near Gothic were studied by Morgan (1969). In addition to sampling sites near Gothic, he also sampled stands in Washington Gulch and Anthracite Creek. None of the sampled stands were located as low as those in Alkali Basin. The four major herb species which he reported for his study areas were the same as those determined by this study.

Production estimates for aspen woodland understory species in Alkali Basin were 682 lbs/acre (76.6 g/m^2) in 1978 (Table I-16) 648 lbs/acre (72.7 g/m^2) in 1979 (Table I-17). Forbs account for approximately 60 percent of the production. The most productive species in both years was peavine (*Lathyrus leucanthus*).

Morgan (1969) concluded that isolated aspen stands bordered by fescue grasslands and meadows were probably represented climax types, whereas those stands which were contiguous with spruce-fir forests probably were successional. The data which were collected as part of this study generally support his conclusions. Subalpine fir saplings were encountered in 69 percent and Engelmann spruce saplings were encountered in 23 percent of the sampled stands. Even though saplings were present they did not occur at high densities, even in apparent old-age stands. While the data appear to suggest eventual replacement of aspen by spruce-fir, it also appears that a considerable length of time will be required for the replacement to occur. In the study area it appears that aspen can become quite old (Table I-18). The data from aspen trees in Alkali Basin suggest that mature aspen woodlands may be as old as 90 years. If there are only a few

Table I-16. Summary of productivity data for Alkali Basin aspen woodland stands (ALK-AW-1 through ALK-AW-2).

Species	Mean ± S. D.	Range
PERENNIAL GRASSES AND SEDGES		
Bromus porteri	0.624	0-1.246
Carex geyeri	2.712	0-17.672
Carex spp.	8.836	0.204-5.220
Elymus sp.	0.474	0-0.946
Festuca thurberi	0.014	0-0.028
Poa pratensis	5.256	0-10.512
Stipa columbiana	0.926	0-1.852
Sub-Total	18.842 ± 23.256	
FORBS		
Achillea lanulosa	1.138	0-2.276
Arnica cordifolia	1.926	0-3.852
Frasera speciosa	2.178	0-4.356
Geranium richardsonii	0.360	0-0.720
Lathyrus leucanthus	21.518	14.686-28.350
Lomatium dissectum	1.266	0-2.532
Lupinus argenteus	2.822	1.044-4.600
Pedicularis grayi	1.942	0-3.884
Potentilla gracilis	0.212	0-0.422
Taraxacum officinale	0.416	0-0.830
Thalictrum fendleri	2.058	1.364-2.752
Vicia americana	5.202	4.464-5.940
Minor Forbs	2.858	1.378-4.338
Sub-Total	43.896 ± 18.056	
WOODY SPECIES		
Pachystima myrsinites	0.740	0-1.480
Rosa woodsii	12.878	11.928-13.826
Symphoricarpos oreophilus	0.302	0-0.604
Sub-Total	13.920 ± 1.962	
TOTAL PRODUCTION	76.658 ± 3.238	74.364-78.942

Values are mean production in grams/m^2 $\pm$ the standard deviation (S.D.) 1978 data.

Table I-17. Mean production ± the standard deviation (S.D.) for Alkali Basin stands AW-MS-3 and AW-MS-5.

Species	AW-MS-3 Mean ± S.D. n = 10	AW-MS-5 Mean ± S.D. n = 10	Sites AW-MS-3 and AW-MS-5 Combined Mean ± S.D. n = 20
GRASSES AND SEDGES			
Agropyron trachycaulum	1.514		0.757
Bromus porteri	0.534	0.262	0.398
Carex geyeri	42.096	0.796	21.446
Koeleria macrantha		0.062	0.031
Poa sp.	0.278	0.048	0.163
Sub-Total	44.422 ± 36.167	1.168 ± 1.404	22.795
FORBS			
Lathyrus leucanthus	22.914	36.074	29.494
Thalictrum fendleri	8.452	1.010	4.731
Vicia americana	6.948	3.720	5.334
Minor Forbs	8.422	6.246	7.334
Sub-Total	46.736 ± 14.419	47.050 ± 7.040	46.893
WOODY SPECIES			
Populus tremuloides		0.036	0.018
Prunus virginiana		1.068	0.534
Rosa woodsii	1.473	3.172	2.323
Sub-Total	1.473 ± 1.361	4.276 ± 5.187	2.875
TOTAL PRODUCTION	92.631 ± 28.262	52.494 ± 17.115	72.563 ± 30.677

Values in grams/m^2 ± the standard deviation (S.D.). n = sample size.

Table I-18. Summary of dendrochronological studies in stands ALK-AW-1, ALK-AW-2, and Keystone Bog.

Stand	Mean Annual Growth ± S. D. (mm.)	Range of Annual Growth (min→max)	Approximate Stand Age	Number of Trees Cored	Range of Years Measured
ALK-AW-1					
Populus tremuloides	1.079 ± 0.436	0.389-2.337	89	10	52-120
ALK-AW-2					
Populus tremuloides	0.937 ± 0.379	0.334-2.285	86	10	62-102
KEYSTONE BOG					
Pinus contorta					
In Bog	0.792 ± 0.482	0.221-2.454	140	8	81-253
Adjacent to Bog	2.190 ± 0.552	1.104-3.250	77	4	43- 96

S.D. equals the standard deviation. 1978 data.

conifer saplings at this stage of development, it is possible for a second generation of aspen to develop once the canopy trees begin to die. If no conifer seed source is readily available, aspen could continue as a dominant for long periods of time.

Riparian Willow Thicket (Type 23). The riparian willow thickets occur along drainages below 9,500 feet (2,895 m). This willow type differs from the subalpine willow thickets in species composition and size of the willows. The riparian willow communities are composed of willow species (*Salix* spp.) ranging up to 20 feet (six meters) tall. This type crosses several elevational zones and has been used to include willow shrublands along the major rivers as well as the linear riparian willow shrublands in the upper parts of Alkali and other similar basins. The type covers approximately 3,304 acres (1,338 hectares); 2.35 percent of the total study area. In Alkali Basin, the riparian willow thickets are utilized heavily by cattle. The thickets are close to streams (water supply), provide shade, and also provide scratching posts for the cattle. The soils are usually moist or wet, and consequently they become heavily trampled. Two alpine species can often be found in the herbaceous layer of the riparian willow thickets. Alpine meadowrue (*Thalictrum alpinum*) and bistort (*Bistorta vivipara*) both occur in the cool, shady, moist understory of willow thickets. Other herbaceous species in these areas include edible valerian (*Valeriana edulis*), iris (*Iris missouriensis*), elephantella (*Pedicularis groenlandica*) and Kentucky bluegrass.

Along the major drainages the riparian willow thickets grade into the cottonwood woodlands. Mixtures of the two types are common.

Moist Meadows (Type 1). The moist meadows occur mostly below 9,000 feet (2,743 m) elevation and tend to be naturally wet or moist. In some cases the meadows are associated with springs and seeps and in other instances may occur

in snowbank areas. Meadows may occur on flat bottomland areas or on gentle slopes. This type covers 209 acres (85 hectares); 0.15 percent of the total area. Common dandelion was the number one ranking species in a sampled stand of this type in Alkali Basin. The other major species were perennial grasses including Arizona fescue (*Festuca arizonica*), needlegrass species (including *Stipa lettermanii* and *Stipa pinetorum*) and Kentucky bluegrass (Table I-19).

Mean production was 2,147 lbs/acre (241 g/m^2) (Table I-20) in the moist meadow stand sampled in Alkali Basin. Most of the production (77 percent) was attributable to Arizona fescue.

The moist meadow type also includes several forb-dominated types which were not sampled. Mules ears (*Wyethia amplexicaulis*) forms dense stands in localized snowbank areas. Silvery lupine (*Lupinus argenteus*) can occur in almost pure stands in similar situations. Both types were mapped as moist meadows. False hellebore occurs in the moist meadow type to a limited extent.

Mountain Grasslands (Type 2). The mountain grasslands occur on sites which are similar to the moist meadow sites, except that they tend to be drier. The type is more widespread than the moist meadows and covers 3,433 acres (1,390 hectares); 2.44 percent of the area. Two mountain grassland stands were sampled in Anthracite Creek and Washington Gulch. The dominant species were Thurber's fescue (*Festuca thurberi*) and fringed brome (*Bromus ciliatus*). Thurber's fescue had a mean cover of 24 percent and the highest importance value. Mean values for fringed brome were approximately half of those measured for Thurber's fescue. Peavine was the most prevalent forb species and ranked third. Showy fleabane (*Erigeron speciosus*) was also a conspicuous component of the mountain grasslands. In some areas the mountain grasslands include a limited shrub component. Big sagebrush (*Artemisia tridentata*) and Rothrock sagebrush (*Artemisia rothrockii*) may both occur. Neither of these species was encountered in stands which were sampled (Table I-21).

Table I-19. Summary statistics for herb layer species in Alkali Basin stand ALK-M-1.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
PERENNIAL GRASSES AND SEDGES							
Agropyron smithii	1.1	1.39	0-7	27	2.13	3.52	17
Carex spp.	2.2	2.79	0-18	13	1.03	3.82	15
Festuca arizonica	17.1	21.67	0-35	93	7.34	29.01	2
Festuca thurberi	1.2	1.52	0-15	13	1.03	2.55	18
Juncus arcticus ssp. ater	1.2	1.52	0-10	27	2.13	3.65	16
Poa pratensis	7.6	9.63	0-35	40	3.16	12.79	4
Sitanion longifolium	1.7	2.15	0-18	47	3.71	5.86	13
Stipa spp.	5.1	6.46	0-20	93	7.34	13.80	3
Sub-Total	37.2						
FORBS							
Achillea lanulosa	0.8	1.01	0-2	80	6.31	7.32	10
Allium geyeri	0.1	0.13	0-1	13	1.03	1.16	23
Arabis drummondii	0.1	0.13	0-2	20	1.58	1.71	20
Arenaria fendleri	0.1	0.13	0-1	20	1.58	1.71	20
Aster laevis	1.5	1.90	0-8	87	6.87	8.77	7
Chenopdium album	<0.1	<0.01	0-<1	7	0.55	0.55	27
Collomia linearis	<0.1	<0.01	0-<1	27	2.13	2.13	19
Delphinium nelsonii	2.5	3.17	0-15	47	3.71	6.88	11
Erigeron pumilus	0.7	0.89	0-10	7	0.55	1.44	22
Gayophytum ramosissimum	0.2	0.25	0-1	93	7.34	7.59	9
Mertensia viridis	1.3	1.65	0-10	47	3.71	5.36	14
Microseris nutans	1.5	1.90	0-8	60	4.74	6.64	12
Polygonum sawatchense	0.9	1.14	0-4	93	7.34	8.48	8
Potentilla gracilis	2.8	3.55	0-15	67	5.29	8.84	6

Based on data from 15 1.0m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1978 data.

Table I-19. (contd.) Summary statistics for herb layer species in Alkali Basin stand ALK-M-1.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
FORBS							
Ranunculus alismaefolius	0.1	0.13	0-1	13	1.03	1.16	23
Senecio sp.	3.5	4.44	1-8	100	7.89	12.33	5
Taraxacum officinale	25.5	32.32	8-54	100	7.89	40.21	1
Viguiera multiflora	0.1	0.13	0-2	13	1.03	1.16	23
Unknown Boraginaceae	<0.1	<0.01	0-<1	7	0.55	0.55	27
Unknown Cruciferae	<0.1	<0.01	0-<1	13	1.03	1.03	26
Sub-Total	41.7						
Sum of Species Cover	78.90		58-116				
Total Cover in Herb Layer	68.00		55-85				
Litter Cover	78.87		55-95				
Bare Soil Cover	21.07		5-45				

Table I-19. (contd.) Summary statistics for herb layer species in Alkali Basin stand ALK-M-1.

Number of Species per Square Meter	Mean	Range
Herb Species	12.73	9-17
Shrub Species	0.00	----
Total Species	12.73	9-17

Additional Herbaceous Species: *Geum triflorum, Iris missouriensis, Potentilla diversifolia, Veratrum tenuipetalum, Wyethia arizonica*

Table I-20. Mean production for Alkali Basin stand ALK-M-1.

Species	Mean ± S. D. n = 5	Range (per 0.25m^2)
PERENNIAL GRASSES AND SEDGES		
Festuca arizonica	185.564	28.791-78.523
Juncus arcticus	10.272	0-7.747
Phleum pratensis	1.124	0-1.403
Stipa columbiana	1.592	0-1.679
Stipa lettermanii	0.540	0-0.366
Sub-Total	199.092 ± 67.327	
ANNUAL FORBS	0.136	0-0.117
PERENNIAL FORBS	42.032	7.046-11.042
Sub-Total	42.168 ± 18.099	
TOTAL PRODUCTION	241.260 ± 58.051	50.986-86.024

S. D. equals the standard deviaiton.
Values in grams/m^2. 1978 data. n = sample size.

Table I-21. Summary of mean cover, percent frequency, and importance values for the top ten ranked species in each of the mountain grassland 1978 study sites ANT-M-4 and WAS-M-6.

Species	Mean Cover (%)	Range of Cover Values (%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Bromus ciliatus	11.25	3.1-19.4	86.50	73.0-100.0	17.65	9.21-26.09	100.00
Festuca thurberi	24.25	9.0-39.5	76.50	53.0-100.0	34.11	12.51-55.71	100.00
Poa pratensis	3.65	0-7.3	16.50	0-33.0	4.76	A-9.52	50.00
FORBS							
Achillea lanulosa	3.65	0.6-6.7	56.50	20.0-93.0	7.45	2.21-12.69	100.00
Agoseris glauca	3.65	0-7.3	40.00	0-80.0	7.43	A-14.86	50.00
Chenopodium album	0.45	<0.1-0.9	73.50	60.0-87.0	5.43	4.45-6.41	100.00
Collomia linearis	0.05	0-0.1	40.00	0-80.0	3.03	A-6.06	50.00
Delphinium nelsonii	0.06	0.3-0.9	47.00	27.0-67.0	4.04	2.01-6.07	100.00
Erigeron speciosus	4.75	0-9.5	36.50	0-73.0	7.14	0-14.28	50.00
Lathyrus leucanthus	9.70	1.7-17.7	56.50	13.0-100.0	13.70	3.05-24.35	100.00
Mertensia viridus	0.55	0.4-0.7	73.50	60.0-87.0	5.57	4.94-6.20	100.00
Polygonum sawatchense	0.40	0.1-0.7	86.50	80.0-93.0	6.39	5.75-7.02	100.00
Potentilla gracilis	2.90	0.3-5.5	37.00	7.0-67.0	6.22	0.75-11.69	100.00
Rudbeckia montanum	2.25	0-4.5	36.50	0-73.3	4.60	A-9.19	50.00
Taraxacum officinale	2.75	0.5-5.0	56.50	20.0-93.0	7.39	1.77-13.01	100.00
Vicia americana	1.45	0-2.9	30.00	0-60.0	3.37	A-6.74	50.00
Viola nuttallii	2.40	0.3-4.5	53.50	27.0-80.0	6.73	2.01-11.44	100.00

A = absent.

Big Sagebrush Shrublands (Type 9). The big sagebrush shrublands are the most extensive and widespread vegetation type within the study area. This type covers 50,626 acres (20,496 hectares); 36.03 percent of the total area. Sagebrush shrublands occur throughout the entire area, but are more abundant in the southern part of the study area. Extensive areas of sagebrush occur in and around Alkali Basin. Sagebrush shrublands are nearly continuous from the mouth of Alkali Basin westward over the divide between the Ohio Creek and East River drainages to the Ohio Creek drainage. The sagebrush continues southward and is the dominant vegetation type on the south side of Flat Top Mountain. It extends to the southern boundary of the study area. Northwards the sagebrush extends up into the Carbon Creek drainage and eventually decreases in abundance as the aspen woodlands increase. In Alkali Basin, sagebrush dominates most of the northern (south facing) side of the Basin and only on the southern side is there a significant development of other vegetation types. In this area, sagebrush shrublands occur on slopes ranging from gentle to steep and on all exposures. They occur on flat bottomland areas as well as ridge crests.

Even though these extensive sagebrush areas appear to be homogeneous, a closer examination reveals subtle differences. Sagebrush on north-facing slopes tend to be larger and occur at higher densities. Stands on ridges have a larger component of Rothrock sagebrush and horsebrush (*Tetradymia canescens*). Stands on floodplains may have larger components of silver sagebrush (*Artemisia cana*).

Because of the importance and extent of this type within the study area, more stands of this type were sampled than for any other type (Figure I-4). Twenty-one stands were sampled in Alkali Basin, on the Almont Triangle, on the south side of Flat Top and on the Ohio Creek side of the Alkali Basin area. Big sagebrush was the number one ranking shrub species in all of the sampled

Figure I-4. Big sagebrush shrublands in Alkali Basin. The people are setting out decomposition packets.

stands. Mean cover for big sagebrush was 23 percent and ranged from 9.7 to 41.7 percent. Sagebrush occurred in all of the sample plots in all of the stands. Mean density was 11,406 individuals per acre (28,173 individuals per hectare; 2.8 individuals per square meter). Density ranged from 5,119 to 30,380 individuals per acre (12,644 to 75,039 individuals per hectare). Douglas rabbitbrush (*Chrysothamnus viscidiflorus*) was the second most prevalent species followed by mountain snowberry (Table I-22).

The herb layer of the sagebrush shrublands is more variable than the shrub layer. In the analysis of top ranking species, 64 species occurred within the top ten species in at least one of the stands (Table I-23). Since big sagebrush is usually less than three feet (one meter) tall, it was included in the herb quadrat analysis. As in the shrub layer, big sagebrush had the highest mean importance value. The most prevalent herbaceous species were muttongrass (*Poa fendleriana*), western wheatgrass (*Agropyron smithii*), and prairie junegrass (*Koeleria macrantha*). Thurber's fescue and Idaho fescue (*Festuca idahoensis*) occur as dominants mostly on north facing stands. Muttongrass and the various needlegrasses (*Stipa* spp.) are more inclined to dominate on the drier sites.

Production data were collected in the big sagebrush shrublands during 1978 and 1979 (Tables I-24, I-25, and I-26). Mean total production ranged from 1,194 lbs/acre (134 g/m^2) in Alkali Basin in 1978 to 1,336 lbs/acre (150 g/m^2) in 1979. In 1978, perennial grasses and sedges accounted for 17 percent of the total production, and big sagebrush accounted for 42 percent of the total. In 1979 perennial grasses and sedges accounted for 12 percent of the total and big sagebrush accounted for 70 percent of the total. These differences reflect differences in the areas sampled. On the south side of Flat Top Mountain, an important big game wintering area, mean production was 1,042 lbs/acre (117 g/m^2) in 1979. Of the total production, big sagebrush

Table I-22. Summary of cover, percent frequency, density, importance values for the top three ranked shrub species in each of the big sagebrush shrubland community study sites.

Species	Mean Cover (%)	Range of Cover Values (%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Density (No./ha)	Range of Density Values
Artemisia tridentata	23.34	9.7-41.7	100.00	100.0-100.0	28173	12644-75039
Ceratoides lanata	0.10	0-2.0	3.87	0-81.3	889	0-18672
Chrysothamnus parryi	0.26	0-1.3	33.43	0-80.0	710	0-2266
Chrysothamnus viscidiflorus	3.00	<0.1-18.2	88.29	13.3-100.0	10584	133-108281
Purshia tridentata	0.40	0-7.1	6.67	0-86.7	222	0-4333
Symphoricarpos oreophilus	1.42	<0.1-10.8	75.51	12.5-100.0	3188	156-19063
Tetradymia canescens	0.34	0-1.9	33.21	0-100.0	2460	0-24023

Species	Mean Importance Value	Range of Importance Values	Presence (%)
Artemisia tridentata	172.69	102.81-226.59	100.00
Ceratoides lanata	2.32	A-48.80	4.76
Chrysothamnus parryi	12.25	A-28.56	76.19
Chrysothamnus viscidiflorus	49.34	5.74-125.23	100.00
Purshia tridentata	3.86	A-63.69	9.52
Symphoricarpos oreophilus	31.34	3.08-83.12	100.00
Tetradymia canescens	12.30	A-57.45	57.14

1978 study sites ALK-SB-1 through ALK-SB-9 and 1979 study sites SB-AS-1 through SB-AS-4, SB-AS-6, SB-AS-7, SB-AS-11, SB-MS-1, SB-MS-2, SB-MS-4, SB-MS-6, and SB-MS-7. A = absent.

Table I-23. Summary of mean cover, percent frequency, and importance values for the top ten ranked species in each of the big sagebrush community study sites.

Species	Mean Cover (%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Agropyron smithii (all varieties)	0.80	0-2.5	49.24	0-95.0	5.28	A-21.89	90.48
Aristida fendleriana	0.08	0-1.3	4.14	0-60.0	0.43	A- 6.50	9.52
Bouteloua gracilis	0.11	0-2.3	2.86	0-53.3	0.53	A-10.56	9.52
Bromus ciliatus	0.04	0-0.9	3.19	0-60.0	0.29	A- 5.56	9.52
Carex rossii	0.39	0-4.1	13.03	0-87.0	1.50	A-10.77	19.05
Carex sp.	1.15	0-5.4	29.27	0-100.0	4.18	A-20.65	47.62
Festuca idahoensis	0.79	0-5.8	25.13	0-90.0	2.81	A-14.85	47.62
Festuca thurberi	1.18	0-7.3	8.89	0-40.0	2.42	A-13.16	47.62
Koeleria macrantha	0.97	0-3.9	48.80	0-93.0	4.77	A-11.76	90.48
Oryzopsis hymenoides	0.14	0-0.9	6.20	0-66.7	0.89	A- 7.83	19.05
Poa fendleriana	3.11	0-8.7	47.63	0-100.0	8.69	A-24.29	76.19
Poa pratensis	0.90	0-9.1	14.08	0-87.0	2.25	A-15.59	38.10
Sitanion longifolium	0.44	0-1.5	34.78	0-93.0	3.70	A- 8.49	95.24
Stipa columbiana	0.28	0-2.0	12.92	0-86.7	1.57	A- 8.04	42.86
Stipa comata	0.50	0-9.5	6.98	0-73.3	1.63	A-28.87	19.05
Stipa pinetorum	0.10	0-1.4	5.40	0-67.0	0.54	A- 6.49	19.05
Stipa sp.	0.21	0-1.9	10.63	0-60.0	1.11	A- 6.94	38.10
FORBS							
Allium geyeri	0.09	0-0.9	12.65	0-93.0	0.92	A- 6.31	28.57
Anaphalis margaritacea	0.51	0-10.8	4.52	0-95.0	0.89	A-18.77	4.76
Antennaria rosea	0.11	0-1.0	5.73	0-53.3	0.53	A- 5.57	23.81
Arenaria fendleri	0.97	0-6.9	16.49	0-100.0	2.58	A-17.57	28.57
Astragalus anisus	0.02	0-0.5	2.62	0-55.0	0.32	A- 6.79	4.76
Astragalus drummondii	0.25	0-1.8	8.10	0-40.0	1.17	A- 7.99	38.10
Astragalus miser	0.61	0-4.3	20.48	0-67.0	2.42	A-10.09	61.90

1978 study sites ALK-SB-1 through ALK-SB-9 and for 1979 study sites SB-AS-1 through SB-AS-4, SB-AS-6, SB-AS-7, SB-AS-11, SB-MS-1, SB-MS-2, SB-MS-4, SB-MS-6, and SB-MS-7. A = absent.

Table I-23. (contd.) Summary of top ten ranked species in the big sgaebrush community 1978 and 1979.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
Astragalus pattersonii	0.10	0-2.0	3.18	0-66.7	0.48	A-10.02	4.76
Castilleja linariaefolia	0.40	0-1.5	26.18	0-87.0	2.54	A- 7.84	76.19
Chenopodium album	0.03	0-0.2	18.40	0-86.7	1.55	A- 5.36	66.67
Crepis occidentalis	0.13	0-1.6	7.39	0-66.7	0.86	A- 7.36	19.05
Epilobium paniculatum	0.20	0-2.7	8.26	0-86.7	1.18	A-14.84	14.29
Erigeron pumilus	0.35	0-2.3	29.76	0-93.0	2.68	A- 8.97	61.90
Erigeron speciosus	0.78	0-4.8	17.58	0-87.0	2.54	A-12.53	61.90
Erigeron sp.	0.19	0-0.8	11.71	0-47.0	1.19	A- 5.15	52.38
Eriogonum umbellatum	1.04	0-6.3	20.09	0-73.0	3.24	A-14.05	76.19
Gayophytum ramosissimum	0.30	0-4.8	9.11	0-86.7	1.15	A-12.71	33.33
Heuchera parviflora	0.21	0-2.2	10.86	0-95.0	0.82	A- 7.49	23.81
Lathyrus leucanthus	1.57	0-10.4	20.48	0-80.0	3.95	A-20.58	57.14
Lupinus argenteus	0.97	0-7.0	21.78	0-67.0	3.36	A-19.96	71.43
Mertensia fusiformis	0.09	0-0.6	11.59	0-60.0	1.02	A- 6.85	38.10
Mertensia viridus	0.49	0-2.7	23.48	0-93.0	2.08	A- 7.65	42.86
Orthocarpus luteus	0.29	0-5.9	6.13	0-80.0	0.82	A-14.18	19.05
Oxytropis sp.	0.14	0-2.7	2.86	0-53.0	0.42	A- 8.11	9.52
Penstemon teucrioides	0.43	0-2.1	26.52	0-95.0	2.61	A-10.26	80.95
Phlox hoodii	0.36	0-5.0	9.84	0-100.0	1.82	A-22.39	14.29
Phlox multiflora	0.97	0-11.1	12.14	0-100.0	2.26	A-19.17	14.29
Polygonum aviculare	0.12	0-2.5	4.44	0-93.3	0.44	A- 9.22	4.76
Polygonum sawatchense	0.10	0-1.1	18.20	0-100.0	1.68	A-10.72	61.90
Potentilla diversifolia	0.20	0-1.4	13.62	0-73.0	1.26	A- 6.95	33.33
Potentilla drummondii	0.10	0-2.1	3.81	0-8.53	0.41	A- 8.53	4.76
Potentilla hippiana	0.10	0-1.1	7.06	0-60.0	0.72	A- 7.10	23.81
Pulsatilla patens	0.27	0-5.7	3.81	0-80.0	0.54	A-11.35	4.76
Taraxacum officinale	0.63	0-4.3	34.16	0-93.0	3.38	A-12.87	90.48
Trifolium gymnocarpon	0.13	0-2.1	8.01	0-85.0	0.86	A- 9.61	19.05
Vicia americana	0.90	0-4.1	24.99	0-73.0	3.14	A- 8.63	71.43
Wyethia arizonica	0.59	0-6.1	10.09	0-53.3	1.88	A-15.66	33.33

Table I-23. (contd.) Summary of top ten ranked species in the big sagebrush community 1978 and 1979.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values (%)	Mean Importance Values	Range of Importance Values	Presence (%)
SEMI-SHRUBS							
Ceratoides lanata	0.06	0-1.3	1.67	0-35.0	0.32	A- 6.73	4.76
Gutierrezia sarothrae	0.51	0-4.7	7.70	0-75.0	2.10	A-19.13	19.05
Leptodactylon pungens	0.04	0-0.9	1.59	0-33.3	0.26	A- 5.39	4.76
WOODY SPECIES							
Artemisia tridentata	20.32	10.3-29.9	96.00	80.0-100.0	45.37	17.88-78.71	100.00
Chrysothamnus parryi	0.44	0-2.0	10.25	0-33.3	1.44	A- 5.43	61.90
Chrysothamnus viscidiflorus	1.96	0-5.8	47.99	0-95.0	7.23	A-18.88	95.24
Mahonia repens	0.13	0-1.8	4.73	0-46.7	0.61	A- 7.70	38.10
Purshia tridentata	0.22	0-4.2	2.54	0-46.7	0.75	A-14.20	9.52
Symphoricarpos oreophilus	1.84	0-10.0	27.40	0-80.0	5.15	A-24.95	85.71
Tetradymia canescens	0.33	0-1.9	11.80	0-65.0	1.71	A-11.24	52.38

Table I-24. Summary of productivity data for Alkali Basin sagebrush stands (ALK-SB-1 through ALK-SB-9).

Species	Mean ± S. D.	Range
PERENNIAL GRASSES AND SEDGES		
Agropyron smithii	0.619	0.012-1.634
Agropyron spicatum	0.017	0-0.099
Agrostis alba	0.053	0-0.478
Bromus porteri	0.040	0-0.333
Bromus richardsonii	0.001	0-0.011
Carex spp.	2.694	0-6.918
Festuca arizonica	0.770	0-6.211
Festuca idahoensis	2.330	0-10.711
Festuca thurberi	1.164	0-2.997
Juncus arcticus	0.101	0-0.912
Koeleria macrantha	2.014	0.163-4.405
Poa fendleriana	4.745	0.204-10.261
Poa pratensis	2.284	0-18.322
Poa sp.	0.079	0-0.600
Sitanion longifolium	2.558	0-7.856
Stipa columbiana	0.695	0-4.083
Stipa comata	0.280	0-2.520
Stipa lettermanii	2.131	0-5.915
Sub-Total	22.575 ± 9.794	
ANNUAL FORBS	0.263	0-1.415
PERENNIAL FORBS	41.390	19.114-65.075
Sub-Total	41.653 ± 12.836	
SEMI-SHRUBS		
Artemisia frigida	1.406 ± 4.154	0-12.483
WOODY SPECIES		
Amelanchier sp.	0.046	0-0.412
Artemisia cana	2.140	0-19.264
Artemisia tridentata	55.917	21.630-111.321
Chrysothamnus parryi	0.900	0-4.149
Chrysothamnus viscidiflorus	5.774	0-16.826

Values are mean production in grams/m^2 ± the standard deviation (S.D.). 1978 data.

Table I-24. (contd.) Summary of productivity data for Alkali Basin sagebrush stands (ALK-SB-1 through ALK-SB-9).

Species	Mean ± S. D.	Range
WOODY SPECIES		
Mahonia repens	0.011	0-0.097
Rosa woodsii	0.406	0-3.658
Symphoricarpos oreophilus	2.141	0-7.762
Tetradymia canescens	0.953	0-3.998
Sub-Total	68.288 ± 27.695	
TOTAL PRODUCTION	133.922 ± 30.192	70.844-160.962

Table I-25. Mean production for Alkali Basin stands SB-MS-1, SB-MS-2, SB-MS-4, and SB-MS-6.

Species	SB-MS-1 Mean ± S.D. n = 10	SB-MS-2 Mean ± S.D. n = 10	SB-MS-4 Mean ± S.D. n = 10	SB-MS-6 Mean ± S.D. n = 10	All Sites Combined Mean ± S.D. n = 40
GRASSES AND SEDGES					
Agropyron smithii	0.631	0.053	0.320	2.221	0.806
Bromus ciliatus		0.144			0.036
Carex spp.	5.168	1.593	2.059	0.339	2.290
Festuca arizonica		4.205	4.119	3.371	2.924
Festuca idahoensis		1.834			0.459
Festuca thurberi		8.490			2.123
Juncus arcticus	0.086				0.022
Koeleria macrantha	2.708	1.238	0.222	2.922	1.773
Muhlenbergia sp.		0.598			0.150
Oryzopsis hymenoides	0.008				0.002
Poa fendleriana		1.383	12.745	6.500	5.157
Poa pratensis		0.244		0.354	0.150
Poa sp.		0.258			0.065
Sitanion longifolium		0.267	1.129	0.138	0.384
Stipa columbiana	0.062	0.140			0.051
Stipa lettermannii	0.997	1.177	0.726	0.577	0.869
Sub-Total	9.660 ± 4.109	21.624 ± 16.201	21.320 ± 7.041	16.422 ± 12.545	17.261

S.D. equals the standard deviation. Values in grams/m^2. 1979 data. n = sample size.

Table I-25. (contd.) Mean production for Alkali Basin stands SB-MS-1, SB-MS-2, SB-MS-4, and SB-MS-6.

Species	SB-MS-1 Mean ± S.D. n = 10	SB-MS-2 Mean ± S.D. n = 10	SB-MS-4 Mean ± S.D. n = 10	SB-MS-6 Mean ± S.D. n = 10	All Sites Combined Mean ± S.D. n = 40
FORBS	13.947 ± 6.641	30.586 ± 13.629	19.607 ± 12.278	18.572 ± 14.617	20.678
SEMI-SHRUBS					
Artemisia frigida	0.094			0.044	0.035
Gutierrezia sarothrae		0.016			0.004
Sub-Total	0.094 ± 0.237	0.016 ± 0.051		0.044 ± 0.108	0.039
WOODY SPECIES					
Artemisia tridentata	170.572	61.582	87.468	100.963	105.146
Chrysothamnus parryi	0.996			0.548	0.386
Chrysothamnus viscidiflorus	6.116	7.296	1.837	1.047	4.074
Mahonia repens			0.363		0.091
Pentaphylloides floribunda		0.016			0.004
Prunus virginiana		1.541			0.385
Rosa woodsii		0.548			0.137
Symphoricarpos oreophilus	0.345	2.908	0.171	0.207	0.908
Tetradymia canescens	1.657		0.740	1.297	0.924
Sub-Total	179.686 ± 65.045	73.891 ± 28.679	90.579 ± 37.120	104.062 ± 48.037	112.055
TOTAL PRODUCTION	203.387 ± 65.607	126.117 ± 35.355	131.506 ± 34.896	139.100 ± 46.023	150.033 ± 55.198

Table I-26. Mean production for the south flank of Flat Top Mountain stand SB-MS-7.

Species	Mean ± S.D. n = 10	Range
GRASSES AND SEDGES		
Agropyron smithii	2.916	0- 4.962
Carex sp.	1.001	0- 10.008
Koeleria macrantha	0.152	0- 1.516
Oryzopsis hymenoides	1.005	0- 5.099
Sitanion longifolium	1.396	0.178- 3.025
Stipa lettermanii	1.539	0- 4.166
Sub-Total	8.008 ± 4.864	2.138- 18.680
FORBS	2.116 ± 1.194	0.574- 3.739
SEMI-SHRUBS		
Artemisia frigida	0.275	0- 1.496
Gutierrezia sarothrae	10.229	0- 37.622
Sub-Total	10.504 ± 11.724	0- 37.622
WOODY SPECIES		
Amelanchier alnifolia	0.993	0- 9.926
Artemisia tridentata	87.833	22.055-152.430
Chrysothamnus viscidiflorus	1.431	0- 12.482
Symphoricarpos oreophilus	0.938	0- 9.376
Tetradymia canescens	5.036	0- 15.992
Sub-Total	96.231 ± 33.725	45.100-152.430
TOTAL PRODUCTION	116.859 ± 32.990	77.917-147.303

S. D. equals the standard deviation. Values in grams/m^2. 1979 data. n = sample size.

accounted for 76 percent and perennial grasses and sedges accounted for only seven percent.

Cottonwood Woodlands (Type 11). The cottonwood woodlands are a deciduous forest type which occur along the major drainages like East River and Ohio Creek. The type is restricted and covers 1,273 acres (515 hectares); 0.91 percent of the total area. The major species in this type is narrow-leaf cottonwood (*Populus angustifolia*). Occasionally, Colorado blue spruce (*Picea pungens*) occurs as a secondary dominant. As mentioned above, this type tends to intergrade with the riparian willow thickets.

Ponderosa Pine Forests (Type 12). The ponderosa pine forests are the most limited vegetation type in the study area. The only place they occur is on the Almont Triangle where they are restricted to one or two small stands. The total areal extent of this type is two acres (one hectare); less than 0.01 percent of the study area. The dominant species is ponderosa pine (*Pinus ponderosa*). This type is more abundant in other parts of Colorado.

Juniper Woodlands (Type 25). The juniper woodlands are limited in extent and occur at the southern edge of the study area. They occur on dry rocky slopes and cover approximately 18 acres (seven hectares); 0.01 percent of the total area. The dominant species is Rocky Mountain red cedar (*Juniperus scopulorum*). The juniper woodland type, in its various phases, is a type characteristic of the semiarid parts of the state and barely extends into the Mount Emmons Project study area.

Hay Meadows and Pastures (Type 17). The hay meadow and pasture type occurs within the study area as a result of agricultural activity. This type is composed of irrigated fields which occur mainly along the major drainages. Extensive meadows and pastures can be seen in the Ohio Creek Valley and the

East River Valley. This type covers approximately 15,685 acres (6,350 hectares); 11.16 percent of the study area.

The hay meadow and pasture type occurs to a limited extent in Alkali Basin. A network of ditches are used to irrigate the broad, flat portions of the basin bottom. European pasture grasses, like timothy (*Phleum pratense*) and red top (*Agrostis alba*), were seeded into these areas. Flood irrigation over the years has favored baltic rush (*Juncus arcticus* spp. *ater*); one of the dominant species in the Alkali Basin irrigated pastures. The areas in Alkali Basin no longer are cut for hay, but rather are used as irrigated pastures.

Two pasture stands were sampled in Alkali Basin in 1978 (Table I-27). The major species were baltic rush, Kentucky bluegrass, and common dandelion. Sedges (*Carex* spp.) also are important in these pastures. Irrigation makes these areas more productive. Mean production was 3,990 lbs/acre (448 g/m^2) in stand ALK-M-2 (Table I-28) and was 5,362 lbs/acre (602 g/m^2) in stand ALK-M-3 (Table I-29). In both stands most of the production was provided by baltic rush, a species of low palatability for livestock.

Sparsely Vegetated Areas (Type 8). The sparsely vegetated areas constitute a heterogeneous group of mapped units. The single factor that these areas have in common is that they support little vegetation. Areas mapped as sparsely vegetated extend from alpine areas down into the zone dominated by big sagebrush. The type includes approximately 1,390 acres (563 hectares); 0.99 percent of the total area. In the alpine, this type includes scree slopes and sparsely vegetated talus slopes. Dominant species could include *Ligularia soldanella* and various species of saxifrage (*Saxifraga* spp.). These areas have slightly more vegetation than the areas mapped as talus slopes and rock outcrops.

At lower elevations [below 8,400 feet (2,560 m)] this type includes some of the barren, rocky areas on the Almont Triangle. In these areas the only

Table I-27. Summary of mean cover, percent frequency, and importance values for the top ten ranked species in each of the hay meadow/pasture 1978 study sites ALK-M-2 and ALK-M-3.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Agropyron desertorum	4.35	0-8.7	50.00	0-100.0	14.71	A-29.42	50.00
Agrostis alba	1.90	0-3.8	26.50	0-53.0	7.18	A-14.35	50.00
Agrostis gigantea	0.40	0-0.8	16.50	0-33.0	2.41	A-4.81	50.00
Carex sp. #1	13.25	9.0-17.5	90.00	87.0-93.3	30.52	20.23-40.81	100.00
Carex sp. #2	0.35	0.3-0.4	10.00	7.0-13.0	1.93	1.15-2.70	100.00
Hordeum brachyantherum	2.85	0-5.7	40.00	0-80.0	7.69	A-15.38	50.00
Juncus arcticus ssp.*ater*	26.50	15.4-37.6	100.00	100.0-100.0	44.53	39.68-49.37	100.00
Phleum pratense	1.10	0.4-1.8	37.00	27.0-47.0	6.23	4.96-7.50	100.00
Poa pratensis	12.45	10.7-14.2	100.00	100.0-100.0	30.31	22.76-37.85	100.00
FORBS							
Achillea lanulosa	0.40	0-0.8	23.50	0-47.0	3.56	A-6.51	50.00
Aster sp.	6.55	<0.1-13.1	50.00	7.0-93.0	12.71	1.13-24.29	100.00
Epilobium adenocaulon	0.45	0-0.9	20.00	0-40.0	2.88	A-5.76	50.00
Polygonum aviculare	0.05	0-0.1	10.00	0-20.0	1.69	A-3.37	50.00
Taraxacum officinale	11.80	4.6-19.0	90.00	80.0-100.0	25.45	19.92-30.97	100.00
Veronica peregrina	0.05	0-0.1	13.50	0-27.0	2.25	A-4.50	50.00

A = absent

Table I-28. Mean production for Alkali Basin stand ALK-M-2.

Species	Mean ± S. D. n=5	Range (per 0.25m^2)
PERENNIAL GRASSES AND SEDGES		
Agrostis alba	33.076	0-26.231
Carex spp.	52.008	0-25.964
Eleocharis macrostachya	0.076	0-0.067
Hordeum brachyantherum	22.084	1.109-8.949
Juncus arcticus	220.928	20.267-99.395
Phleum pratense	39.948	0-42.478
Poa pratensis	45.220	0-37.072
Poa sp.	27.578	0-34.472
Sub-Total	440.918 ± 99.888	
PERENNIAL FORBS	7.321 ± 7.573	0.035-4.674
TOTAL PRODUCTION	448.239 ± 95.864	82.088-137.768

S.D. equals the standard deviation. Values in grams/m^2. 1978 data.
n = sample size.

Table I-29. Mean production for Alkali Basin stand ALK-M-3.

Species	Mean ± S. D. n = 5	Range (per 0.25m^2)
PERENNIAL GRASSES AND SEDGES		
Agrostis alba	6.795	0-6.499
Carex spp.	36.261	1.111-28.718
Glyceria sp.	0.367	0-0.459
Hordeum brachyantherum	40.119	3.715-14.472
Juncus arcticus	419.574	66.036-158.788
Phleum pratensis	43.274	0-19.054
Poa pratensis	35.598	3.886-13.832
Sub-Total	581.988 ± 141.206	
PERENNIAL FORBS	20.329 ± 6.268	2.813-6.639
TOTAL PRODUCTION	602.317 ± 136.142	106.861-197.071

S. D. equals the standard deviation. Values in grams/m^2. 1978 data.
n = sample size.

vegetation consists of scattered ponderosa pine and shrubs like antelope bitterbrush (*Purshia tridentata*) and rock spiraea (*Holodiscus dumosus*).

Rock Outcrops and Talus Slopes (Type 20). The rock outcrop and talus slope type is characterized by being almost totally nonvegetated. This type covers approximately 4,781 acres (1,936 hectares); 3.4 percent of the study area. Rock brake (*Cryptogramma crispa*) is one of the few species which grows in among the rocks. Rock glaciers and talus slopes occur on Carbon Peak and the areas around the base of Carbon Peak (Figure I-5). In Alkali Basin deposits of talus occur below the face of Flat Top Mountain and extend downslope almost to the basin floor.

Ponds and Open Water (no type number). Ponds, lakes and reservoirs occur throughout the study area. This type covers 214 acres (86 hectares); 0.15 percent of the study area. Although the vegetation in the ponds was not specifically sampled, certain aquatic species were noted. Water lily (*Nuphar polysepalum*) occurs rarely in subalpine ponds. Pondweed species (*Potamogeton* spp.) were noted in some of the shallow ponds in upper Alkali Basin.

Disturbed Areas (Type 18). The disturbed area type was used for mapping a variety of major disruptions in the vegetation. This type includes gravel pits, tailing disposal sites, old coal mine areas, large ranchyards, the Roaring Judy Trout Hatchery, and the Crested Butte airport. Disturbed areas cover 372 acres (151 hectares); 0.27 percent of the total study area. The disturbed areas are essentially nonvegetated.

Urban Areas (Type 19). The urban area type was used to map the areas including the towns of Crested Butte and Almont. The total area of this type is approximately 584 acres (236 hectares); 0.42 percent of the study area. The

Figure I-5. Talus slopes/rock glaciers in the Carbon Peak Area.

vegetation in these areas consists of lawns, flower gardens, and ornamental tree and shrub plantings.

Descriptions of Component Study Areas.

In the previous section each of the units portrayed on the vegetation map was described in terms of important, dominant species. Data from all over the study area were used to prepare the descriptions. The purpose of this section is to provide general vegetational descriptions of the various component study areas. These are the areas of anticipated impacts, or they are areas where substantial amounts of vegetation data were collected. Following the general descriptions, tabular references are given to assist in locating the summary data for each of the areas. Most of the summary data is presented in the vegetation studies Appendix. Several of the sampled stand summaries were presented in the previous section.

Alkali Basin. The vegetation in Alkali Basin is composed of three major vegetation types (Figure I-6). Big sagebrush shrublands occupy 50 to 75 percent of the Basin, and occur on all slopes and aspects. The big sagebrush shrublands form the matrix in which the other vegetation types grow. Aspen woodlands are the second most abundant type and they occupy 10 to 20 percent of the Basin. The woodlands are much more abundant on the south side (north-facing) of the valley. Isolated aspen stands occur on the south-facing side of the valley. The third major vegetation type in Alkali Basin is the irrigated pasture type located on the valley floor. It accounts for less than five percent of the total. In addition to these major types, numerous minor types occur. Riparian willow thickets occur along Alkali Creek, in the ephemeral drainages at the head of the basin, and along the drainages from Red Mountain. Moist meadows occur around the upper rim of the Basin in the areas where snowbanks persist into early summer. Mountain grasslands occur as scattered stands

Figure I-6. Vegetation in Alkali Basin. The grassy areas in the foreground are irrigated pastures. Big sagebrush shrublands and aspen woodlands can be seen on the slopes in the background. The coniferous forests are Douglas-fir.

on exposed ridges. A limited number of sparsely vegetated areas occur on the south-facing flank of Red Mountain. Stands of Douglas-fir forest occur on the upper north-facing slope of Flat Top Mountain. At the base of the Basin isolated stands of juniper occur on the south-facing slopes. These minor vegetation types were not all sampled, but were examined relative to species composition and general botanical characteristics.

Stand summaries for study sites in Alkali Basin, Almont Triangle, south side of Flat Top Mountain and areas at the head of Alkali just west of the divide between the East River and Ohio Creek are presented in the following Tables and Appendix Tables:

Big Sagebrush Shrublands:	Tables I-25 and I-26 Appendix Tables I-1 to I-51
Aspen woodlands:	Table I-16 to I-18 Appendix Tables I-52 to I-65
Hay Meadows and Pastures:	Tables I-28 and I-29 Appendix Tables I-66 and I-67
Moist Meadows:	Tables I-19 and I-20

Mount Axtell - Alkali Basin Corridor. The corridor between Mount Axtell and Carbon Creek and the area above Alkali Basin is a mosaic of aspen woodlands, big sagebrush shrublands and a limited amount of lodgepole pine forest. Aspen is the most abundant type and is more prevalent at the Carbon Creek end of the Corridor. At the Alkali end, big sagebrush is more prevalent.

Stand summaries for the Mount Axtell-Alkali Basin Corridor are presented in the following Appendix Tables:

Aspen Woodlands: Appendix Tables I-68 to I-73

Lodgepole Pine Forests: Appendix Tables I-74 to I-76

Red Lady Basin, Keystone Mine and Coal Creek Area. The vegetation in the Red Lady Basin, Keystone Mine and Coal Creek area is characteristically upper

montane, subalpine and alpine in nature. The lower elevations are characterized by a mosaic of aspen woodlands, subalpine meadows, and spruce-fir forests. Just northeast of the Basin (in Coon Basin) extensive stands of lodgepole pine occur. At higher elevations the woodland-meadow mosaic gives way to expanses of sparsely vegetated, rocky areas. Alpine meadows and fellfields occur above tree limit on Mount Emmons.

Stand summaries for vegetation types in the Red Lady Basin, Mount Emmons, Keystone Mine and Coal Creek area are presented in the following Tables and Appendix Tables:

Aspen Woodlands:	Appendix Tables I-77 to I-80
Lodgepole Pine Forests:	Appendix Tables I-82 to I-83
Spruce-fir Forests:	Appendix Tables I-84 to I-91 Table I-10
Subalpine Meadows:	Appendix Tables I-92 to I-94 Table I-7
Alpine Meadows:	Appendix Tables I-95 to I-96
Fellfields:	Table I-4

Anthracite Creek-Kebler Pass Area. The vegetation in the Anthracite Creek-Kebler Pass area is composed primarily of spruce-fir forests, aspen woodlands and subalpine meadows. Spruce-fir is the dominant vegetation in the area immediately around Kebler Pass and at elevations above 9,500 feet (2,895 m) in Anthracite Creek. In the main part of the creek valley and the areas around Horse Ranch Park, aspen woodlands are the prevalent type. The subalpine meadows form the matrix in which the aspen woodlands occur. The wet streamsides and the areas surrounding the numerous beaver ponds are characterized by riparian willow thickets.

Stand summaries for vegetation types in the Anthracite Creek Valley and Kebler Pass Area are presented in the following Appendix Tables:

Aspen Woodlands:	Appendix Tables I-96 to I-106
Spruce-fir Forests:	Appendix Tables I-106 to I-110
Mountain Grasslands:	Appendix Table I-111
Subalpine Meadow:	Appendix Table I-112

Washington Gulch. The vegetation in Washington Gulch is composed primarily of spruce-fir forests, aspen woodlands, and subalpine meadows. In addition to these major types, mountain grasslands, wet sedge meadows and subalpine willow thickets also occur. The spruce-fir forests occur mostly at the upper end of the Gulch with the aspen woodlands and meadows forming a mosaic in the middle portions of the valley. The willow thickets and wet sedge meadows occur on the valley floor.

Stand summaries for the vegetation types in Washington Gulch are presented in the following Tables and Appendix Tables:

Aspen Woodlands:	Appendix Tables I-113 to I-115
Spruce-fir Forests:	Appendix Tables I-115 to I-117
Mountain Grassland:	Appendix Table I-118
Wet Sedge Meadow:	Table I-11

Antelope Creek. The vegetation of Antelope Creek is similar to that in Alkali Basin with the exception that sagebrush is more abundant and the aspen woodlands tend to be less prevalent (Plate 2). Riparian shrub thickets occur along Antelope Creek. No sampling data were collected in Antelope Creek. A list of species observed in the valley is presented in Appendix Table I-119 and the vegetation of the area is presented as Plate 2.

Cabin Creek. The vegetation in Cabin Creek is also similar to that in Alkali Basin. Big sagebrush shrublands cover most of the area with riparian willow thickets occurring along Cabin Creek. Cottonwood woodlands occur to a

limited extent in the upper portion of the valley. In the lower part of the valley, black sage (*Artemisia nova*) occurs as a secondary dominant with big sagebrush.

The list of species observed in Cabin Creek is presented as Appendix Table I-120 and the vegetation map is included in Plate 3.

Bog Studies

Keystone Bog. The vegetation studies and sampling programs conducted throughout the project study area were conducted at an intermediate level of detail. At this level the Keystone Bog was mapped as a sphagnum-sedge bog and was the only area mapped as this type within the study area. Because of the interest in the Keystone Bog, the level of detail was increased and focused on a more refined definition of the vegetation within the area mapped as sphagnum-sedge bog. With this increase in detail it was possible to segregate five recognizable communities within and adjacent to the Bog. Each of these was sampled separately to better describe the component communities.

Lodgepole Pine Forest with Dry Understory

The lodgepole pine forest with a dry understory occurs at the periphery of the bog, especially on the northern and eastern uphill sites. It occurs as a narrow fringe on the southern edge and becomes wider on the western edge (Figure I-7). The herbaceous species composition (Table I-30) is similar to that encountered in other lodgepole pine stands. Dominant species were myrtle blueberry, mountain lover [shrubs less than 1 foot (0.3 meters) tall], elk sedge, and curly-leaf lousewort. Total herb cover in the understory was approximately 9 percent and cover by the low shrub species was 20 percent.

The most predominant components in the shrub layer were saplings of Engelmann spruce and subalpine fir (Table I-31). Cover by subalpine fir was 3.2 percent.

Figure I-7. Keystone Bog. The coniferous forest in the background is a mixture of Engelmann spruce, subalpine fir and lodgepole pine.

Table I-30. Summary statistics for herb layer species in the Keystone Bog stand KB-1.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
GRASSES AND SEDGES							
Bromus porteri	0.2	0.63	0-2	30.0	4.84	5.47	6
Calamagrostis sp.	0.3	0.95	0-2	20.0	3.23	4.18	10
Carex aquatilis	0.2	0.63	0-1	20.0	3.23	3.86	12
Carex brevipes	0.8	2.52	0-8	10.0	1.61	4.13	11
Carex geyeri	0.9	2.84	0-8	70.0	11.29	14.13	3
Sub-Total	2.4						
FORBS							
Achillea lanulosa	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Antennaria rosea	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Arenaria macrophylla	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Arnica longifolia	0.1	0.32	0-1	10.0	1.61	1.93	19
Dugaldia hoopesii	0.5	1.58	0-5	20.0	3.23	4.81	8
Epilobium angustifolium	0.1	0.32	0-1	30.0	4.84	5.16	7
Fragaria ovalis	<0.1	<0.01	0-<1	20.0	3.23	3.23	13
Gayophytum ramosissimum	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Hieracium albiflorum	0.8	2.52	0-6	20.0	3.23	5.75	5
Ligusticum porteri	0.5	1.58	0-5	10.0	1.61	3.19	16
Pedicularis racemosa	5.6	17.67	0-33	50.0	8.06	25.73	2
Polygonum sawatchense	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Pyrola secunda	<0.1	<0.01	0-<1	20.0	3.23	3.23	13
Senecio purshianus	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Taraxacum officinale	0.1	0.32	0-1	10.0	1.61	1.61	23
Thalictrum fendleri	0.3	0.95	0-3	10.0	1.61	2.56	17
Vicia americana	0.2	0.63	0-2	10.0	1.61	2.24	18
Sub-Total	8.2						

Based on data fron 10 1.0m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1979 data.

Table I-30. (contd.) Summary statistics for herb layer species in the Keystone Bog stand KB-1.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
WOODY SPECIES							
Abies lasiocarpa							
Shrub Layer	<0.1	<0.01	0-<1	20.0	3.23	3.23	13
Herb Layer	0.5	1.58	0-3	20.0	3.23	4.81	8
Pachystima myrsinites							
Shrub Layer							
Herb Layer	0.9	2.84	0-3	40.0	6.45	9.29	4
Picea engelmannii							
Shrub Layer	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Herb Layer	0.1	0.32	0-1	10.0	1.61	1.93	19
Pinus contorta							
Shrub Layer	<0.1	<0.01	0-<1	10.0	1.61	1.61	23
Herb Layer	0.1	0.32	0-1	10.0	1.61	1.93	19
Vaccinium caespitosa							
Shrub Layer							
Herb Layer	0.2	0.63	0-2	10.0	1.61	1.93	19
Vaccinium myrtillus							
Shrub Layer							
Herb Layer	19.3	60.88	0-66	70.0	11.29	72.17	1
Sub-Total	21.1						
Sum of Species Cover	31.7		3-76				
Total Herb Cover	8.6		0-34				
Total Woody Cover in Herb Layer	20.3		<1-66				

Table I-30. (contd.) Summary statistics for herb layer species in the Keystone Bog stand KB-1.

Species	Mean Cover (%)	Range of Cover Values (%)
Lichen Cover	2.9	0-10
Moss Cover	3.1	0-21
Litter Cover	91.0	77-100
Bare Soil	3.2	0-15
Rock Cover	6.0	0-4

Number of Species per Square Meter	Mean ± S.D.	Range
Herb Species	4.20 ± 2.97	0-9
Woody Species	1.60 ± 1.07	1-4
Total Species	5.80 ± 3.29	1-11

Additional Herbaceous Species: *Agoseris aurantiaca, Arenaria fendleri, Arnica cordifolia, Aster englemannii* (?), *Festuca thurberi, Polemonium delicatum, Senecio serra.*

Additional Woody Species: *Amelanchier alnifolia, Lonicera involucrata, Ribes montigenum*

Table I-31. Cover, frequency, and density for shrub species in Keystone Bog stand KB-1 (dry lodgepole understory).

Species	Height Class	Mean Cover (%)	Relative Cover (%)	Percent Frequency	Relative Frequency(%)	Mean No. per Hectare	Relative Density(%)	Importance Value	Rank
Abies lasiocarpa	Total	3.2	82.05	80.0	53.33	1,500	73.77	209.15	1
	I					633			
	II					300			
	III					33			
	IV					133			
	V					400			
Betula glandulosa	Total	<0.1	<0.01	10.0	6.67	33	1.64	8.31	5
	I								
	II								
	III					33			
Lonicera involucrata	Total	<0.1	<0.01	10.0	6.67	100	4.92	11.59	3
	I					100			
Picea engelmannii	Total	0.7	17.95	40.0	26.67	333	16.39	61.01	2
	I					33			
	II								
	III					33			
	IV					267			
Pinus contorta	Total	<0.1	<0.01	10.0	6.67	67	3.28	9.95	4
	I					67			
TOTAL		3.9							

Based on data from 10 2m x 15m line strip transects. Height Class I = 0.10m-0.25m; Class II = 0.26m-0.50m; Class III = 0.51m-0.75m; Class IV= 0.76m-1.00m; Class V = >1.00m. Importance Value = Relative Cover + Relative Frequency + Relative Density. 1979 data.

The tree canopy in these forests is composed of almost equal amounts of Engelmann spruce, subalpine fir, and lodgepole pine (Table I-32). The spruce and pine trees tend to be larger than the firs, however the firs are more abundant.

The dry understory lodgepole pine forests forms a buffer around the bog and separates it from the surrounding meadows and disturbed areas.

Lodgepole Pine Forest with Wet Understory

The lodgepole pine forest with a wet understory occurs within the bog and also below the bog in the areas saturated by the water from the outlet. The understory is different from the dry understory type. Wet sphagnum moss covers approximately 55 percent of the ground layer and the entire substrate is spongy. The number one ranking species was water sedge (*Carex aquatilis*) and saplings of lodgepole pine ranked second (Table I-33). Lodgepole pine seedlings ranked seventh, suggesting that seedling establishment occurs regularly. Two other sedge species (*Carex canescens* and *Carex rostrata*) ranked third and eighth respectively. Total vegetation cover was approximately 50 percent.

The shrub layer was different in the wet understory type. Engelmann spruce and subalpine fir both occur, but ranked third and fourth, respectively. Bog birch (*Betula glandulosa*) was the number one ranking shrub followed by lodgepole pine saplings which ranked second (Table I-34). Mean density for lodgepole pine saplings was nearly 2,834 individuals per acre (7,000 individuals per hectare).

The tree layer in these forests reflects the dominance of lodgepole pine (Table I-35). Density for lodgepole pine was 513 trees per acre (1,267 trees per hectare), which was nearly ten times greater than that for Engelmann spruce.

Table I-32. Tree layer summaries for forested stand KB-1 in the Keystone Bog.

Species	No. of Trees	Frequency (%)	Density (No./ha)	Mean Diameter ± S.D. (cm)	Mean Basal Area per Tree (cm^2) ± S.D.	Basal Area per Hectare (m^2/ha)	Importance Value
Abies lasiocarpa	29	70.0	644	13.71 ± 5.81	173.18 ± 137.76	11.16	91.05
Picea engelmannii	26	70.0	578	18.80 ± 11.18	371.96 ± 401.95	21.49	107.17
Pinus contorta	25	70.0	556	20.16 ± 6.16	347.95 ± 214.35	19.33	101.77

Based on data from 10 3m x 15m quadrats. Importance Value = Relative Frequency + Relative Density + Relative Basal Area. ± values equal the standard deviation. 1979 data.

Table I-33. Summary statistics for herb layer species in the Keystone Bog stand KB-2.

Species	Mean Cover(%)	Relative Cover (%)	Range of Cover Values(%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
GRASSES AND SEDGES							
Agrostis thurberiana	0.1	0.18	0-1	30.0	5.00	5.18	9
Calamagrostis scopulorum	0.4	0.72	0-2	20.0	3.33	4.05	11
Carex aquatilis	35.3	63.26	13-64	100.0	16.67	79.93	1
Carex canescens	3.7	6.63	0-10	90.0	15.00	21.63	3
Carex rostrata	0.4	0.72	0-3	30.0	5.00	5.72	8
Carex spp. (seedlings)	0.1	0.18	0-1	30.0	5.00	5.18	9
Deschampsia caespitosa	3.8	6.81	0-18	50.0	8.33	15.14	4
Sub-Total	43.8						
FORBS							
Eriophorum angustifolium	<0.1	<0.01	0-<1	20.0	3.33	3.33	14
Viola palustris	0.4	0.72	0-3	20.0	3.33	4.05	11
Sub-Total	0.4						
WOODY SPECIES							
Betula glandulosa							
Shrub Layer	1.6	2.87	0-8	50.0	8.33	11.20	5
Herb Layer	0.3	0.54	0-2	50.0	8.33	8.87	6
Pinus contorta							
Shrub Layer	8.4	15.05	0-55	60.0	10.00	25.05	2
Herb Layer	<0.1	<0.01	0-<1	40.0	6.67	6.67	7
Vaccinium caespitosum							
Shrub Layer							
Herb Layer	1.3	2.33	0-13	10.0	1.67	4.00	13
Sub-Total	11.6						

Based on data from 10 0.1m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1979 data.

Table I-33. (contd.) Summary statistics for herb layer species in the Keystone Bog stand KB-2.

Species	Mean Cover (%)	Range of Cover Values (%)
Sum of Species Cover	55.8	36-76
Total Herb Cover	48.9	15-94
Total Woody Cover in Herb Layer	1.6	0-13
Total Woody Cover in Shrub Layer	9.8	0-59
Litter Cover	42.7	0-76
Sphagnum Moss Cover	54.9	0-94
Other Moss Cover	3.9	0-18
Water Cover	14.6	0-52
Bare Soil	1.0	0-5
Number of Species per Square Meter	Mean ± S.D.	Range
Herb Species	3.90 ± 1.29	3-7
Woody Species	1.40 ± 0.84	0-3
Total Species	5.30 ± 1.42	4-8

Additional Woody Species: *Abies lasiocarpa, Picea engelmannii*

Table I-34. Cover, frequency, and density for shrub species in Keystone Bog stand KB-2 (wet sphagnum understory).

Species	Height Class	Mean Cover(%)	Relative Cover(%)	Percent Frequency	Relative Frequency(%)	Mean No. per Hectare	Relative Density(%)	Importance Value	Rank
Abies lasiocarpa	Total	<0.1	<0.01	20.0	6.45	233	1.31	7.76	4
	I								
	II					167			
	III					67			
Betula glandulosa	Total	5.4	58.70	100.0	32.26	10,267	57.46	148.42	1
	I					3,533			
	II					3,333			
	III					1,967			
	IV					800			
	V					633			
Picea engelmannii	Total	0.8	8.70	80.0	25.81	333	1.87	36.38	3
	I					100			
	II					67			
	III					33			
	IV								
	V					133			
Pinus contorta	Total	3.0	32.61	100.0	32.26	6,967	38.99	103.86	2
	I					600			
	II					1,467			
	III					1,367			
	IV					1,067			
	V					2,467			

Based on data from 10 2m x 15m line strip transects. Height Class I = 0.10m-0.25m; Class II = 0.26m-0.50m; Class III = 0.51m-0.75m; Class IV = 0.76m-1.00m; Class V = >1.00m. Importance Value = Relative Cover + Relative Frequency + Relative Density. 1979 data.

Table I-34. (contd.) Cover, frequency, and density for shrub species in Keystone Bog stand KB-2 (wet sphagnum understory).

Species	Height Class	Mean Cover (%)	Relative Cover (%)	Percent Frequency	Relative Frequency (%)	Mean No. per Hectare	Relative Density (%)	Importance Value	Rank
Salix sp.	Total	<0.1	<0.01	10.0	3.23	67	0.37	3.60	5
	I								
	II								
	III								
	IV					33			
	V					33			
TOTAL		9.2							

Table I-35. Tree layer summary for forested stand KB-2 in the Keystone Bog.

Species	No. of Trees	Frequency (%)	Density (No./ha)	Mean Diameter ± S.D. (cm)	Mean Basal Area per Tree (cm^2) ± S.D.	Basal Area per Hectare (m^2/ha)	Importance Value
Abies lasiocarpa	1	10.0	22	6.60	34.21	0.08	8.15
Picea engelmannii	6	50.0	133	13.63 ± 5.57	166.31 ± 123.51	2.22	50.60
Pinus contorta	57	10.0	1267	12.27 ± 7.12	157.40 ± 219.45	19.94	241.24

Based on data from 10 3m x 15m quadrats. Importance Value = Relative Frequency + Relative Density + Relative Basal Area. ± values equal the standard deviation. 1979 data.

An interesting aspect of this forest type is the success of lodgepole pine. Lodgepole pine is traditionally considered a dry upland species, and yet it occures as the dominant species on this wet site. Based on the sapling and seedling data, it is unlikely that the stand is a relict of drier times. Even though the site is wet, water may not be readily available because the acid conditions in the bog create a physiologically dry site.

Water Sedge (*Carex aquatilis*) Meadow

The water sedge meadows constitute a simple community and are composed of dense mats of water sedge with scattered individual clumps of *Carex canescens*. Other than these two sedges, bog birch was the only species encountered (Table I-36).

Water sedge is a highly rhizomatous species and tends to form densely interwoven mats. These mats act like gigantic sponges, thus this type is perennially wet. Springs flow into the upper edges of the mats, and the water trickles through to the pond in the center of the bog.

Beaked Sedge (*Carex rostrata*) Community

The beaked sedge (*Carex rostrata*) community occurs in standing water at the southern edge of the bog. The only species which occurs in this type is beaked sedge. The community occurs in a band adjacent to the shore and is approximately 30 feet (nine meters) wide and extends along the southern edge. Mean cover by beaked sedge was approximately 10 percent (Table I-37).

Cottongrass-Sedge Meadow

The cottongrass-sedge meadow type is similar to the understory in the wet understory lodgepole pine forests. Essentially, it is composed of the same

Table I-36. Summary statistics for herb layer species in the Keystone Bog stand KB-3.

Species	Mean Cover(%)	Relative Cover (%)	Range of Cover Values(%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
GRASSES AND SEDGES							
Carex aquatilis	47.7	98.76	17-85	100.0	88.18	186.94	1
Carex canescens	0.5	1.04	0-7	6.7	5.91	6.95	2
Sub-Total	48.2						
WOODY SPECIES							
Betula glandulosa	0.1	0.21	0-2	6.7	5.91	6.12	3
Sum of Species Cover	48.3		22-85				
Sphagnum Moss	20.1		0-85				
Other Moss Cover	15.9		0-55				
Litter Cover	69.6		15-100				
Bare Substrate	0.6		0-5				
Water Cover	15.7		0-80				
Number of Species per Square Meter	Mean ± S.D.		Range				
Herb Species	1.07 ± 0.26		1-2				
Woody Species	0.07 ± 0.26		0-1				
Total Species	1.13 ± 0.35		1-2				

Based on data from 15 1.0m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1979 data.

Table I-37. Summary statistics for herb layer species in the Keystone Bog stand KB-4.

Species	Mean Cover(%)	Relative Cover (%)	Range of Cover Values(%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
GRASSES AND SEDGES							
Carex rostrata	9.6	100.0	3-18	100.0	100.0	200.00	1
Litter Cover	94.0		50-100				
Water Cover	100.0		100-100				

Based on data from 15 0.1m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1979 data.

species except that there is no lodgepole pine overstory. The dominant species are cottongrass (*Eriophorum angustifolium*), which ranked first, and water sedge which ranked second (Table I-38). *Carex canescens* ranked third.

The most interesting feature of this community is the presence of round-leaved sundew (*Drosera rotundifolia*) (Figure I-8). This is the only known location to date for sundew in Colorado. The community covers approximately 6,500 square feet (600 m^2). The sundew had a mean cover of approximately one percent and occurred at a density of 4.5 individuals per 0.1 m^2. They tend to be aggregated in clumps and patches right at the water line of the small rivulets which drain the community and also at the edge of the pond in the bog. In the 15 quadrats which were sampled the density ranged from zero to 29 individuals per 0.1 m^2.

History and Origin of the Bog

One of the questions which remains unanswered pertains to the origin of the bog. Based on the presence of large amounts of sphagnum bog (nearly 100 percent cover in some areas), the presence of high densities of bog birch, the presence of a vigorous population of cottongrass, and the presence of sundew, it appears that the acid bog conditions have been present on the site for a considerable length of time. The source of water for the bog comes from springs and seeps which are adjacent to the sedge communities previously described. Because of the proximity of the bog to old prospect adits and the Keystone Mine, the possibility exists that acid waters from the mine were drained onto the bench where the bog occurs. It is possible that during the course of prospecting and mining operations mine water was diverted across the bench. It seems probable, however, that the bog was there prior to mining, and received water that had flowed naturally from a mineralized area.

a.

b.

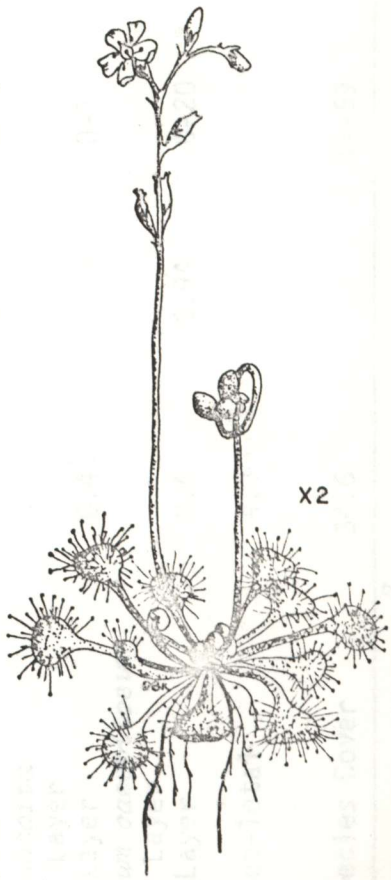

Figure I-8. a) *Drosera rotundifolia* growing in the Keystone Bog.
b) *Drosera rotundifolia*

Table I-38. Summary statistics for herb layer species in the Keystone Bog stand KB-5.

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency	Relative Frequency (%)	Importance Value	Rank
GRASSES AND SEDGES							
Calamagrostis scopulorum	0.1	0.29	0-2	6.7	1.36	1.65	12
Carex aquatilis	6.5	18.79	0-31	66.7	13.52	32.31	2
Carex canescens	6.5	18.79	0-21	46.7	9.46	28.25	3
Carex spp. (seedlings)	0.3	0.87	0-3	46.7	9.46	10.33	7
Deschampsia caespitosa	5.2	15.03	0-36	46.7	9.46	24.49	4
Eleocharis pauciflora	0.5	1.45	0-7	20.0	4.05	5.50	10
Eriophorum angustifolium	10.3	29.77	3-30	100.0	20.26	50.03	1
Sub-Total	29.4						
FORBS							
Drosera rotundifolia	0.9	2.60	0-5	33.3	6.75	9.35	8
WOODY SPECIES							
Betula glandulosa							
Shrub Layer	0.3	0.87	0-4	6.7	1.36	2.23	11
Herb Layer	1.2	3.47	0-15	20.0	4.05	7.52	9
Pinus contorta							
Shrub Layer							
Herb Layer	0.4	1.16	0-1	53.3	10.80	11.96	6
Vaccinium caespitosum							
Shrub Layer							
Herb Layer	2.4	6.94	0-20	46.7	9.46	16.40	5
Sub-Total	4.3						
Sum of Species Cover	34.6		14-59				

Based on data from 15 0.1m^2 quadrats. Importance Value = Relative Cover + Relative Frequency. 1979 data.

Table I-38. (contd.) Summary statistics for herb layer species in the Keystone Bog stand KB-5.

Species	Mean Cover (%)	Range of Cover Values (%)
Total Herb Cover	27.0	12-45
Total Woody Cover in Herb Layer	4.1	0-20
Total Woody Cover in Shrub Layer	0.3	0-4
Sphagnum Moss Cover	61.5	0-100
Other Moss Cover	4.5	0-34
Litter Cover	60.4	15-100
Bare Soil	0.6	0-6
Water Cover	6.3	0-40
Number of Species per Square Meter	Mean ± S.D.	Range
Herb Species	3.67 ± 0.90	2-5
Woody Species	1.20 ± 0.77	0-2
Total Species	4.87 ± 1.41	2-7

Additional Woody Species: *Amelanchier alnifolia, Vaccinium scoparium*

The bog has been influenced in other ways by mining activities. Evidence of old roads and past cutting can be seen around the bog. Most recently, the stand of lodgepole pine just upslope from the bog was accidentally burned.

Regional Bog Studies. The regional bog studies were conducted to determine if other populations of sundew could be located. In the immediate areas of Mount Emmons, two similar bogs were searched. One was in Red Lady Basin just below the M-MS-9 sampling site. The second was in Redwell Basin immediately across the divide from Red Lady Basin. Habitats similar to those in the Keystone Bog were observed, however no sundews were found. These studies were conducted at the end of July; the time when the sundew is in flower. Sundews are difficult to locate even in areas where they are known to occur. Searching at flowering time increased the chance of finding them.

On a wider regional basis, bogs in similar mining districts were searched. Areas in the upper parts of the Tomichi and Quartz Creek drainages near the old Bon Ton Mine and near White Pine were searched. Bog birch, water sedge, and western wintergreen (*Gaultheria humifusa*) were observed but no sundews were found. One of the most promising areas with similar acid water conditions was the area near Red Mountain Pass and Ironton Park in the San Juan Mountains. Six different sites between the summit of Red Mountain Pass and Ironton Park were searched. Bog birch was encountered at four of the sites, and cottongrass was observed at one location. No sundews were located. Mine areas near Telluride and Rico also were checked, but the bogs that were located were different from the Keystone Bog and none of the characteristic species were present. The most similar bog which was searched was just up-valley from the town of Old Ophir in the San Juans. This bog had extensive limonitic deposits like those in the Keystone Bog. Sphagnum moss was common, and bog birch, *Carex canescens*, and water sedge were all present. The habitat appeared to be suitable for sundews, but none were located.

One other location was checked in South Park near Hartsel. Cottongrass and water sedge occurred in this bog, but no sundews were observed.

Of all the bogs which were checked, the one near Old Ophir seemed to provide the best habitat for sundews. The end result, however, was that no sundews were located in any of the regional areas which were checked.

Successional Studies

Examination of data from the sampled road cut sites provides some insight into those species which do well on disturbed sites (Table I-39). Golden aster (*Heterotheca villosa*) was one of the most prevalent species along the old roadway. Common dandelion (an introduced weed) and showy fleabane were both high ranking species. All three of these species are in the Family Compositae and tend to have light air borne seeds. Common dandelion and showy fleabane are both common components in the meadows adjacent to the old roadway. Major grass species were Kentucy bluegrass, Letterman needlegrass (*Stipa lettermanii*) and Porter brome (*Bromus porteri*).

The data from these sites does not provide insight into the rates at which the species become established. It does allow for qualitative evaluation of the species which can naturally colonize disturbed areas. Stand summaries for each of these sites are presented in Appendix Tables I-97 through I-99.

Sensitive Areas

Sensitive areas are those which are highly susceptible to external disturbing influences. It would be possible to develop a sensitivity rating for all the communities within the study area, since to a degree all communities are susceptible to disturbance. The sensitive areas addressed in this section are those which have slow regeneration potential or are those with high scientific value.

Table I-39. Summary of mean cover, percent frequency and importance values for the top ten ranked species in each of the 1979 study sites (RC-AS-13, RC-AS-14, RC-AS-15) on the abandoned Kebler Pass road right-of-way.

Species	Mean Cover(%)	Range of Cover Values(%)	Mean Percent Frequency	Range of Frequency Values(%)	Mean Importance Values	Range of Importance Values	Presence (%)
GRASSES AND SEDGES							
Agropyron trachycaulum	1.20	<0.1-2.6	55.57	26.7-86.7	6.16	1.63-9.48	100.00
Bromus porteri	3.13	0-8.1	42.20	0-93.3	11.33	A-29.89	66.66
Festuca arizonica	0.70	0-2.1	31.10	0-80.0	3.41	A-9.39	66.66
Poa pratensis	4.73	2.0-6.1	73.33	60.0-93.3	15.12	7.95-22.19	100.00
Stipa lettermanii	2.60	1.5-3.5	80.00	66.7-93.3	11.40	8.10-17.59	66.66
FORBS							
Agoseris aurantiaca	0.77	<0.1-1.3	46.67	13.3-66.7	4.46	1.17-6.86	100.00
Agoseris glauca	0.53	0-1.3	31.10	0-73.3	6.17	A-6.64	66.66
Arenaria fendleri	3.80	0.3-8.1	51.13	6.7-100.0	10.80	1.39-23.48	100.00
Erigeron speciosus	1.93	1.0-2.5	51.13	26.7-66.7	7.27	5.03-9.02	100.00
Galium bifolium	0.17	0-0.5	33.33	0-80.0	3.23	A-8.40	66.66
Heterotheca villosa	13.07	3.3-19.1	66.67	20.0-100.0	28.90	10.58-42.15	100.00
Ligusticum porteri	1.07	0-3.2	17.77	0-53.3	4.42	A-13.26	33.33
Polygonum sawatchense	0.13	<0.1-0.3	73.33	60.0-100.0	5.75	3.66-9.62	100.00
Potentilla gracilis	2.80	0-6.5	57.77	0-93.3	8.26	A-15.83	66.66
Senecio crassulus	1.13	0-2.3	31.13	0-66.7	3.88	A-6.43	66.66
Taraxacum officinale	2.63	0.5-3.9	82.23	73.3-86.7	11.37	6.36-16.90	100.00
Viola nuttallii	2.87	0.8-4.1	88.90	80.0-100.0	12.36	6.60-18.71	100.00

A = absent.

The alpine tundra areas are sensitive in that the tundra communities require long time periods to become re-established.

The other sensitive area is the Keystone Bog. The vegetation in the bog is, because of its botanical components, unusual in Colorado, and the loss of this site would be unfortunate. Any time disjunct populations of species are located, there is an opportunity to evaluate mechanisms of species distribution. At this time the most unusual component of the bog is the sundew. Other disjunct populations may be present.

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Consultations with Government Agency Representatives

Date	Person
Mid-September 1978	Gerald Nyborg - Regional Forester, U.S. Forest Service, Delta
July 26, 1979	Jim Simonsen, U.S. Forest Service, EIS Team
September 27, 1979	Jim Simonsen, U.S. Forest Service, EIS Team

SECTION II

WILDLIFE STUDIES

Prepared by: Robert E. Stoecker
Jill A. Stoecker

LIST OF TABLES

Appendix Tables

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PLATES

(Located in a separate volumn)

This report presents the results of a two-year baseline investigation of terrestrial wildlife in the Mount Emmons Project area. The project area, for the purposes of wildlife studies, includes approximately 570 km^2 (220 mi^2; Plate 5, sheets 1 and 2). Observations were also made at Anthracite Creek, Antelope Creek, and Carbon Creek.

The rationale for choosing the component studies discussed in this report fall into two categories. Namely, studies had to be considered: 1) meaningful in terms of identifying important wildlife areas during the pre-development phase, or 2) appropriate for quantifying possible changes due to development and operation. The first criterion requires largely qualitative observations; the second requires data that are amenable to statistical analyses.

The companion report on vegetation should be consulted for details of vegetational composition in areas described here as wildlife habitats.

The wildlife habitats within the project area are grouped into four major categories, each of which is divided into a number of subtypes (Plate 5, sheets 1 and 2).

The four major wildlife habitat types are as follows:

- Alpine and subalpine
- Montane forests
- Big sagebrush shrubland
- Agricultural land

Alpine and Subalpine.

Alpine habitat includes areas above or near timberline, generally above 3,475 m (11,400 ft). Within the project area, alpine meadows are limited to the slopes of Whetstone Mountain, Mount Axtell, and Mount Emmons. Some of the more conspicuous wildlife species include the white-tailed ptarmigan (*Lagopus leucurus*), white-crowned sparrow (*Zonotrichia leucophrys*), water pipit (*Anthus spinoletta*), and gray-crowned rosy finch (*Leucosticte tephrocotis*). Typically, few species are observed in alpine meadows, since the habitat is characterized by strong winds, cold temperatures, and sparse protective cover. During winter, most animals that are common in summer either move to lower elevations or hibernate. Exceptions are northern pocket gophers (*Thomomys talpoides*), which remain active beneath the ground in areas that retain a protective snowpack. Ptarmigan will remain as well, although they will sometimes move to lower valley areas. During the severe winter of 1978-79, flocks of six to ten ptarmigan were seen on two occasions on the valley floor near the Slate River.

Subalpine meadows above 3,200 m (10,500 ft) have habitat features common to the alpine and the adjacent coniferous forest. Boundaries cannot be clearly defined in all cases, but twisted and stunted trees (Krummholz) with interspersed alpine meadow are characteristic. Conspicuous wildlife includes the mountain bluebird (*Sialia currucoides*), Cassin's finch (*Carpodacus cassinii*), Clark's nutcracker (*Nucifraga columbiana*), and the least chipmunk (*Eutamias minimus*). Heavy snow accumulations commonly occur in open areas between stands of trees, and these may last into summer. Yellow-bellied marmots (*Marmota flaviventris*) must sometimes emerge from hibernation by burrowing upward through deep snow. Subalpine areas, as occur in Red Lady Basin on Mount Emmons, are the upper distributional limits of such important prey species as the red-backed vole (*Clethriomonys gapperi*) and long-tailed vole (*Microtus longicaudus*). These rodents provide an important food source for short-tailed weasels (*Mustela erminea*), long-tailed weasels (*M. frenata*), and coyotes (*Canis latrans*), all common predatory mammals that sometimes venture to timberline (Figures II-1 and II-2).

The subtype talus occurs from 2,438 m (8,000 ft) to 3,657 m (12,000 ft) in the Mount Emmons Project area. Cliff faces above talus slopes are potential nesting habitat for raptorial birds. Pine marten (*Martes americana*) and long-tailed weasels, both highly secretive animals, are occasionally seen on talus slopes, although the pika (*Ochotona princeps*) is clearly the most characteristic and conspicuous animal that occurs here. Pikas can be seen sitting on top of large talus blocks, but more often only their peculiar vocalizations are heard among the boulders. Pikas were observed in the project area at the top of Mount Emmons (3,657 m; 12,000 ft) and in Alkali Basin (2,682 m; 8,800 ft).

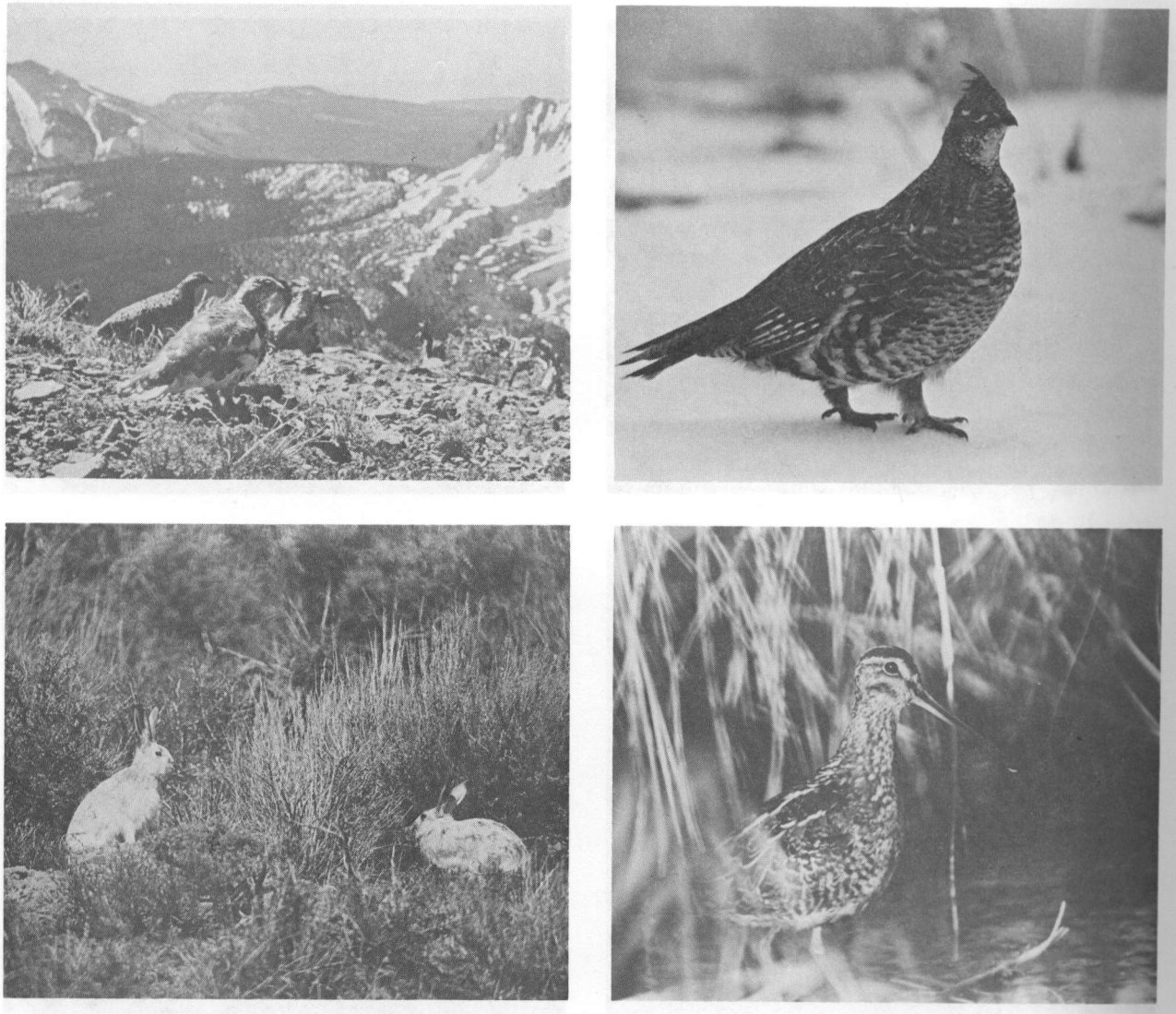


Figure II-1. Characteristic wildlife of the major habitat types. From left to right: white-tailed ptarmigan, the alpine of Mount Emmons looking south; blue grouse, montane forests; white-tailed jackrabbit, big sagebrush shrubland; common snipe, agricultural land.

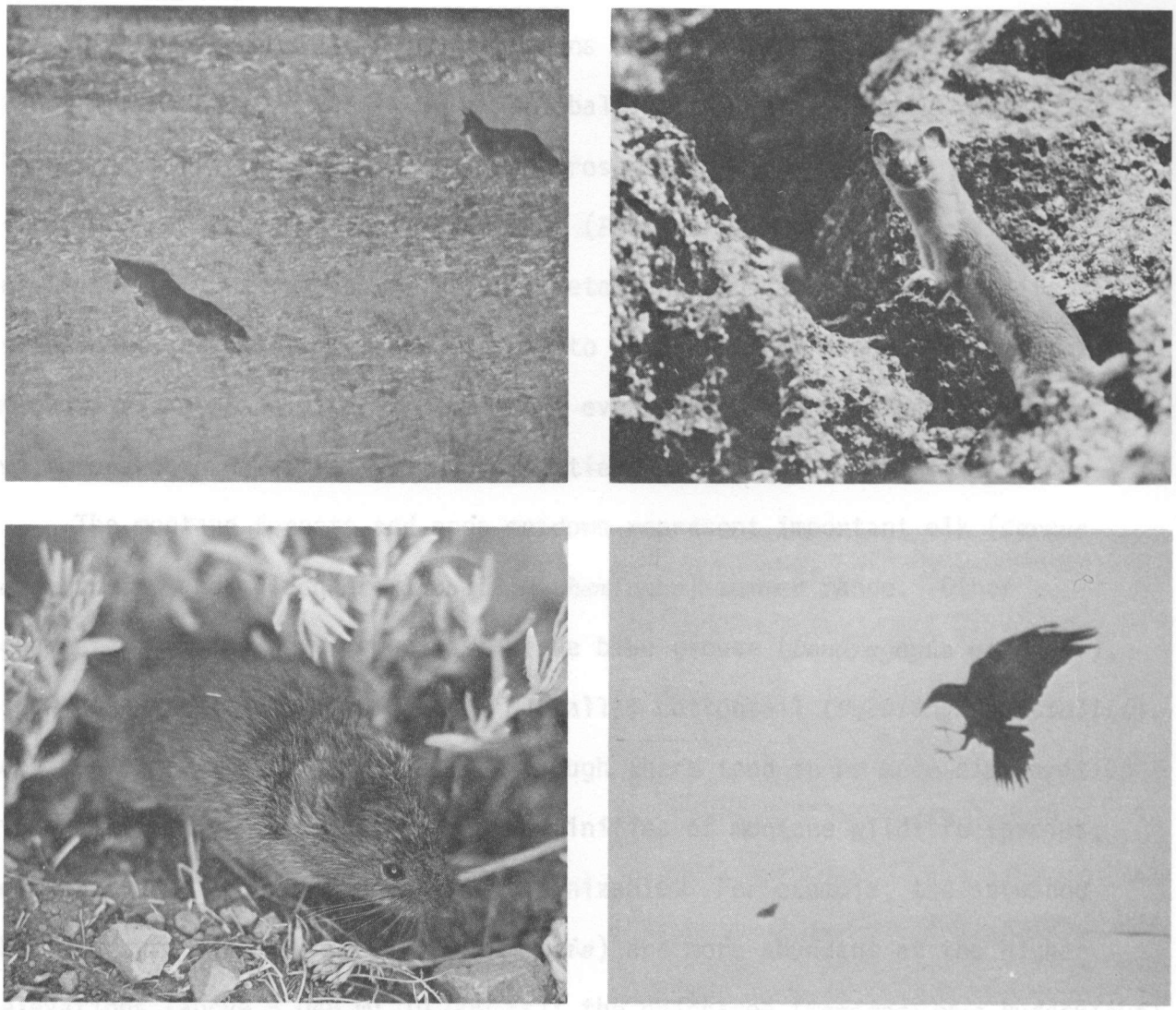


Figure II-2. Common predators and prey species. From left to right: coyotes hunting voles in montane meadow habitat; long-tailed weasel on talus slope; montane vole, one of the most important prey species in the Mount Emmons Project area; raven catching a vole in a hay meadow of Ohio Creek.

Montane Forests.

Montane forests in the Mount Emmons Project area include spruce-fir (Engelmann spruce; *Picea engelmannii*-Subalpine fir; *Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), ponderosa pine (*P. ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), and aspen (*Populus tremuloides*) forests, all of which are more or less distinct vegetational units. From a wildlife standpoint, however, it is convenient to combine them, along with montane meadows and montane riparian habitats, even though some differences occur with regard to wildlife habitat affinities.

The montane forests and open meadows represent important elk (*Cervus canadensis*) and mule deer (*Odocoileus hemionus*) summer range. Other characteristic wildlife species include blue grouse (*Dendragapus obscurus*), snowshoe hare (*Lepus americanus*), Nuttall's cottontail (*Sylvilagus nuttallii*), and beaver (*Castor canadensis*). Although there tend to be more similarities than differences among the habitat affinities of montane wildlife species, distinct habitat preferences are recognizable. For example, the snowshoe hare and gray jay (*Perisoreus canadensis*) are more abundant at the higher elevations (above 3,048 m; 10,000 ft); the chickaree (*Tamiasciurus hudsonicus*) is most common in spruce-fir forests; warbling vireos (*Vireo gilvus*) and nesting tree swallows (*Iridoprocne bicolor*) typically occur in aspen woodlands; broad-tailed hummingbirds (*Selasphorus platycercus*) commonly frequent montane meadows, although they are more numerous in big sage-brush (*Artemisia tridentata*) habitat. Differences between spruce-fir and lodgepole pine forests relate mainly to wildlife abundance: fewer rodents were captured in lodgepole pine forests than in spruce-fir forests; birds common to spruce-fir and lodgepole pine forests, the ruby-crowned kinglet (*Regulus calendula*), red-breasted nuthatch (*Sitta canadensis*), mountain chickadee (*Parus gambeli*), hermit thrush (*Catharus guttatus*),

olive-sided flycatcher (*Nuttallornis borealis*), and red crossbill (*Loxia curvirostra*), were more numerous in spruce-fir. In general, however, habitats that are a mixture of subtypes support the most species. Mixtures of aspen, coniferous tree species, and meadows, especially when in close proximity to streams, support the greatest number and the greatest diversity of wildlife.

Big Sagebrush Shrubland.

Big sagebrush shrubland typically separates the montane forests from the agricultural hay meadows of the major valleys. Certain local areas are important elk and deer winter range. Similarly, some areas are important to sage grouse (*Centrocercus urophasianus*). The most characteristic bird species of sagebrush areas include the Brewer's sparrow (*Spizella breweri*), green-tailed towhee (*Chlorura chlorura*), sage thrasher (*Oreoscoptes montanus*), vesper sparrow (*Pooecetes gramineus*), and the sage grouse. Few mammals are characteristic of sagebrush areas, although white-tailed jackrabbits (*Lepus townsendii*) and meadow voles (*Microtus pennsylvanicus*) were found only in this habitat type.

Agricultural Land.

Agricultural land refers to the hay meadows, pastures, and riparian areas of the major valley floors. The riparian areas are especially varied, consisting of cottonwood (*Populus angustifolia*) woodlands, willows (*Salix* sp.), alder (*Alnus tenuifolia*), grazed areas, and moist meadows. The riparian areas are of considerable importance to wildlife, since they provide cover, water, and an abundance of food. Songbird diversity was highest in the riparian habitat of lower Carbon Creek near its confluence with Ohio Creek. Ducks and other waterbirds, while not abundant anywhere

within the project area, were most often observed in low-elevation riparian habitats. Characteristic wildlife include the red-winged blackbird (*Agelaius phoeniceus*), belted kingfisher (*Megaceryle alcyon*), mallard (*Anas platyrhynchos*), and in some areas, the raccoon (*Procyon lotor*) and striped skunk (*Mephitis mephitis*). Characteristic species of the open hay meadows and pastures include the marsh hawk (*Circus cyaneus*), particularly in the fall, common snipe (*Capella gallinago*), brown-headed cowbird (*Molothrus ater*), black-billed magpie (*Pica pica*), and raven (*Corvus corax*).

OBJECTIVES

The main objectives of big game studies were to identify important winter range areas and to quantify habitat utilization within these areas. Additionally, during the severe winter that occurred the first year of baseline investigations (1978-79), data were obtained on age-specific mortality and herd distributions. Preliminary studies concerning distributions of big game on summer range were performed as well; however, these studies were terminated the second year after radio telemetry studies conducted by the Colorado Cooperative Wildlife Research Unit were initiated. Research design and data analysis emphasized the following three components:

- Distributions of elk and mule deer on winter range
- Relative importance of winter range habitats
- Utilization of big sagebrush by elk and mule deer
- Mule deer mortality during the winter of 1978-79

METHODS

Pellet-group counts were used to evaluate localized distributions of elk and mule deer in selected areas of winter range. Pellet-group transects consisted of 20 circular quadrats, $10m^2$ ($108\ ft^2$) each, spaced at 10m (32.8 ft) intervals. All quadrats were cleaned of pellet-groups in the fall before elk and deer moved into these areas from higher summer range. Estimates of pellet-group densities for the winter periods were made in spring after elk and deer had returned to summer range. Randomization of quadrat location was achieved by using a systematic random design (the first location of regularly-placed transects was chosen at random; see Cochran, 1977). The locations of transects are shown on Plate 5, sheet 2, and Plate 6.

Production and utilization studies of big sagebrush were performed concurrently with pellet-group studies, and along a selected number of the same transects. Production of big sagebrush was estimated by randomly choosing one stem from a shrub greater than 15cm (6 in) tall nearest the center stake of each quadrat. A terminal group of approximately ten shoots on the stem was marked using a small tag. The length of the current year's growth of each shoot above this tag was then measured. The average length of new shoot growth per shrub was used as the estimate of annual forage production. In early spring, the same stems were relocated and measurements were again made of these same shoots. The amount of the previous year's growth consumed was used as an estimate of utilization.

Mule deer mortality studies were conducted on 7 and 8 April 1979. Age class estimates were made by examination of tooth wear following the methods of Robinette et al. (1957).

RESULTS AND DISCUSSION

Distributions of Elk and Mule Deer on Winter Range.

Elk and mule deer pellet-group densities were estimated at five locations: in Alkali Basin; on the south-facing slope of Flat Top (Figure II-3); at two locations on the Almont Triangle; and in Antelope Creek valley (Plate 5, sheet 2, and Plate 6). All transects were in big sagebrush habitat.

A summarization of elk pellet-group data for 1979-80 is given in Table II-1, where the five winter range locations sampled are arranged in decreasing order of mean pellet-group densities. The highest elk pellet-group density (381 groups per hectare; 154 per acre) occurred on the southern part of the Almont Triangle. The lowest densities were found in Alkali Basin and in the Antelope Creek valley, where estimates for both locations were 50 groups per

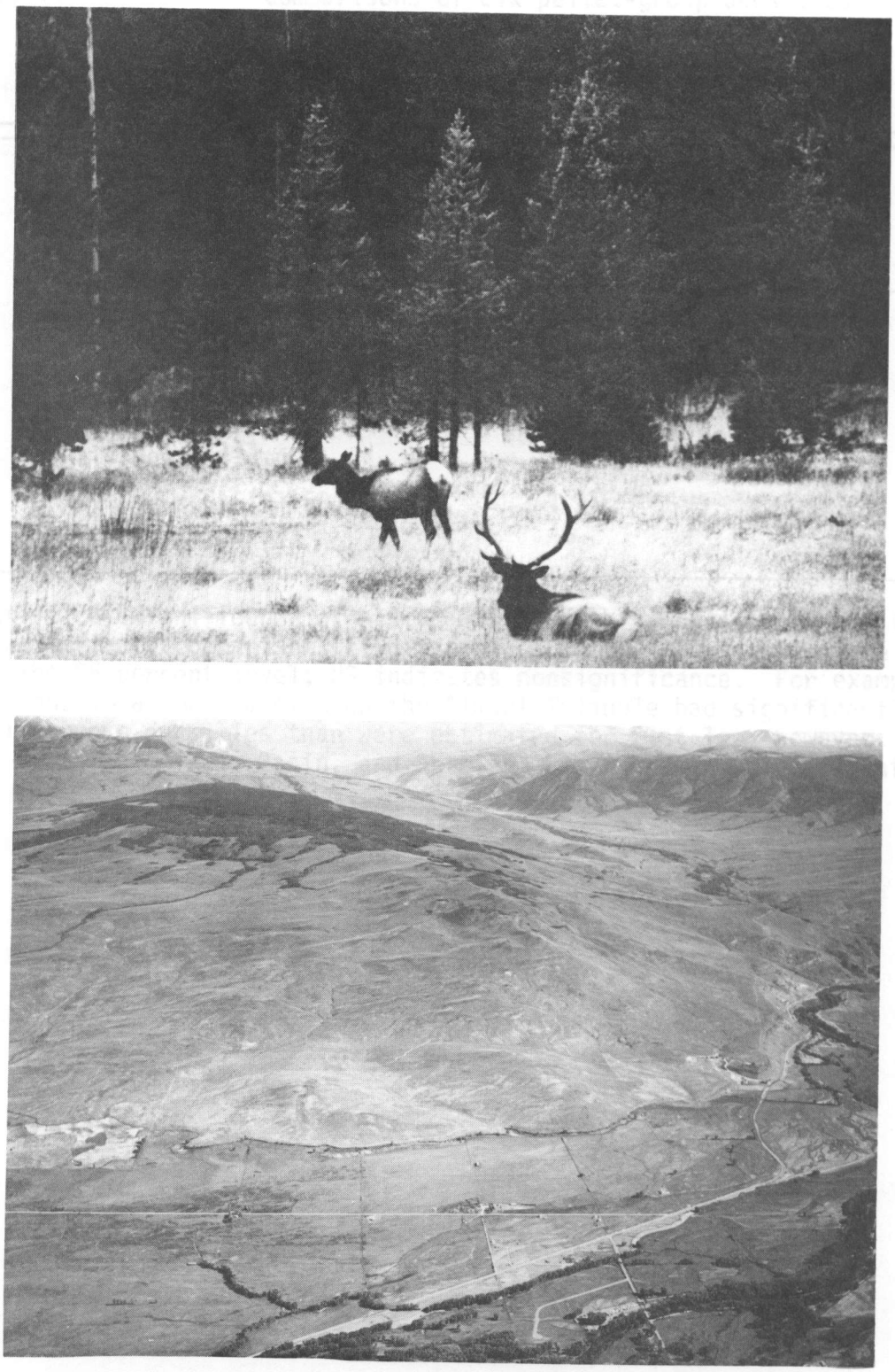


Figure II-3. Typical elk habitats. Upper photo: bull and cow elk on summer range. Lower photo: the south-facing slope of Flat Top, elk winter range.

Table II-1. Comparisons of elk pellet-group densities among sagebrush winter range habitats during 1979-80. Habitats are ranked from highest to lowest in terms of mean number of pellet-groups per hectare.

			Comparison of Ranked Locations				
			RANK				
MEANS	LOCATION (Transects)	RANK	5	4	3	2	1
381	Almont Triangle (21-30)	5	--	NS	*	*	*
337	Almont Triangle (51-55)	4		--	*	*	*
127	Flat Top (1-13)	3			--	NS	NS
50	Alkali Basin (31-40)	2				--	NS
50	Antelope Creek (41-50)	1					--

The statistical significance of all possible comparisons is given in the matrix. Asterisks indicate comparisons of differences between means which are significant at the 95 percent level; NS indicates nonsignificance. For example, both winter range locations sampled on the Almont Triangle had significantly higher elk pellet-group densities than were estimated for Flat Top; however, differences between Flat Top, Alkali Basin, and Antelope Creek were nonsignificant.

hectare (20 per acre). In all cases, counts were made of pellet-groups deposited from approximately mid-November to April.

The distributions of elk on winter range in the project area are strongly influenced by snow depth and the locations of unprotected haystacks. During the winter of 1978-79, movements of elk were restricted due to the deep snowfalls which occurred in January. Also, an elk feeding program conducted by the Division of Wildlife further concentrated many of the herds. During the winter of 1979-80 snow conditions were less severe, but agricultural hay stacks and livestock feeding again influenced locations and movement patterns, particularly on the south-facing slopes of Flat Top.

Because pellet-group transects were numerous and regularly spaced, localized areas where elk spent considerable time during the two winters of baseline investigation can be easily recognized (Tables II-2 through II-5). The extent to which elk may be more widely dispersed during mild winters will be evaluated during future years.

Mule deer pellet-group density estimates (Tables II-6 through II-9) were similar to elk in that winter range use tended to occur in localized areas. A significant correlation was found between the spatial distributions of elk and deer pellet-groups for the 1979-80 period ($p<0.05$). Discussions of statistical tests are given in Appendix B. Even though deer are less gregarious than elk, snow depth and the availability of agricultural hay also serves to concentrate and otherwise influence distributional patterns.

Differences between the first and the second year of baseline studies, in terms of pellet-group density estimates for both elk and deer, were not significangly different. Additional information on pellet-group distributions for elk and deer are shown in Appendix Tables II-1 through II-4.

Table II-2. Elk pellet-group densities in Alkali Basin.

Transects	Mean pellet-groups per hectare ± SE(n)* 1978-79	1979-80
31	50±50 (20)	0±0 (20)
32	200±92 (20)	0±0 (20)
33	100±69 (20)	0±0 (20)
34	56±56 (18)	0±0 (20)
35	50±50 (20)	150±82 (20)
36	50±50 (20)	100±69 (20)
37	0±0 (20)	0±0 (20)
38	200±92 (20)	250±123 (20)
39	0±0 (20)	0±0 (20)
40	0±0 (20)	0±0 (20)
Combined	71±18 (198)	50±17 (200)

*n = Number of $10m^2$ ($108\ ft^2$) quadrats.

Table II-3. Elk pellet-group densities on south-facing slopes of Flat Top.

Transect	Mean pellet-groups per hectare ± SE(n)* 1978-79	1979-80
1	50±50 (20)	50±50 (20)
2	50±50 (20)	150±109 (20)
3	150±82 (20)	300±105 (20)
4	0±0 (20)	100±69 (20)
5	0±0 (20)	250±123 (20)
6	0±0 (20)	50±50 (20)
7	0±0 (20)	100±69 (20)
8	50±50 (20)	50±50 (20)
9	200±156 (20)	50±50 (20)
10	150±109 (20)	200±92 (20)
11	150±109 (20)	100±69 (20)
12	0±0 (20)	200±117 (20)
13	50±50 (20)	50±50 (20)
Combined	65±20 (260)	127±23 (260)
14		0±0 (20)
15		0±0 (20)
16		0±0 (20)
17		0±0 (20)
18		0±0 (20)
19		0±0 (20)
20		0±0 (20)
Combined		0±0 (140)
56	158±86 (19)	
57	300±105 (20)	
58	0±0 (20)	
59	0±0 (20)	
60	0±0 (20)	
Combined	91±29 (99)	

*n = Number of 10 m^2 (108 ft^2) quadrats.

Table II-4. Elk pellet-group densities on the Almont Triangle.

Transects	Mean pellet-groups per hectare ± SE (n)* 1978-79	1979-80
21	200±92 (20)	0±0 (20)
22	150±82 (20)	0±0 (20)
23	0±0 (20)	500±185 (20)
24	50±50 (20)	50±50 (20)
25	53±53 (19)	500±212 (20)
26		850±196 (20)
27		600±210 (20)
28		211±96 (19)
29		400±112 (20)
30		700±219 (20)
Combined	91±29 (99)	381±52 (199)
51	250±99 (20)	100±69 (20)
52	200±92 (20)	650±150 (20)
53	0±0 (20)	684±188 (20)
54	100±69 (20)	200±92 (20)
55	100±69 (20)	50±50 (20)
Combined	130±34 (100)	337±59 (100)

* n = Number of 10 m^2 (108 ft^2) quadrats.

Table II-5. Elk pellet-group densities in Antelope Creek valley.

Transects	Mean pellet-groups per hectare ± SE(n)* 1979-80
41	150±82 (20)
42	50±50 (20)
43	250±99 (20)
44	50±50 (20)
45	0±0 (20)
46	0±0 (20)
47	0±0 (20)
48	0±0 (20)
49	0±0 (20)
50	0±0 (20)
Combined	50±15 (200)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Table II-6. Mule deer pellet-group densities in Alkali Basin.

Transects	Mean pellet-groups per hectare ± SE (n)* 1978-79	1979-80
31	50±50 (20)	50±50 (20)
32	0±0 (20)	50±50 (20)
33	0±0 (20)	150±82 (20)
34	167±90 (18)	100±69 (20)
35	100±69 (20)	0±0 (20)
36	350±150 (20)	350±150 (20)
37	200±92 (20)	200±92 (20)
38	150±82 (20)	250±123 (20)
39	50±50 (20)	0±0 (20)
40	150±82 (20)	50±50 (20)
Combined	121±25 (198)	120±26 (200)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Table II-7. Mule deer pellet-group densities on south-facing slopes of Flat Top.

Transects	Mean pellet-groups per hectare ± SE (n)* 1978-79	1979-80
1	450±135 (20)	100±69 (20)
2	150±82 (20)	50±50 (20)
3	300±164 (20)	200±92 (20)
4	0±0 (20)	150±82 (20)
5	0±0 (20)	100±69 (20)
6	0±0 (20)	0±0 (20)
7	0±0 (20)	0±0 (20)
8	0±0 (20)	0±0 (20)
9	0±0 (20)	0±0 (20)
10	100±69 (20)	0±0 (20)
11	50±50 (20)	0±0 (20)
12	0±0 (20)	0±0 (20)
13	200±200 (20)	0±0 (20)
Combined	96±25 (260)	46±13 (260)
14		0±0 (20)
15		0±0 (20)
16		0±0 (20)
17		0±0 (20)
18		0±0 (20)
19		0±0 (20)
20		0±0 (20)
Combined		0±0 (140)
56	158±86 (19)	
57	150±82 (20)	
58	0±0 (20)	
59	100±69 (20)	
60	50±50 (20)	
Combined	91±29 (99)	

*n = Number of 10 m^2 (108 ft^2) quadrats.

Table II-8. Mule deer pellet-group densities on the Almont Triangle.

Transects	Mean pellet-groups per hectare ± SE (n)* 1978-79	1979-80
21	400±112 (20)	0±0 (20)
22	350±150 (20)	50±50 (20)
23	150±82 (20)	50±50 (20)
24	550±185 (20)	250±99 (20)
25	158±86 (19)	300±164 (20)
26		250±99 (20)
27		300±105 (20)
28		53±53 (19)
29		500±212 (20)
30		100±69 (20)
Combined	323±59 (99)	186±35 (199)
51	50±50 (20)	200±117 (20)
52	350±150 (20)	150±82 (20)
53	0±0 (20)	0±0 (20)
54	50±50 (20)	50±50 (20)
55	100±69 (20)	200±92 (20)
Combined	110±37 (100)	120±36 (100)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Table II-9. Mule deer pellet-group densities in Antelope Creek valley.

Transects	Mean pellet-groups per hectare ± SE (n)* 1979-80
41	150±82 (20)
42	300±164 (20)
43	100±100 (20)
44	50±50 (20)
45	100±100 (20)
46	0±0 (20)
47	0±0 (20)
48	0±0 (20)
49	0±0 (20)
50	200±92 (20)
Combined	90±26 (200)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Utilization of Big Sagebrush.

Utilization of big sagebrush (*Artemisia tridentata*) by elk and deer on winter range was estimated on the Almont Triangle and on the south-facing slope of Flat Top. Data for both years of study are presented in Tables II-10 through II-13. A very limited amount of utilization was found for both winter periods. Namely, 5 and 0.8 percent was estimated for the south-facing slopes of Flat Top, and 3 and 5 percent was estimated for the Almont Triangle, for the 1978-79 and 1979-80 winter periods respectively. This amount of utilization is very low. In terms of range condition, winter-use levels somewhat in excess of 50 percent for southwestern Colorado have been reported as acceptable (Shepherd 1971).

Visual examination of other browse species in these two areas indicated low to moderate utilization as well. Bitterbrush (*Purshia tridentata*) was utilized surprisingly little on the Almont Triangle even though it is common there. Bitterbrush is absent from the south-facing slopes of Flat Top in the vicinity of transect locations. Black sagebrush (*Artemisia nova*) occurs, however, but utilization appeared low. The only browse species observed to be heavily utilized were choke cherry (*Prunus virginiana*) and serviceberry (*Amelanchier utahensis*). However, these species are uncommon and constitute a very small percentage of winter range forage.

As mentioned, elk and deer pellet-group counts were conducted at the same quadrat locations that were used for big sagebrush utilization estimates. Correlations of elk and deer pellet-group counts with percent utilization were highly significant ($p<0.001$ for both comparisons).

Mule Deer Mortality During the Winter of 1978-79.

Deer mortality studies were conducted during the severe winter of 1978-79. Of 905 live deer counted during road count studies conducted on 24 February 1979

Table II-10 Production and utilization of big sagebrush on south-facing slopes of Flat Top, 1978-79.

Transect	A PRODUCTION: Length of new shoots in Fall (mm) Mean ± SE (n)*	B Length of shoots remaining in Spring (mm) Mean ± SE (n)*	C UTILIZATION: in percent $C = \frac{A-B}{A} \times 100$
1	32±2.4 (20)	27±2.2 (20)	16
2	57±5.4 (20)	50±6.2 (20)	12
3	63±3.9 (20)	57±4.3 (20)	10
4	37±2.2 (20)	37±2.2 (20)	0
5	40±3.7 (20)	40±3.7 (20)	0
6	51±3.1 (20)	51±3.1 (20)	0
8	51±3.7 (20)	51±3.7 (20)	0
9	36±2.8 (20)	35±2.8 (20)	3
10	40±3.6 (20)	37±3.1 (20)	8
13	39±2.5 (20)	39±2.5 (20)	0
Combined	45±1.3 (200)	42±1.3 (200)	5

*n = Number of shrubs sampled

Table II-11 Production and utilization of big sagebrush on south-facing slopes of Flat Top, 1979-80.

Transect	A PRODUCTION: Length of new shoots in Fall (mm) Mean ± SE (n)*	B Length of shoots remaining in Spring (mm) Mean ± SE (n)*	C UTILIZATION: in percent $C = \frac{A-B}{A} \times 100$
1	72±5.5 (10)	72±5.5 (10)	0
2	73±7.5 (10)	73±7.5 (10)	0
3	50±2.9 (10)	47±3.9 (10)	6
4	48±2.5 (10)	48±2.5 (10)	0
5	53±4.3 (10)	53±4.3 (10)	0
6	80±7.4 (10)	80±7.4 (10)	0
7	64±4.4 (10)	62±4.2 (10)	4
8	68±8.7 (10)	68±8.7 (10)	0
9	49±4.2 (10)	49±4.2 (10)	0
10	56±5.3 (10)	56±5.3 (10)	0
11	57±4.5 (10)	57±4.5 (10)	0
12	52±7.4 (10)	52±7.4 (10)	0
13	62±6.5 (10)	62±6.5 (10)	0
Combined	60±1.8 (130)	59±1.8 (130)	0.8

*n = Number of shrubs sampled

Table II-12 Production and utilization of big sagebrush on the Almont Triangle, 1978-79.

Transect	A PRODUCTION: Length of new shoots in Fall (mm) Mean ± SE (n)*	B Length of shoots remaining in Spring (mm) Mean ± SE (n)*	C UTILIZATION: in percent $C = \frac{A-B}{A} \times 100$
21	61±3.8 (20)	57±3.4 (20)	7
22	45±3.8 (20)	44±3.8 (20)	2
23	58±4.6 (20)	57±4.6 (20)	2
24	51±3.6 (20)	49±3.6 (20)	4
25	58±3.8 (20)	58±3.8 (18)	0
Combined	55±1.8 (100)	53±1.8 (98)	3

*n = Number of shrubs sampled

Table II-13 Production and utilization of big sagebrush on the Almont Triangle, 1979-80.

Transect	A PRODUCTION: Length of new shoots in Fall (mm) Mean ± SE (n)*	B Length of shoots remaining in Spring (mm) Mean ± SE (n)*	C UTILIZATION: in percent $C = \frac{A-B}{A} \times 100$
21	40±3.5 (10)	40±3.5 (10)	0
22	61±5.4 (10)	59±5.8 (10)	2
23	41±2.8 (10)	39±3.7 (10)	3
24	54±4.7 (10)	49±5.6 (10)	9
25	55±5.1 (10)	52±7.2 (10)	6
26	51±4.4 (10)	48±3.6 (10)	6
27	53±3.7 (10)	46±5.6 (10)	14
28	53±4.7 (10)	53±4.7 (10)	0
29	61±4.7 (10)	59±5.9 (10)	4
30	52±5.4 (10)	49±6.4 (10)	5
Combined	52±1.5 (100)	49±1.7 (100)	5

*n = Number of shrubs sampled

(Appendix Table II-6), only 24 were fawns, or 2.7 percent of the population. Mortality affected all age classes, however, as evidenced by the data shown in Table II-14, which suggests that approximately 60 percent of the deer that died were adult animals.

Most of the winter mortality occurred between mid-January and mid-February. Deep snows during the first and second weeks of January virtually immobilized many deer that had not yet moved to low-elevation winter range. Clear nights and cold temperatures followed the January snow storms. Many deer that were being fed near roads starved in spite of the hay and processed pellets that were provided. A number of deer were also killed by vehicle collisions. Locations where most of the observed deer mortality occurred were near Highway 50 (Figure II-4). Relatively few deer died within the actual Mount Emmons Project area based on field observations that were conducted later in the spring.

Table II-14. Mule deer mortality. Age class estimates are of deer that died during the winter of 1978-79.

Age Class	Number Examined
Fawn	82
Yearling	43
2½ year old	30
3½ year old	16
4½ year old	24
5½ year old	7
6½ year old and older	7
Total	209

Ratio of fawns:adults = 65 fawns:100 adults

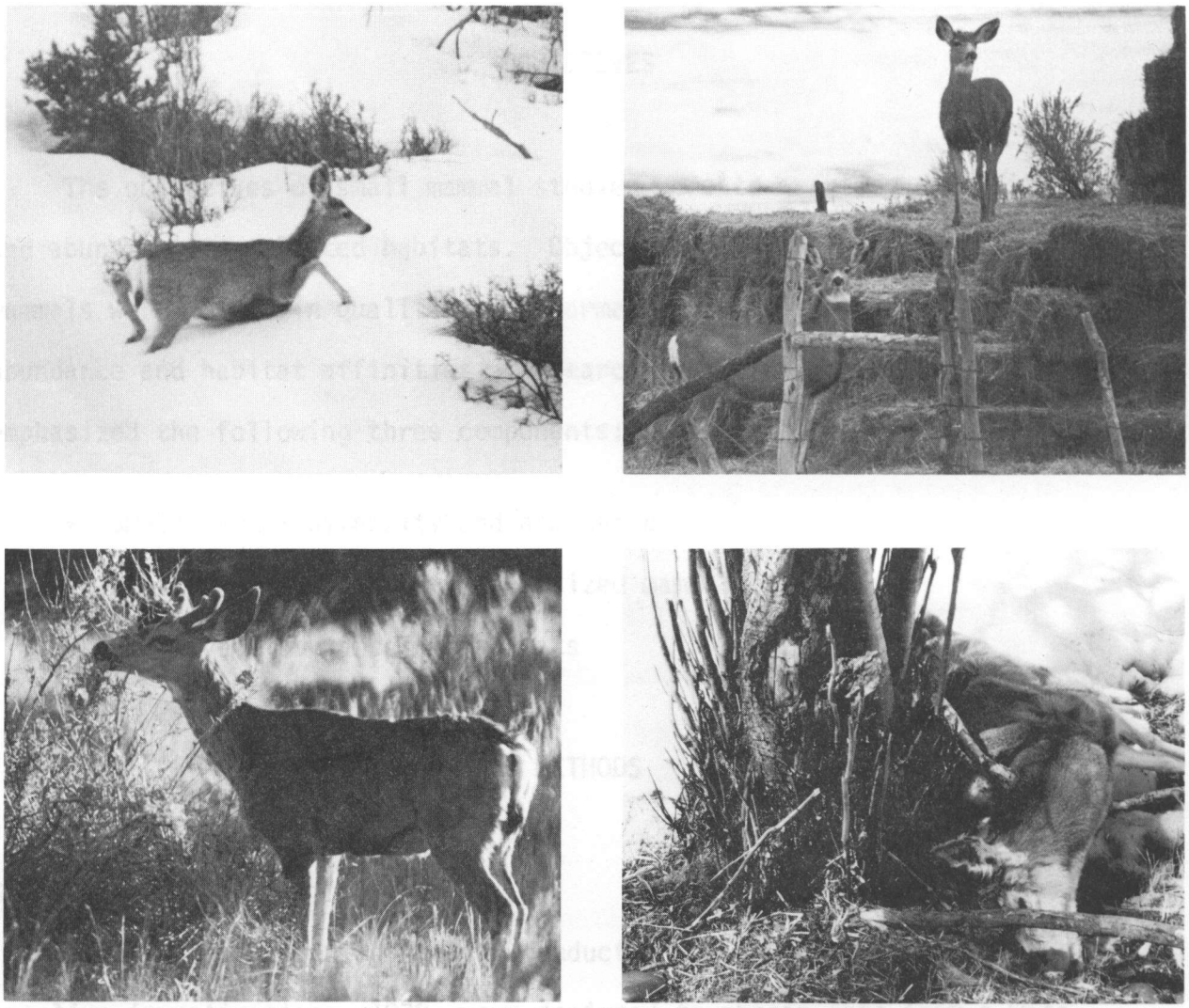


Figure II-4. Mule deer on winter range. From left to right: deer feeding on browse; use of hay stacks during times of deep snow; fawn struggling through crusted snow; starvation and severe browsing of woody vegetation.

OBJECTIVES

The objectives of small mammal studies were to quantify diversity and abundance in selected habitats. Objectives of studies on medium-sized mammals were to obtain qualitative information on general levels of abundance and habitat affinities. Research design and data analysis emphasized the following three components:

- Small mammal diversity and abundance
- Habitat affinities of medium-sized mammals
- Relative importance of habitats

METHODS

Small Mammals.

Small mammal trapping studies conducted during the first year of baseline investigations, 1978, were designed to obtain data from a wide range of habitats. Prior to the second year, capture results were evaluated for sampling efficiency. Based on these results, the methods for the second year were modified to optimize the field effort.

Methods used during the second year, 1979, consisted of using a linear arrangement of live traps (transects) consisting of ten traps spaced at 10 m (32.8 ft) intervals. In areas where future long-term monitoring might occur, transects were repositioned on each successive day of trapping to obtain better information on spatial variation of populations and to minimize recaptures. Transects were not repositioned

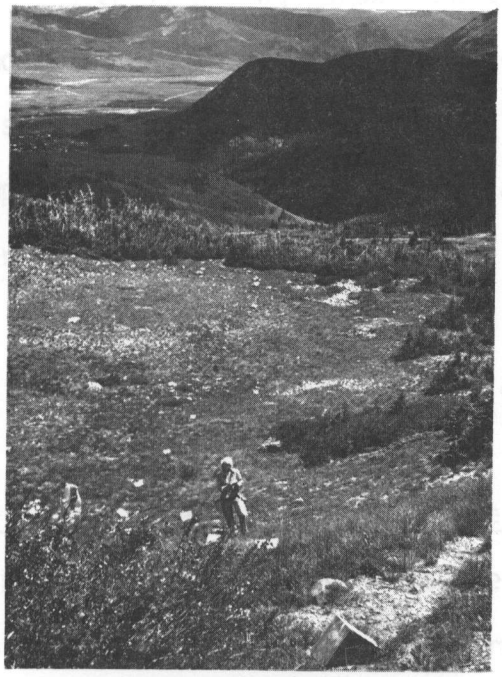
at other sampling locations. Randomization of transect location was accomplished using systematic sampling procedures (the first location of regularly-placed transects was chosen at random; see Cochran, 1977). All trapping during 1979 occurred in early August. Traps were baited with rolled oats and checked each day. Hoods were placed over the traps to provide protection against heat and rain (Figure II-5).

During the first year of baseline studies, trapping occured in July and in August, with transects consisting of 25 and 15 traps per transect for each month respectively.

The sampling adequacy attempted was obtaining standard errors within 10 to 15 percent of the mean for the most abundant species. This is equivalent to estimating the true mean within 20 to 30 percent of the sample mean 95 percent of the time. This level of accuracy was usually obtained using 30 transects (300 trap-nights) per sampling location.

Medium-sized Mammals.

Mammals ranging in size from cottontails to coyotes were studied mainly by qualitative methods designed to generally characterize levels of abundance and local habitat affinities. Beaver populations were evaluated by recording beaver ponds from an airplane, and by field examination of ponds, dams, and available habitat. Coyotes were counted from an airplane, and vocalizations, scats, and sightings were recorded during the course of other field activities. The apparent levels of abundance of jackrabbits, snowshoe hares, and cottontails were based on direct sightings and observations of droppings or gnawed shrubs. Colonies of Gunnison's prairie dogs (*Cynomys gunnisoni*) were recorded as to location and estimated size. Less common species that usually are not active in winter, such as skunks, raccoons, and marmots, were recorded when



A small mammal trapline in Red Lady Basin on Mount Emmons.

Examination of freshly scarred aspen trees resulting from winter feeding by voles beneath deep snowpack.

Figure II-5. Quantitative and qualitative field investigations.

observed in the field or as road kills, or identified by tracks. During winter and early spring, snow transects were traversed on skis and by snowmobiles, and identifications were made of tracks on snow. This method was used for identifying marten and long-tailed weasels, and for attempting to identify such species as lynx (*Lynx canadensis*) and wolverine (*Gulo gulo*).

RESULTS AND DISCUSSION

Small Mammal Diversity and Abundance.

Results of live trapping studies for the two years of baseline investigation (Table II-15) show strong similarities in small mammal species composition among the habitats sampled. The preferred measure of species diversity for small mammals is richness, S, the number of species present. Diversity for the 1979 period was highest in the riparian habitat of Coal Creek (S = 9) and the riparian habitat of Alkali Basin (S = 8), and lowest in the conifer and aspen habitats, and low-elevation sagebrush habitats where richness values ranged from 3 to 5.

In Table II-16 habitats are ranked in terms of relative abundance of cricetid rodents (deer mice and voles). These data emphasize differences in abundance among trapping locations for those species that are ecologically similar prey species. Sciurid rodents (chipmunks and ground squirrels) were omitted, because the varying amount of time that traps are operative during daylight hours introduces unanalyzable variability into capture results.

Habitat affinities for each species of cricetid rodent are shown in Figure II-6 . There is a tendency for deer mice to occur in the drier sagebrush habitats, while red-backed voles are virtually restricted to habitats with conifers. These patterns of habitat affinities are typical

Table II-15. Summary of small mammal diversity and abundance. The table compares differences between 1978 and 1979 in the same locations. Data shown are means (number of captures per transect) ± standard errors; n equals the number of 10-trap transects; sec is the section where transects were located.

Location and Habitat	Species*	RELATIVE ABUNDANCE $\bar{X}$±SE(n) 1978	1979
Lower Alkali Basin:			
Sage (sec 22)	Pm	1.4 ±0.19(30)	3.4 ±0.37(30)
	Em	0.7 ±0.17(30)	1.0 ±0.15(30)
	Sl	1.3 ±0.15(30)	0.2 ±0.09(30)
	Ml	-0-	0.2 ±0.08(30)
Sage (sec 21,22)	Pm		3.4 ±0.35(30)
	Em	n o	0.9 ±0.20(30)
	Sl	d a t a	0.2 ±0.07(30)
	Ml		0.1 ±0.07(30)
	Mm		0.1 ±0.05(30)
Riparian (sec 21,22)	Pm	0.1 ±0.06(30)	1.2 ±0.29(30)
	Mp	-0-	0.9 ±0.26(30)
	Mm	0.2 ±0.07(30)	0.8 ±0.16(30)
	Sv	-0-	0.03±0.03(30)
	Sc	-0-	0.03±0.03(30)
	Em	-0-	0.03±0.03(30)
	Ml	0.1 ±0.06(30)	-0-
	Zp	0.1 ±0.05(30)	-0-
Upper Alkali Basin:			
Sage (sec 24,25)	Pm	0.5 ±0.12(30)	2.3 ±0.34(30)
	Em	0.1 ±0.06(30)	0.2 ±0.07(30)
	Sl	-0-	0.1 ±0.10(30)
	Mm	-0-	0.1 ±0.05(30)
Sage (sec 19,30)	Pm	0.8 ±0.18(27)	1.8 ±0.22(30)
	Em	-0-	0.5 ±0.12(30)
	Ml	-0-	0.3 ±0.10(30)
	Mm	-0-	0.3 ±0.10(30)
	Sl	-0-	0.1 ±0.06(30)
	Sv	0.03±0.03(30)	0.03±0.03(30)
Sage (sec 20,29)	Pm	1.5 ±0.17(30)	2.2 ±0.25(30)
	Ml	-0-	0.3 ±0.10(30)
	Em	0.03±0.03(30)	0.3 ±0.10(30)
	Mm	-0-	0.2 ±0.07(30)

Table II-15. (Cont.) Summary of small mammal diversity and abundance.

Location and Habitat	Species*	RELATIVE ABUNDANCE $\bar{X}$±SE(n) 1978	1979
Carbon Creek Drainage:			
Conifer-Aspen (sec 32,33)	Em	0.8 ±0.20(18)	1.9 ±0.26(30)
	Ml	-0-	1.5 ±0.22(30)
	Pm	1.6 ±0.36(18)	0.8 ±0.17(30)
	Cg	0.1 ±0.06(18)	0.5 ±0.13(30)
	Mm	0.1 ±0.06(18)	0.1 ±0.06(30)
	Sl	0.1 ±0.06(18)	0.1 ±0.06(30)
Aspen (sec 32,33)	Mm		1.7 ±0.29(30)
	Ml	no	1.7 ±0.25(30)
	Em	data	1.1 ±0.28(30)
	Pm		1.0 ±0.17(30
Riparian (sec 32,29)	Mm	0.4 ±0.24(9)	
	Pm	0.2 ±0.15(9)	
	Sp	0.1 ±0.11(9)	no
	Sv	0.1 ±0.11(9)	data
	Zp	0.2 ±0.15(9)	
	Em	0.1 ±0.11(9)	
Ohio Pass:			
Conifer	Cg	no	2.6 ±0.30(30)
	Pm	data	0.4 ±0.11(30)
	Em		0.2 ±0.10(30)
Mount Emmons:			
Subalpine meadow (sec 31)	Mm		0.3 ±0.08(30)
	Ml		0.2 ±0.13(30)
	Em	no	0.2 ±0.07(30)
	Sl	data	0.1 ±0.06(30)
	Cg		0.1 ±0.06(30)
	Pm		0.03±0.03(30)
Conifer (sec 5,6)	Pm	0.7 ±0.22(30)	
	Cg	0.6 ±0.14(30)	no
	Em	o.8 ±0.17(30)	data
	Mm	0.03±0.03(30)	
Aspen (sec 5,6,32)	Em	2.5 ±0.40(15)	1.3 ±0.20(30)
	Pm	1.7 ±0.32(15)	1.2 ±0.19(30)
	Ml	-0-	0.4 ±0.13(30)
	Mm	-0-	0.1 ±0.05(30)
	Zp	-0-	0.03±0.03(30)

Table II-15. (Cont.) Summary of small mammal diversity and abundance.

Location and Habitat	Species*	RELATIVE ABUNDANCE $\bar{X}$±SE(n) 1978	1979
Bog (sec 6)	Cg		1.0 ±0.21(30)
	Em		0.5 ±0.12(30)
	Mm	n o	0.2 ±0.07(30)
	Pm	d a t a	0.1 ±0.08(30)
	Ml		0.1 ±0.05(30)
	Me		0.03±0.03(30)
Grass-Forb meadow (sec 5,6)	Pm	1.5 ±0.29(30)	
	Em	1.6 ±0.22(30)	n o
	Sl	1.0 ±0.17(30)	d a t a
	Ml	0.03±0.03(30)	
	Zp	0.03±0.03(30)	
Coal Creek Riparian (sec 4,5,6,7)	Em	0.5 ±0.16(30)	0.4 ±0.14(30)
	Pm	0.7 ±0.14(30)	0.3 ±0.12(30)
	Ml	0.03±0.03(30)	0.2 ±0.10(30)
	Mm	0.2 ±0.07(30)	0.1 ±0.08(30)
	Cg	0.1 ±0.08(30)	0.03±0.03(30)
	Zp	0.2 ±0.08(30)	0.03±0.03(30)
	Sv	0.03±0.03(30)	0.03±0.03(30)
	Me	-0-	0.03±0.03(30)
	Sp	0.1 ±0.07(30)	-0-
Washington Gulch:			
Conifer (sec 15,16)	Pm	1.3 ±0.22(14)	n o
	Em	0.9 ±0.29(14)	d a t a
	Cg	1.0 ±0.26(14)	
Aspen (sec 15,16)	Em	1.3 ±0.16(15)	n o
	Pm	0.7 ±0.16(15)	d a t a

* Pm = *Peromyscus maniculatus*, Deer Mouse
Em = *Eutamias minimus*, Least Chipmunk
Sl = *Spermophilus lateralis*, Golden-mantled Ground Squirrel
Ml = *Microtus longicaudus*, Long-tailed Vole
Mm = *Microtus montanus*, Montane Vole
Mp = *Microtus pennsylvanicus*, Meadow Vole
Sv = *Sorex vagrans*, Wandering Shrew
Sc = *Sorex cinereus*, Masked Shrew
Sp = *Sorex palustris*, Water Shrew
Cg = *Clethrionomys gapperi*, Gapper's Red-backed Vole
Me = *Mustela erminea*, Ermine
Zp = *Zapus princeps*, Western Jumping Mouse

Table II-16. Comparison of small mammal abundance among habitats during 1979. Trapping locations are ranked from highest to lowest in terms of mean number of captures per 10-trap transect.

MEANS	HABITAT AND LOCATION	RANK	Comparison of Ranked Habitats: RANK 13	12	11	10	9	8	7	6	5	4	3	2	1
4.40	Aspen, Carbon Creek (sec 32,33)	13	--	NS	NS	*	*	*	*	*	*	*	*	*	*
3.70	Sage, Lower Alkali Basin (sec 21,22)	12		--	NS	NS	NS	NS	*	*	*	*	*	*	*
3.60	Sage, Lower Alkali Basin (sec 21,22)	11			--	NS	NS	NS	NS	*	*	*	*	*	*
2.97	Conifer, Ohio Pass	10				--	NS	NS	NS	NS	*	*	*	*	*
2.87	Riparian, Lower Alkali Basin (sec 21,22)	9					--	NS	NS	NS	NS	*	*	*	*
2.87	Conifer-Aspen, Carbon Creek (sec 32,33)	8						--	NS	NS	NS	*	*	*	*
2.63	Sage, Upper Alkali Basin (sec 19,24,25,30)	7							--	NS	NS	NS	*	*	*
2.37	Sage, Upper Alkali Basin (sec 19,24,25,30)	6								--	NS	NS	NS	*	*
2.33	Sage, Upper Alkali Basin (sec 19,24,25,30)	5									--	NS	NS	*	*
1.63	Aspen, Mount Emmons (sec 5, 6, 32)	4										--	NS	*	*
1.37	Bog, Mount Emmons (sec 6)	3											--	NS	NS
0.63	Subalpine, Mount Emmons (sec 31)	2												--	NS
0.63	Riparian, Coal Creek (sec 4, 5, 6, 7)	1													--

The statistical significance of all possible comparisons is given in the matrix. Asterisks indicate comparisons of differences between means which are significant at the 95 percent level; NS indicates nonsignificance. For example, the abundance of small mammals in the Aspen habitat that ranks 4 is significantly greater than the abundance of small mammals in the Subalpine habitat that ranks 2; differences are not significantly different, however, between the habitats that rank 4 and 3. Comparisons relate only to cricetid rodents (deer mice and voles).

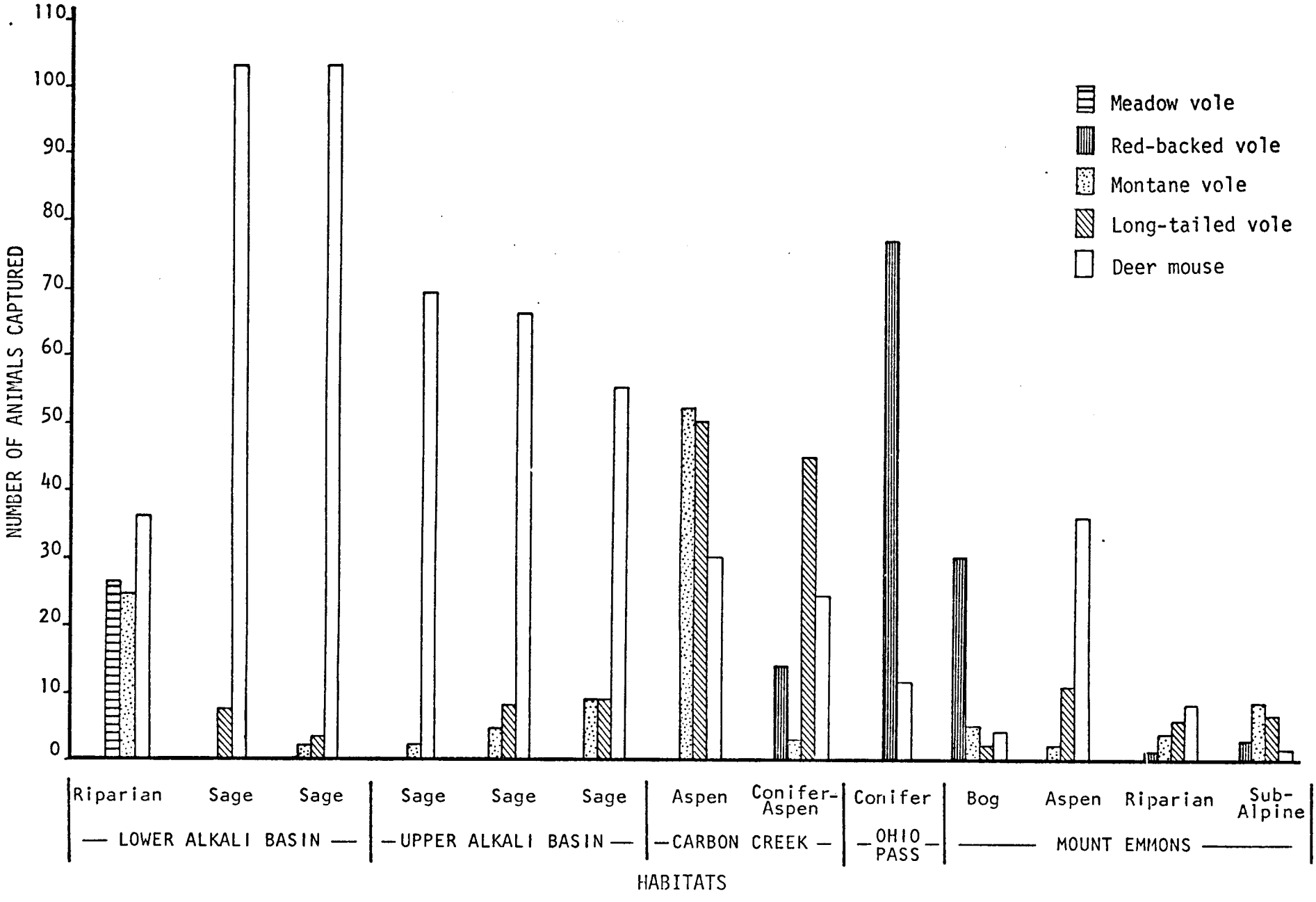


Figure II-6. Habitat affinities of small mammals based on trapping results, 1979. An equal trapping effort (300 trap-nights) occurred in each habitat.

over wide geographic areas. The habitat affinities of the long-tailed vole, meadow vole, and montane vole (*Microtus montanus*), however, tend not to be the same geographically or even regionally. The meadow vole has a restricted distribution in the project area, and was identified only in the riparian habitat of lower Alkali Basin. The habitat affinities of the long-tailed and montane vole within the project area were surprisingly similar and were significantly correlated ($p<0.05$). Discussions of statistical tests are presented in Appendix B.

Examination of the data in Table II-15 suggests that populations of small mammals might have been higher in 1979 than in 1978. Differences between years, however, were not significantly different. No statistically significant differences were found between successive trapping days in the big sagebrush of Alkali Basin, the aspen or the conifer-aspen habitat of Carbon Creek. In 1978, results obtained using snap traps and live traps were compared for differences in capture success. Peanut butter and rolled oats were used in snap traps and live traps respectively. Differences were not significant.

Identifications of small mammals followed Armstrong (1972) and Lechleitner (1969). Chipmunks were identified following the criterion of White (1953). Efforts were made to identify the Colorado chipmunk (*Eutamias quadrivittatus*). All bacula examined, however, were of the least chipmunk (*Eutamias minimus*). One specimen of a Colorado chipmunk was identified by Findley and Negus (1953) during their work in the vicinity (referred to by them as the Say chipmunk). The pygmy shrew (*Microsorex hoyi*) was reported in the area by DeMott and Lindsey (1975); the heather vole (*Phenacomys intermedius*) was reported by Findley and Negus (1953). Neither of these species was identified during baseline studies. No bats were identified. Six species of bats are listed in the East River Unit wildlife inventory species list (USDA 1978).

Habitat Affinities of Medium-sized Mammals.

Thirteen species of medium-sized mammals were identified during the two years of baseline investigation (Table II-17). The studies of medium-sized mammals emphasized presence of animals rather than numbers.

The Nuttall's cottontail (or mountain cottontail) was observed in montane habitats throughout the project area.

Snowshoe hares were observed in the higher elevations of montane, coniferous and aspen forests.

White-tailed jackrabbits were observed only in sagebrush habitats.

Yellow-bellied marmots were observed in montane habitats and in agricultural meadows along Ohio Creek just north of Carbon Creek. Two were observed at timberline on Mount Emmons.

Gunnison's prairie dogs (*Cynomys gunnisoni*) were observed at five locations: in section 23 of lower Alkali Basin; section 15, north of Almont; section 36, on the south-facing slope of Flat Top near Ohio Creek; section 14, approximately 3.2 km (2 mi) southwest of Flat Top; and in section 27, near Ohio Creek approximately 6.4 km (4 mi) south of Mill Creek. None of the colonies appeared to consist of more than twenty adult animals.

Fourteen beaver dams showing recently gnawed wood were counted in Coal Creek. An elaborate and extensive clustering of beaver ponds occurs in upper Carbon Creek. One active beaver pond occurs in upper Alkali Creek. Recent signs of beaver were found along the Slate, Ohio, and East Rivers.

Two muskrats (*Ondatra zibethicus*) were observed in Ohio Creek.

Porcupines (*Erethizon dorsatum*) were observed in coniferous forest and sagebrush habitats. Signs of porcupine damage to trees were not observed to be extreme at any location.

Table II-17. Summary of identifications and habitat affinities of mammals. Nomenclature follows Armstrong (1972).

Species	Comments Based on Two Yrs. of Baseline investigation
INSECTIVORES:	
Masked Shrew *Sorex cinereus*	One specimen captured in riparian habitat of lower Alkali Creek.
Wandering Shrew *Sorex vagrans*	Collected in moist, riparian habitats and in big sagebrush.
Water Shrew *Sorex palustris*	Three collected from montane, riparian habitat.
LAGOMORPHS:	
Pika *Ochotona princeps*	Talus slopes. Observed as low as 8,800 feet (2,682m) in Alkali Basin.
Nuttall's Cottontail *Sylvilagus nuttallii*	Montane habitats.
Snowshoe Hare *Lepus americanus*	Coniferous forests.
White-tailed Jackrabbit *Lepus townsendii*	Only observed in big sagebrush habitat.
RODENTS:	
Least Chipmunk *Eutamias minimus*	Observed in all habitats.
Yellow-bellied Marmot *Marmota flaviventris*	Rocky montane habitats.
Golden-mantled Ground Squirrel *Spermophilus lateralis*	Montane habitats.
Gunnison's Prairie Dog *Cynomys gunnisoni*	Colonies occur in lower Alkali Basin and near Almont.
Chickaree (Red Squirrel) *Tamiasciurus hudsonicus*	Coniferous forest.
Northern Pocket Gopher *Thomomys talpoides*	Montane meadow and aspen habitats.

Table II-17. (Cont.) Summary of identifications and habitat affinities of mammals.

Species	Comments Based on Two Yrs. Baseline Investigation
Beaver *Castor canadensis*	Streams.
Deer Mouse *Peromyscus maniculatus*	All habitats.
Gapper's Red-backed Vole *Clethrionomys gapperi*	Coniferous forest.
Montane Vole *Microtus montanus*	Big sagebrush and grassy montane habitats.
Meadow Vole *Microtus pennsylvanicus*	Found only in riparian of lower Alkali Creek.
Long-tailed Vole *Microtus longicaudus*	Big sagebrush and grassy montane habitats.
Muskrat *Ondatra zibethicus*	Observed in agricultural riparian habitats.
Western Jumping Mouse *Zapus princeps*	Montane meadow habitats.
Porcupine *Erethizon dorsatum*	Observed in big sagebrush and coniferous forest.
CARNIVORES:	
Coyote *Canis latrans*	All habitats.
Raccoon *Procyon lotor*	Tracks observed in riparian habitat of East River at Almont and in Alkali Basin.
Black Bear *Ursus americanus*	Sign observed in conifer and aspen habitats.
Marten *Martes americana*	Tracks observed in montane habitat.
Ermine *Mustela erminea*	Observed in montane meadow habitat.
Long-tailed Weasel *Mustela frenata*	Observed in montane meadow and aspen habitats.

Table II-17. (Cont.) Summary of identifications and habitat affinities of mammals.

Species	Comments Based on Two Yrs. of Baseline Investigation
Striped Skunk *Mephitis mephitis*	Observed in agricultural riparian habitats.
Bobcat *Lynx rufus*	Tracks observed twice in montane habitat.
UNGULATES:	
American Elk *Cervus canadensis*	Winter range is typically big sagebrush habitat; summer range is typically mixed conifer-aspen-meadow habitat.
Mule Deer *Odocoileus hemionus*	Winter range is typically big sagebrush habitat; summer range is typically mixed conifer-aspen-meadow habitat.
Bighorn Sheep *Ovis canadensis*	Winter range occurs on the Almont Triangle; not observed in project area during summer.

Coyotes were observed from the air during winter and summer, especially in Alkali Basin and areas to the west and north. Tracks on snow were seen in these areas as well. Coyotes are a wide-ranging animal, and could be expected to occur in most habitats.

Raccoon tracks were observed near Almont in the riparian habitat of the East River, and in the mud by a pond in upper Alkali Basin. The raccoon is not recorded for Gunnison County by Armstrong (1972), but is included in the species list of the East River Unit management plan (USDA 1978).

Marten tracks were observed in the snow on Mount Emmons, in the Carbon Creek drainage, and near Ohio Pass. They probably occur widely throughout montane forest areas.

Striped skunks were observed in agricultural riparian habitats at the southern end of the project area. They were also observed as road kills south of Almont.

Bobcat (*Lynx rufus*) tracks were observed on snow on two occasions. Both observations were made on Mount Emmons in mixed conifer-aspen habitat.

OBJECTIVES

The objectives of bird studies were to quantify breeding bird diversity and abundance in the major habitat types, and to evaluate potentially critical areas. Research design and data analysis emphasized the following four components:

- Breeding bird diversity and abundance
- Raptorial birds
- Game bird habitat affinities
- Relative importance of habitats

METHODS

Studies of bird diversity and abundance were conducted using replicated belt transect procedures similar to the methods of Emlen (1971). The counts were performed by recording the number of birds of each species that were observed along transects approximately 100 m (328 ft) wide by 800 m (2,625 ft) long. Counts along each transect were of a one-hour duration. Birds seen at distances greater than 50 m (164 ft) from the observer were not included in results used for comparisons of differences among habitats. This procedure was followed to reduce bias due to visibility differences between dense and open habitats. Counts were conducted between 0600 and 1000 hours during June, and only on calm and clear days. Qualitative observations were made during other seasons of the year.

Raptorial birds were identified at all seasons of the year and recorded as to location and habitat. Active nests were recorded as well, although

no efforts were made to count the number of young fledged. Raptorial bird counts also occurred as part of the diversity and abundance studies described above. Considerable field effort was expended during fall and spring to identify migrating or nesting raptors in suitable habitats.

Game bird observations also were made at all seasons of the year. Observations of sage grouse, white-tailed ptarmigan, and blue grouse were recorded by location, and information on number of young and adult birds was obtained when possible. Waterfowl were recorded when observed and suitable aquatic habitats were examined periodically, especially during fall and spring migration periods.

Sage grouse studies conducted in the spring of 1980 consisted of fixed-wing aerial flights, counts of strutting males, and pellet counts. Three aerial flights were conducted the last week in April primarily for the purposes of locating leks (strutting grounds). Flights began shortly before dawn and occurred over approximately the southern half of the project area. Counts of strutting males were conducted from the ground using binoculars and spotting scopes. Pellet counts were conducted by recording the presence of droppings along eight transects, four 2 m x 2 km (6.6 ft x 1.2 mi) and four 2 m x 4 km (6.6 ft x 2.5 mi). The shorter transects were positioned near leks. The longer transects were positioned west of Alkali Basin.

RESULTS AND DISCUSSION

Breeding Bird Diversity and Abundance.

The number of birds identified in the project area totaled 120 species (Table II-22). Six are not listed on the checklist of birds for Gunnison

National Forest (USDA 1977, 78), or by Keeler-Wolf et al. (1973): the cattle egret (*Bubulcus ibis*), American avocet (*Recurvirostra americana*), mockingbird (*Mimus polyglottos*), gray-cheeked thrush (*Catharus minimus*), LeConte's sparrow (*Ammospiza caudacutus*), and lark bunting (*Calamospiza melanocorys*).

Because of the vast size of the project area, sampling design and data analysis focused on detecting patterns or consistencies in bird diversities that would permit generalizations. The data obtained from two years of baseline investigation are presented in Tables II-18 and II-19, and in Appendix Tables II-8 and II-9. Table II-18 summarizes the results of transect counts for 1978 and 1979. Table II-19 ranks species diversity across habitats, and compares diversity and abundance estimates for each location sampled. Appendix Tables II-8 and II-9 are first reductions of field data that show abundance values for each species at each sampling location.

The average number of different birds one is likely to encounter in a given habitat is a valid and meaningful expression of diversity. The results of transect counts shown in Table II-18 are expressed in this way. The standard error, SE, is simply the range within which the average value would be expected to occur should another sample be taken. The number of species observed, S (or richness), is shown as well. Elaboration of all statistical tests is provided in Appendix B.

In Table II-19, habitats are ranked from highest to lowest in terms of average diversity. Richness was strongly correlated with average diversity ($p<0.001$), thus the order of the ranked habitats would be similar regardless of the diversity parameter used.

Breeding bird diversities throughout Alkali Basin did not differ greatly among locations. The only statistically significant differences

Table II-18. Summary of breeding bird diversities. The table compares differences between 1978 and 1979 in the same locations. Data shown are means ± standard errors; n equals the number of one-hour transect counts; S is richness, the total number of species observed; sec is the section where transects were located.

Location and Habitat	BIRD DIVERSITY: Avg. No. of Species Observed During One-Hour Transect Counts $\bar{X}$±SE(n)		BIRD DIVERSITY: Total No. of Species Observed S	
	1978	1979	1978	1979
Lower Alkali Basin:				
Riparian (sec 21,22)	12.2±0.40(6)	--	29	--
Sage (sec 22)	5.8±0.95(6)	7.7±1.43(6)	14	20
Riparian (sec 21,22)	10.8±1.56(5)	11.8±2.07(6)	29	34
Upper Alkali Basin:				
Sage (sec 24,25)	5.0±0.63(6)	6.7±0.72(6)	11	17
Sage (sec 19,20,30)	--	6.0±0.52(6)	--	15
Aspen (sec 28,29)	--	8.5±0.99(6)	--	20
Carbon Creek Drainage:				
Sage (sec 17)	--	7.8±1.22(6)	--	21
Conifer-Aspen (sec 32,33)	8.0±0.41(4)	12.5±1.80(6)	18	31
Aspen (sec 32,33)	--	13.2±0.54(6)	--	32
Riparian (sec 17,20)	--	15.5±1.50(6)	--	36
Riparian (sec 5,32)	--	12.0±2.03(6)	--	28
Ohio Pass:				
Conifer	--	7.7±0.49(6)	--	17
Ohio Creek:				
Riparian (sec 18,19,20,29)	--	14.2±1.33(6)	--	37
Mount Emmons:				
Alpine (sec 31)	6.8±1.28(5)	4.3±0.67(6)	15	11
Conifer (sec 5,6)	7.5±0.50(2)	7.0±0.93(6)	13	19
Aspen (sec 5,6,32)	--	15.3±0.88(6)	--	37
Bog (sec 6)	--	14.0±2.10(6)	--	30
Riparian (sec 4)	7.4±0.68(5)	7.5±0.89(6)	18	28
Riparian (sec 5,6)	6.6±1.29(5)	8.3±0.92(6)	19	26
Riparian (sec 34,35)	--	13.2±1.01(6)	--	28
Washington Gulch:				
Conifer (sec 15,16)	10.0±3.00(2)	--	14	--
Aspen (sec 15,16,22)	11.0±0.71(4)	--	23	--

Table II-18.(Cont) Summary of breeding bird diversities.

Location and Habitat	BIRD DIVERSITY: Avg. No. of Species Observed During One-Hour Transect Counts $\bar{X}$±SE(n)		BIRD DIVERSITY: Total No. of Species Observed S	
	1978	1979	1978	1979
Anthracite Creek:				
Conifer	9.7±1.80(6)	--	24	--
Aspen	14.8±1.45(8)	--	32	--
Riparian	15.2±0.83(6)	--	34	--

Table II-19. Comparison of bird diversities among habitats during 1979.

BIRD DIVERSITY $\bar{X}$[1]	BIRD DIVERSITY S[2]	AVERAGE ABUNDANCE[3]	HABITAT	LOCATION
15.5	36	71	Riparian	Carbon Creek (sec 17, 20)
15.3	37	45	Aspen	Mount Emmons (sec 5, 6, 32)
14.2	37	54	Riparian	Ohio Creek (sec 18, 19, 20, 29)
14.0	30	39	Bog	Mount Emmons (sec 6)
13.2	28	57	Riparian	Slate River (sec 34, 35)
13.2	32	43	Aspen	Carbon Creek (sec 32, 33)
12.5	31	41	Conifer-Aspen	Carbon Creek (sec 32, 33)
12.0	28	37	Riparain	Carbon Creek (sec 5, 32)
11.8	34	43	Riparian	Lower Alkali Basin (sec 21, 22)
8.5	20	29	Aspen	Upper Alkali Basin (sec 28, 29)
8.3	26	22	Riparain	Coal Creek (sec 5, 6)
7.8	21	30	Sage	Carbon Creek (sec 17)
7.7	17	28	Conifer	Ohio Pass
7.7	20	26	Sage	Lower Alkali Basin (sec 22)
7.5	28	20	Riparian	Coal Creek (sec 4)
7.0	19	20	Conifer	Mount Emmons (sec 5, 6)
6.7	17	25	Sage	Upper Alkali Basin (sec 24, 25)
6.0	15	15	Sage	Upper Alkali Basin (sec 19, 30)
4.3	11	18	Alpine	Mount Emmons (sec 31)

Sampling locations are ranked from highest to lowest in terms of mean number of species observed during one-hour transect counts. Note, however, that bird diversity is not strongly associated with habitat type or location, rather the relationship appears to correspond most closely to the degree of interspersion or patchiness of habitat (see Figure 11).

[1] $\bar{X}$ = The average number of species observed during one-hour transect counts.
[2] S = The number of species observed during six transect counts conducted in each habitat.
[3] Average Abundance = the average number of birds of all species combined.

found were between the riparian habitat of lower Alkali Basin and the two sagebrush sampling locations of the upper basin area ($p<0.05$).

Bird diversities on Mount Emmons for 1979 (Table II-18) are significantly different for the bog, aspen, and riparian (sec 34, 35) habitats, compared to the alpine, conifer, and the two remaining riparian habitats ($p<0.05$), the first group of habitats having the highest average diversity. These two groups of habitats do not show significant differences among themselves, however.

Among the five habitats sampled in the Carbon Creek drainage, only the sagebrush habitat significantly differs in average diversity ($p<0.05$).

Breeding bird diversities increased significantly during the second year of baseline investigation in terms of S diversities ($p<0.05$).

The extent to which breeding bird diversities are associated with the various habitat types in the Mount Emmons Project area is easiest to evaluate using Table II-19, but it will be noticed that there is no clearly recognizable pattern. Some riparian areas, for example, rank relatively low, whereas others rank high. Based on observed differences in habitat uniformity, however, there appears to be a positive correlation between habitat interspersion or large-scale patchiness (Figure II-7) and bird diversity. Low-ranking habitats in the project area tend to have a uniform vegetational structure over a large area (the sagebrush of Alkali Basin, for example) whereas high-ranking habitats tend to exist within a mosaic of structurally distinct plant communities (in Carbon Creek, for example, riparian thickets, agricultural meadows, sagebrush, grass-forb meadows, aspen and conifer forests, all occur in close proximity). Frequently the interspersion of habitat that attracts a wide variety of birds is also a landscape having high visual quality.

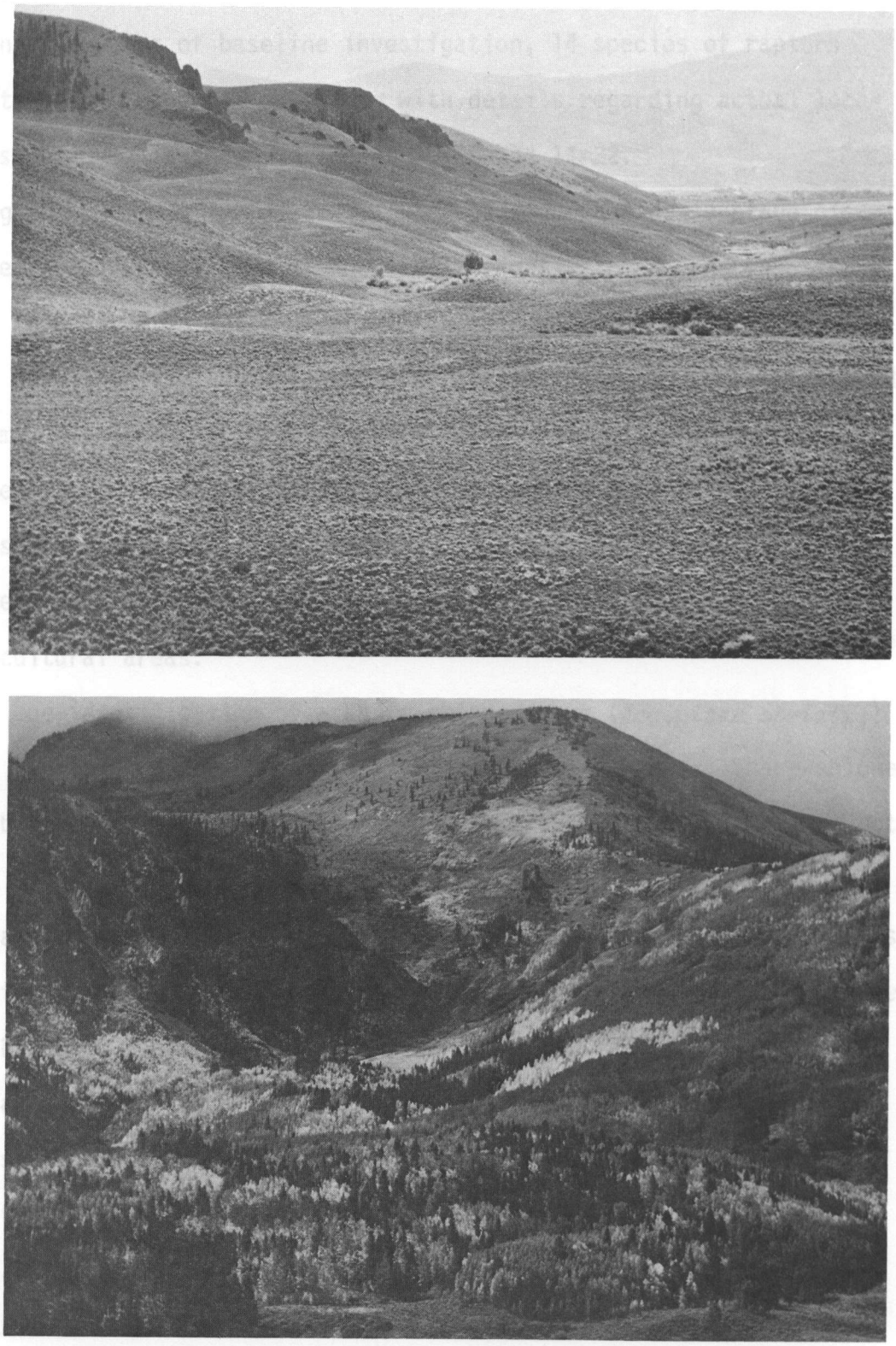


Figure II-7. Comparison of a relatively uniform habitat with a habitat displaying interspersion or large-scale patchiness of vegetation type. Wildlife diversity tends to be greatest in habitats having the most structural complexity.

Raptorial Birds.

In the two years of baseline investigation, 14 species of raptors were identified. Each species, along with details regarding actual locations of sightings, is shown in Tables II-20 and II-22.

One goshawk (*Accipiter gentilis*) was observed in a dense stand of conifer near Coal Creek. The goshawk is a secretive bird, and relatively difficult to observe in spite of its large size. Blue grouse are an important prey species, and were abundant in the immediate area. The bird observed may have been nesting in the vicinity.

Cooper's hawks (*Accipiter cooperii*) were seen on five occasions, and in all instances the birds were hunting. No nests were located, although it is likely that Cooper's hawks regularly nest within riparian habitats near agricultural areas.

Only one identification of a sharp-shinned hawk (*Accipiter striatus*) was made, although several probable sightings were recorded. Sharp-shinned hawks probably nest within the aspen and coniferous forests of the project area.

Migrating marsh hawks were observed hunting over agricultural meadows in early fall. No evidence of nesting within the project area was obtained.

Rough-legged hawks (*Buteo lagopus*) were seen in fall and winter. The earliest arrival date recorded was 7 October. Rough-legged hawks are winter residents; nesting occurs in Canada and Alaska.

Red-tailed hawks (*Buteo jamaicensis*) were the most common hawk observed. Nests probably occurred in the vicinity of the repeated observations that were recorded for June and July (Table II-20), although no active nests were identified. Red-tailed hawks were observed in fall and winter, but primarily in agricultural areas below 2,560 m (8,400 ft).

Table II-20. Raptorial birds identified within the project area.

Species	Locations Where Sightings Occurred
Goshawk	One observation at Coal Creek, conifer-riparian, June 79 (sec 5).
Cooper's hawk	Five observations: 2 at Coal Creek, conifer, June 78 (sec 7, 5); 2 at Alkali Creek, aspen, June 79 (sec 20); 1 at Ohio Creek, riparian, June 79 (sec 12).
Sharp-shinned hawk	One observation at Carbon Creek, aspen, June 79 (sec 33).
Marsh hawk	Migrants observed in early fall in agricultural meadows at south end of project area.
Rough-legged hawk	Migrants observed in late fall and winter in agricultural meadows and sage habitat at south end of project area.
Red-tailed hawk	June and July observations clustered as follows: Coal Creek (sec 4,5,6); Slate River (sec 28); Ohio Creek (sec 18,21); Carbon Creek (sec 5,8); Alkali Creek (sec 21,22). Nesting probably occurred in these five locations.
Swainson's hawk	June and July observations clustered as follows: Ohio Creek (sec 7,16,18,27,34); Carbon Creek (sec 4,9,33); Alkali Creek (sec 25,30); Almont Triangle (sec 24); East River (sec 18,19,20,28). Immature birds observed at the first three locations. Nesting probably occurred in all five locations.
Golden eagle	June and July observations clustered as follows: Red Mountain area; NW of Mount Emmons. Nesting probably occurred in these locations.
Bald eagle	Two to three bald eagles were repeatedly observed during winter in the cottonwood grove near Roaring Judy Trout Hatchery (sec 35).
Prairie falcon	June and July observations clustered as follows: west of Alkali Basin near Ohio Creek (sec 9); north side of Almont Triangle (sec 19). Nesting probably occurred in these locations.
Merlin	One observation at Carbon Creek, sage, August 78 (sec 17). Believed to be a migrant.

Table II-20. (Cont.) Raptorial birds identified within the project area.

Species	Locations Where Sightings Occurred
American kestrel	Observed spring through summer, mostly in agricultural hay meadows and sage, south half of project area.
Great horned owl	Two observations: 1 at Coal Creek, conifer, July 78 (sec 6); 1 at Alkali Creek, aspen, June 79 (sec 21).
Short-eared owl	One observed from Jack's Cabin Cutoff Road, January 80 (by Tom Henry, Division of Wildlife).

Swainson's hawks (*Buteo swainsoni*) were seen during spring and summer, and typically in mixtures of aspen, conifer, and sage habitat. No nests were found, but immature birds were recorded at three widely separate locations (Table II-20).

Golden eagles (*Aquila chrysaetos*) were typically observed above 3,048 m (10,000 ft) during summer, and below 2,560 m (8,400 ft) during winter. Particular attention was given to obtaining evidence of nesting in the Mount Emmons , Mount Axtell, Carbon Peak, Red Mountain, and Flat Top areas, but no indications were detected of activities close to ledges or other areas which suggested the presence of a nest.

Two to three bald eagles (*Haliaeetus leucocephalus*) were repeatedly observed during winter in the cottonwood grove between Almont and the Roaring Judy Trout Hatchery. Bald eagles are attracted to this area by the fish discarded at the hatchery. Typically from two to three bald eagles were observed at the hatchery from November through February. For periods of several days these birds were noted to be absent from the area, and it is assumed they occasionally move back and forth from Blue Mesa Reservoir.

Prairie falcons (*Falco mexicanus*) were observed at two locations during early summer of both years (Table II-20). It is possible that nesting occurred in the vicinity of these observations, but no immature birds were recorded.

One merlin (*Falco columbarius*) was observed hunting over sagebrush habitat near lower Carbon Creek in August 1978. Presumably this was a migrating individual, since this particular area was intensively studied during spring and no observations of merlins were made.

American kestrels (*Falco sparverius*) were observed in the lower section of the Carbon Creek drainage and near hay meadows and pastures in

the southern half of the project area. Observations were made from June through October. Typical nesting habitat includes holes in trees and abandoned magpie nests.

Great horned owls (*Bubo virginianus*) were observed in the riparian of Coal Creek and Alkali Creek. One active nest was located near Coal Creek in an Engelmann spruce.

One short-eared owl (*Asio flammeus*) was observed from Jack's Cabin Cutoff Road in January 1980 by Tom Henry, Colorado Division of Wildlife.

Game Birds.

Three species of grouse were identified in the project area: sage grouse, white-tailed ptarmigan, and blue grouse. Additional game birds included the mourning dove (*Zenaidura macroura*) and six species of waterfowl (Table II-22).

Sage grouse were observed during spring, summer, and fall in the sagebrush habitat of the Almont Triangle, Flat Top, Alkali Basin, and west of Alkali Basin toward Ohio Creek. Sage grouse were recorded on two bird diversity transect counts conducted in June, 1979 in the Alkali Basin area (Appendix Table II-9). Additionally, 14 counts of sage grouse were recorded during the summer periods, which were sightings of different individual birds (Table II-21).

During April, 1980, six sage grouse leks (strutting grounds) were identified near Ohio Creek (Plate 5, sheet 2). The maximum number of strutting males present occurred during the last week of April and the first week of May. Counts of strutting males for the six leks, in order from north to south, were 7, 17, 2, 26, 11, and 7, or a total of 70 strutting males. The frequency of sage grouse droppings was recorded along eight transects on 3 and 4 May. Four transects (2 m x 4 km;

Table II-21. Sage grouse observations in Alkali Basin and west toward Ohio Creek.

Period	No. of Groups	Group Sizes	No. Adults
June 78	1	2	2
June 78	1	1	1
June 78	1	2	2
Aug 78	3	6, 1, 2	4
Aug 78	1	8	1
June 79	1	1	1
June 79	1	2	2
June 79	2	1, 3	4
June 79	1	5	5
Aug 79	4	3, 11, 3, 2	3
Aug 79	6	2, 8, 3, 11, 2, 2	11
Aug 79	3	27, 2, 3	?
Aug 79	1	5	1
Aug 79	3	4, 9, 9	3

6.6 ft x 2.5 mi) were positioned in big sagebrush habitat near the existing access road leading from the Ohio Creek road to Alkali Basin. Results of data gathered along these transects are shown in Figure II-8, and suggest that most sage grouse habitat use occurs at an intermediate elevation (approximately 2,682 m; 8,800 ft) and between 1.4 and 3.0 km (0.9 and 1.9 mi) from the Ohio Creek road. Four additional transects (2 m x 2 km; 6.6 ft x 1.2 mi) were positioned in big sagebrush habitat immediately next to the two leks in section 26,and extended away from the leks in an easterly direction. Comparisons of sage grouse abundance, based on total counts of droppings along comparable lengths of transects, suggest that on a year-round basis significantly more sage grouse occur near the Alkali Basin access road than near the lek locations ($p<0.001$).

White-tailed ptarmigan were observed in the alpine and subalpine of Mount Emmons, and were observed on two occasions in January and February of 1979 on the valley floor near the Town of Crested Butte, and five miles south along the Slate River. Nests of ptarmigan were located in the alpine of Mount Emmons, but estimates of numbers of nests or of total population size were not obtained. Suitable ptarmigan habitat is not abundant on Mount Emmons or, for that matter, on any of the mountains within the project area. Ptarmigan habitat consists primarily of alpine meadows and fellfields, which occupy only 1.6 percent of the project area.

Blue grouse studies were conducted on Mount Emmons and Mount Axtell in conjunction with the Colorado Division of Wildlife during July 1978. According to the Division of Wildlife, the area studied is excellent blue grouse habitat. Personal observations are in agreement. Other areas where blue grouse were observed include the montane habitat of the Carbon Creek drainage and the conifer and aspen habitats along the proposed corridor route from Mount Axtell to Alkali Basin.

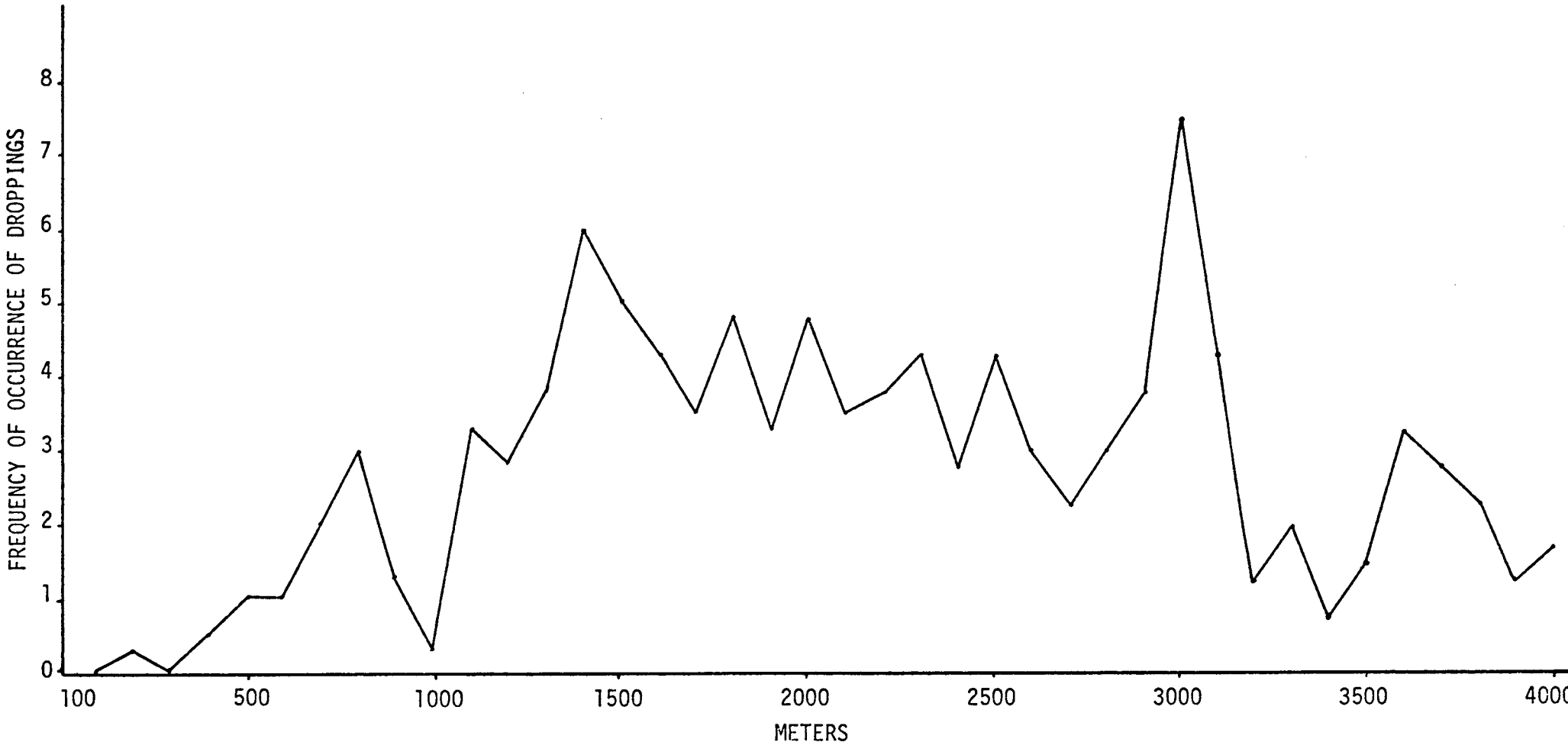


Figure II-8. Frequency of occurrence of sage grouse droppings along east-west transects. Counts began at the edge of big sagebrush habitat near Ohio Creek (elev. 2536m; 8320 ft) and terminated at the proposed mill site location near Alkali Basin (elev. 3895m; 9500 ft). Data are means of frequency values obtained along four parallel transects. The frequency values are the occurrence of droppings within 20 contiguous 2x5m transect segments.

Mourning doves were recorded at 9 out of the 19 breeding bird diversity transects of 1979 (Appendix Table II-9). The highest count was obtained in the aspen habitat of the Carbon Creek drainage. During the fall migration periods of both years, flocks of doves were observed in agricultural hay meadows and in sagebrush habitat, particularly near open water.

Six species of waterfowl were identified during the two years of baseline investigation (Table II-22). Only the mallard was found to nest in the area; broods were observed in Ohio Creek and on two ponds near the upper part of Alkali Basin.

Table II-22. Summary of identifications and habitat affinities of birds. Nomenclature follows Robbins et al. (1966), modified to conform to A.O.U. (1973).

Species	Status[1]	Comments Based on Two Yrs. of Baseline Investigation[2]
WATERFOWL:		
Mallard *Anas platyrhynchos*	S	Uncommon. Riparian areas, particularly near agricultural meadows.
Pintail *Anas acuta*	M	Seldom seen. Three sightings near Ohio Creek.
Gadwall *Anas strepera*	M	Seldom seen. Two observed near Ohio Creek.
Blue-winged Teal *Anas discors*	M	Uncommon. One observed on Coal Creek; also observed in agricultural riparian areas.
Green-winged Teal *Anas carolinensis*	M	Uncommon. Observed on Ohio Creek and Slate River.
Common merganser *Mergus merganser*	M	Seldom seen. One pair observed on Ohio Creek.
HAWKS, EAGLES, FALCONS:		
Goshawk *Accipiter gentilis*	S	Seldom seen. One observation in conifer habitat.
Cooper's Hawk *Accipiter cooperii*	S	Uncommon. Dense riparian habitats.
Sharp-shinned Hawk *Accipiter striatus*	S	Seldom seen. One observation in aspen habitat.
Marsh Hawk *Circus cyaneus*	M	Seldom seen during summer; uncommon in fall. Agricultural and big sagebrush shrubland.
Rough-legged Hawk *Buteo lagopus*	W	Uncommon during fall and winter. Agricultural and big sagebrush shrubland.
Red-tailed Hawk *Buteo jamaicensis*	R	Common. Ubiquitous.
Swainson's Hawk *Buteo swainsoni*	R	Common. Widespread; typically found in lower montane.

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
Golden Eagle *Aquila chrysaetos*	R	Uncommon. Ubiquitous, mainly at lower elevations in winter.
Bald Eagle *Haliaeetus leucocephalus*	W	Uncommon during fall and winter. Wintering area occurs near Roaring Judy Trout Hatchery.
Prairie Falcon *Falco mexicanus*	S	Seldom seen. Most frequently seen in sagebrush habitat.
Merlin *Falco columbarius*	M	Seldom seen. One observation in big sagebrush shrubland.
American Kestrel *Falco sparverius*	S	Common. Agricultural and big sagebrush shrubland.
GALLINACIOUS BIRDS:		
Blue Grouse *Dendragapus obscurus*	R	Uncommon. Mixed montane habitat.
Sage Grouse *Centrocercus urophasianus*	R	Common in big sagebrush shrubland on Flat Top and in Alkali Basin.
White-tailed Ptarmigan *Lagopus leucurus*	R	Common in alpine of Mount Emmons; two flocks observed on valley floor during winter near the Town of Crested Butte.
HERONS:		
Cattle Egret *Bubulcus ibis*	O	Seldom seen. One observed in June 1978, in lowland agricultural meadow south of Flat Top near Ohio Creek.
Great Blue Heron *Ardea herodias*	S	Uncommon. Observed in lower Ohio and East Rivers.
Black-crowned Night Heron *Nycticorax nycticorax*	S	Seldom seen. Two observed near Ohio Creek.
CRANES:		
Sandhill Crane *Grus canadensis*	M	Seldom seen. Two groups seen flying over during spring 1979 migration.

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
SHOREBIRDS:		
American Avocet *Recurvirostra americana*	M	Seldom seen. Three observed in agricultural riparian of Gunnison River.
Killdeer *Choradrius vociferus*	S	Common. Agricultural Valleys.
Solitary Sandpiper *Tringa solitaria*	S	Seldom seen. Two observed on Coal Creek.
Spotted Sandpiper *Actitis macularia*	S	Common. Ponds and streams.
Wilson's Phalarope *Steganopus tricolor*	M	Uncommon. Observed in agricultural riparian.
Common Snipe *Capella gallinago*	S	Uncommon. Observed in moist agricultural meadows.
DOVES:		
Mourning Dove *Zenaidura macroura*	S	Common. Agricultural areas.
OWLS:		
Great Horned Owl *Bubo virginianus*	R	Seldom seen. Observed in riparian habitats of Coal Creek and Alkali Creek.
Short-eared owl *Asio flammeus*	O	Seldom seen. One observed near agricultural meadows (by Tom Henry, Div. of Wildlife).
HUMMINGBIRDS, SWIFTS:		
Broad-tailed Hummingbird *Selasphorus platycercus*	S	Abundant. Montane meadows and big sagebrush shrubland.
Rufous Hummingbird *Selasphorus rufus*	S	Uncommon. Arrives in July; observed in montane meadow habitats and in big sagebrush shrubland.

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
Calliope Hummingbird *Stellula calliope*	S	Uncommon. Arrives in July; observed in montane meadow habitat.
White-throated Swift *Aeronautes saxatalis*	S	Uncommon. Observed near lower Carbon Creek.
KINGFISHERS:		
Belted Kingfisher *Megaceryle alcyon*	R	Common. Lower Ohio Creek and East Rivers.
WOODPECKERS:		
Common Flicker (red-shafted) *Colaptes auratus*	S	Common in aspen habitat.
Red-headed Woodpecker *Melanerpes erythrocephalus*	O	Seldom seen. One observed in lower Ohio Creek valley.
Yellow-bellied Sapsucker *Sphyrapicus varius*	S	Common in aspen habitat.
Williamson's Sapsucker *Sphyrapicus thyroideus*	S	Seldom seen. One observed in lower Coal Creek valley.
Hairy Woodpecker *Dendrocopos villosus*	S	Seldom seen. Conifer habitat.
Downy Woodpecker *Dendrocopos pubescens*	S	Seldom seen. Observed in aspen habitat.
PERCHING BIRDS:		
Western Kingbird *Tyrannus verticalis*	S	Uncommon. Big sagebrush shrubland.
Willow Flycatcher *Empidonax traillii*	S	Common in willow-riparian habitat.
Dusky Flycatcher *Empidonax oberholseri*	S	Common in sagebrush and riparian habitat.
Western Flycatcher *Empidonax difficilis*	S	Common in montane riparian, and forested habitat.

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
Western Wood Pewee *Contopus sordidulus*	S	Common in montane riparian, and forested habitat.
Olive-sided Flycatcher *Nuttallornis borealis*	S	Common in conifer and aspen habitat.
Horned Lark *Eremophila alpestris*	R	Uncommon. Alpine during summer; open sage in winter.
Barn Swallow *Hirundo rustica*	S	Common in lowland agricultural areas.
Cliff Swallow *Petrochelidon pyrrhonota*	S	Uncommon. Lowland sage habitat.
Violet-green Swallow *Tachycineta thalassina*	S	Common. Riparian areas.
Tree Swallow *Iridoprocne bicolor*	S	Common in aspen habitat.
Stellar's Jay *Cyanocitta stelleri*	R	Uncommon in conifer habitat.
Gray Jay *Perisoreus canadensis*	R	Common in conifer habitat.
Black-billed Magpie *Pica pica*	R	Common. Agricultural habitat.
Clark's Nutcracker *Nucifraga columbiana*	R	Uncommon. Conifer habitat.
Common Raven *Corvus corax*	R	Common. Ubiquitous.
Common Crow *Corvus brachyrhychos*	S	Uncommon. Agricultural habitat.
Black-capped Chickadee *Parus atricapillus*	R	Seldom seen. Two observed in aspen habitat.
Mountain Chickadee *Parus gambeli*	R	Common. Montane habitat.

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
Dipper *Cinclus mexicanus*	S	Uncommon. Carbon and Coal Creeks.
White-breasted Nuthatch *Sitta carolinensis*	R	Uncommon. Conifer and aspen habitat.
Red-breasted Nuthatch *Sitta canadensis*	R	Uncommon. Conifer and aspen habitat.
Brown Creeper *Certhia familiaris*	R	Uncommon. Conifer habitat.
House Wren *Troglodytes aedon*	S.	Common. Aspen and montane riparian habitat.
Rock Wren *Salpinctes obsoletus*	S	Uncommon. Observed only in big sagebrush shrubland.
Mockingbird *Mimus polyglottos*	O	Seldom seen. One observed in lower agricultural meadow.
Sage Thrasher *Oreoscoptes montanus*	S	Uncommon. Observed only in big sagebrush shrubland.
American Robin *Turdus migratorius*	S	Abundant. Ubiquitous.
Townsend's Solitaire *Myadestes townsendi*	R	Uncommon. Montane riparian habitat.
Veery *Catharus fuscenscens*	S	Uncommon. Moist, montane forest.
Hermit Thrush *Catharus guttatus*	S	Common. Aspen and conifer habitat.
Swainson's Thrush *Catharus ustulatus*	S	Uncommon. Aspen and conifer habitats.
Gray-cheeked Thrush *Catharus minimus*	S	Seldom seen. Conifer habitat.
Mountain Bluebird *Sialia currocoides*	S	Common in alpine meadow, lowland sage, and in agricultural areas.

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
Golden-crowned Kinglet *Regulus satrapa*	S	Seldom seen. One identified in coniferous forest.
Ruby-crowned Kinglet *Regulus calendula*	S	Abundant in coniferous forest.
Water Pipit *Anthus spinoletta*	S	Common. Alpine.
Loggerhead Shrike *Lanius ludovicianus*	R	Uncommon. Most frequently observed in big sagebrush surubland and agricultural habitat during fall and winter.
Starling *Sturnus vulgaris*	R	Common. Lowland agricultural areas.
Solitary Vireo *Vireo solitarius*	S	Seldom seen. Two observed in lower Alkali Basin riparian.
Warbling Vireo *Vireo gilvus*	S	Abundant in aspen habitat.
Orange-crowned Warbler *Vermivora celata*	S	Seldom seen. One observed in aspen habitat near Carbon Creek.
Yellow Warbler *Dendroica petechia*	S	Common, usually in riparian areas.
Yellow-rumped Warbler *Dendroica coronata*	S	Common in conifer and aspen habitats.
MacGillivray's Warbler *Oporornis tolmiei*	S	Uncommon, usually seen in montane riparian areas.
Wilson's Warbler *Wilsonia pusilla*	S	Common, usually in montane riparian habitat.
House Sparrow *Passer domesticus*	R	Uncommon. Restricted to lowland agricultural areas.
Western Meadowlark *Sturnella neglecta*	S	Common in lowland sage and agricultural meadows.
Red-winged blackbird *Agelaius phoeniceus*	S	Abundant in most riparian habitats at lower elevations.

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
Brewer's Blackbird *Euphagus cyanocephalus*	S	Uncommon. Usually in lowland agricultural areas.
Brown-headed Cowbird *Molothrus ater*	S	Common. Usually in lowland agricultural areas.
Western Tanager *Piranga ludoviciana*	S	Uncommon. Usually in conifer and aspen habitats.
Black-headed Grosbeak *Pheucticus melanocephalus*	S	Uncommon. Usually in montane riparian habitat.
Cassin's Finch *Carpodacus cassinii*	S	Uncommon. Usually in conifer habitat.
House Finch *Carpodacus mexicanus*	S	Seldom seen. Lowland agricultural habitat.
Pine Grosbeak *Pinicola enucleator*	S	Uncommon. Conifer habitat.
Gray-crowned Rosy Finch *Leucosticte tephrocotis*	R	Common in alpine during summer, and montane valleys in winter.
Pine Siskin *Spinus pinus*	R	Common in montane habitat.
American Goldfinch *Spinus tristis*	S	Seldom seen. Two observed near Slate River.
Red Crossbill *Loxia curvirostra*	R	Uncommon. Only observed in conifer habitat.
Green-tailed Towhee *Chlorura chlorura*	S	Common in sage habitat.
Rufous-sided Towhee *Pipilo erythrophthalmus*	S	Seldom seen. Only observed in lowland riparian habitat.
Savannah Sparrow *Passerculus sandwichensis*	S	Uncommon. Observed in agricultural and montane meadows.
LeConte's Sparrow *Ammospiza caudacutus*	O	Seldom seen. One identified near the Town of Crested Butte in riparian habitat of Slate River (by Allen Crockett, CDM biologist).

Table II-22. (Cont.) Summary of identifications and habitat affinities of birds.

Species	Status	Comments Based on Two Yrs. of Baseline Investigation
Lark Bunting *Calamospiza melanocorys*	S	Seldom seen. Observed in agricultural meadows.
Vesper Sparrow *Pooecetes gramineus*	S	Abundant in sagebrush habitat.
Sage Sparrow *Amphispiza belli*	O	Seldom seen. One observed in sage habitat.
Gray-headed Junco *Junco caniceps*	R	Common in montane habitat.
Chipping Sparrow *Spizella passerina*	S	Uncommon. Most often seen in subalpine.
Brewer's Sparrow *Spizella breweri*	S	Common in sagebrush habitat.
White-crowned Sparrow *Zonotrichia leucophrys*	S	Common in montane riparian and subalpine habitats.
Lincoln's Sparrow *Melospiza lincolnii*	S	Uncommon, sage riparian and montane habitats.
Song Sparrow *Melospiza melodia*	S	Uncommon, usually in riparian areas.

[1] Apparent status within the study area: R, resident; S, summer resident; W, winter resident; M, migrant; O, occasional.

[2] Abundant; likely to be seen in large numbers on any outing.

Common; likely to be seen much of the time but in smaller numbers.

Uncommon; occurs in small numbers and in limited habitat.

Seldom seen; occupies a small percentage of its preferred habitat.

Three species of amphibians and one species of reptile were identified (Table II-23). Although no structured sampling programs were followed, small ponds and moist riparian areas were examined for amphibians during the late spring and summer periods. Identification of reptiles occurred during the course of other activities.

Locations where chorus frogs (*Pseudacris triseriata*) occurred were identified by vocalizations in spring. This species occurs in the valleys of the Slate and Ohio Rivers, and in moist habitats throughout Alkali Basin.

Two adult boreal toads (*Bufo boreas*) were found, both in the meadows of upper Coal Creek near Kebler Pass (2,987 m; 9,800 ft).

Larval tiger salamanders (*Ambystoma tigrinum*) were identified in two small ponds in upper Alkali Basin (2,804 m; 9,200 ft). No adult salamanders were found.

The western terrestrial garter snake (*Thamnophis elegans*) was found in agricultural riparian areas and in moist meadows of Carbon Creek. Approximately 20 were observed during the two-year baseline period.

Table II-23. Amphibians and reptiles identified in the study area. Nomenclature follows Stebbins (1966).

AMPHIBIANS
Chorus frog *Pseudacris triseriata*
Boreal toad *Bufo boreas*
Tiger salamander *Ambystoma tigrinum*
REPTILES
Western terrestrial garter snake *Thamnophis elegans*

The bald eagle, a federally listed endangered species, occurs within the project area during the winter period. Two or three individuals were frequently seen near the Roaring Judy Trout Hatchery from November through February during both years of baseline investigation. Sightings also were made at Blue Mesa Reservoir. Additional discussion of bald eagles can be found in the sections on raptorial birds and sensitive areas.

The greater sandhill crane (*Grus canadensis tabida*), a state endangered subspecies, was observed on two occasions during the spring of 1979. Two flocks of approximately 15 birds each were observed in migration. On 29 April 1980 a group of nine sandhill cranes was observed feeding in an agricultural meadow of Ohio Creek 3.2 km (2 mi) south of Mill Creek (section 16).

The Mount Emmons Project area is within the migration route of the whooping crane (*Grus americana*), a federally listed endangered species (Torres et al., 1978). No sightings were made during baseline investigation, however.

A questionable identification of a peregrine falcon (*Falco peregrinus*) occurred during late August 1978 at lower Carbon Creek. The bird was observed at a distance of approximately 100 m (328 ft), and the distinguishing features were not clearly recognizable. The area was returned to repeatedly during the next week, but no sightings were made. If the bird observed was a peregrine falcon, it was likely a migrant. A considerable amount of field investigation was performed in the same area during the spring of 1979, but no sightings of peregrine falcons were made.

Evidence of black-footed ferrets (*Mustela nigripes*) were searched for at the colonies of Gunnison's prairie dogs that occur in the project area. Plugged burrows, characteristic furrows, droppings, and tracks were the signs looked for most closely. No nighttime observations were performed. There was no evidence of black-footed ferrets in these colonies, and in view of the small size of the colonies and the distance between them, it seems unlikely that black-footed ferrets occur in or near the project area.

The Mount Emmons Project area is within the historical range of the state endangered wolverine and lynx (Torres et al., 1978). No evidence of either species was found.

A sensitive area is defined here as any local area of special significance to wildlife. Four sensitive areas within the Mount Emmons Project area have been identified (Plate 5, sheet 2).

The South-facing Slope of Flat Top.

This area is important winter range for elk and mule deer, as discussed in the section on Large Mammals.

The Almont Triangle.

The Almont Triangle, between the Taylor and the East Rivers, has long been recognized as important winter range for elk, mule deer, and bighorn sheep. The importance of this area is also discussed in the section on Large Mammals.

The Cottonwood Grove North of Almont.

The cottonwood grove along the East River between Almont and the Roaring Judy Trout Hatchery is wintering habitat for bald eagles. The bald eagle is presently classified as an endangered species. During baseline studies, two or three bald eagles were regularly observed in this cottonwood grove throughout the winter period. They are attracted to the area by the numerous dead fish thrown out onto the ground at the fish hatchery.

The Sage Grouse Strutting Grounds Near Ohio Creek.

From mid-March through mid-June, the sage grouse strutting grounds near Ohio Creek should be considered sensitive areas. The strutting ground locations (Plate 5, sheet 2) are major breeding grounds for the sage grouse of Alkali Basin and vicinity.

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Consultations with Government Agency Representatives

1978

27 June	Meeting with Colorado Division of Wildlife, DOW (Tom Henry, Jim Houston) to discuss scope of work for the Mount Emmons Project.
28 June	Big game aerial survey with DOW (Tom Henry).
18 July	Meeting with DOW (Al Whitaker) to discuss wildlife methods.
24 July	Telephone conversation with U.S. Forest Service, USFS (Fred Wild) regarding wildlife methods.
25 July	Field trip with DOW (Tom Henry, Jim Houston, Rick Hoffman).
26 July	Meeting with Rocky Mt. Biological Lab, RMBL (Richard Richards, Robert and Ruth Willey) to discuss wildlife methods.
27 July	Meeting with RMBL (Bill Calder) to discuss Mount Emmons Project.
22 August	Meeting with DOW to discuss elk tagging study.
24 August	Big game aerial survey with DOW (Tom Henry).
12 September	Meeting with DOW and Colorado Cooperative Wildlife Research Unit to discuss elk tagging study.
12 September	Meeting with USFS (Fred Wild, Tom Eberhart) to discuss wildlife methods.
18 September	Field trip with DOW (Tom Henry).
28 October	Big game aerial survey with DOW (Tom Henry).
26 April	Meeting with DOW and Colorado Cooperative Wildlife Research Unit to discuss elk tagging study.

1979

22 June	Jim Simonson and Dennis Hovel, U.S. Forest Service: Project review.
5 October	Tom Henry, Colorado Division of Wildlife: Alternate Mill/ Tailings Pond Sites evaluation; in addition, numerous informal meetings occurred throughout the project.
16 November	Jim Simonson, U.S. Forest Service: Field study sites and methods evaluation.

Appendix Table II-1 Elk and mule deer pellet-group densities on south-facing slopes of Alkali Basin. Counts were made in September, 1978 (on unswept quadrats--pellets were of unknown age).

Transect	Mean pellet-groups per hectare ± SE (n)* Elk	Mule Deer
31	0±0 (20)	50±50 (20)
32	50±50 (20)	100±69 (20)
33	100±69 (20)	50±50 (20)
34	150±109 (20)	100±69 (20)
35	100±69 (20)	150±82 (20)
36	50±50 (20)	250±123 (20)
37	100±69 (20)	350±131 (20)
38	200±92 (20)	150±82 (20)
39	0±0 (20)	50±50 (20)
40	50±50 (20)	400±197 (20)
Combined	80±20 (200)	155±31 (200)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Appendix Table II-2 Elk and mule deer pellet-group densities on south-facing slopes of Flat Top. Counts were made in September, 1978 (on unswept quadrats--pellets were of unknown age).

Transect	Mean pellet-groups per hectare ± SE (n)* Elk	Mule Deer
East Side of Mountain		
1	100±69 (20)	1,300±371 (20)
2	2,700±529 (20)	2,150±477 (20)
3	1,400±222 (20)	1,750±315 (20)
4	200±92 (20)	350±150 (20)
5	400±112 (20)	300±164 (20)
6	400±184 (20)	50±50 (20)
7	400±112 (20)	0±0 (20)
Combined	800±115 (140)	843±122 (140)
West Side of Mountain		
8	400±169 (20)	0±0 (20)
9	300±164 (20)	50±50 (20)
10	1,400±387 (20)	50±50 (20)
11	550±185 (20)	0±0 (20)
12	350±167 (20)	0±0 (20)
13	150±82 (20)	0±0 (20)
Combined	525±93 (120)	17±12 (120)
Upper Area of Slope		
56	600±210 (20)	850±196 (20)
57	1,650±221 (20)	900±204 (20)
58	400±152 (20)	550±198 (20)
59	250±123 (20)	600±328 (20)
60	650±150 (20)	150±82 (20)
Combined	710±91 (100)	610±98 (100)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Appendix Table II-3 Elk and mule deer pellet-group densities on the Almont Triangle. Counts were made in September, 1978 (on unswept quadrats--pellets were of unknown age).

Transect	Mean pellet-groups per hectare ± SE (n)* Elk	Mule Deer
North of Jack's Cabin Cut-Off		
51	1,550±312 (20)	100±69 (20)
52	1,550±320 (20)	650±244 (20)
53	1,700±300 (20)	100±69 (20)
54	850±244 (20)	300±164 (20)
55	850±209 (20)	300±164 (20)
Combined	1,300±128 (100)	290±71 (100)
Central Area		
21	2,150±319 (20)	800±287 (20)
22	1,900±228 (20)	1,500±199 (20)
23	2,000±218 (20)	750±228 (20)
24	1,750±176 (20)	1,800±401 (20)
25	1,600±234 (20)	1,850±293 (20)
Combined	1,880±107 (100)	1,340±136 (100)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Appendix Table II-4 Elk and mule deer pellet-group densities in Antelope Creek valley. Counts were made in November, 1979 (on unswept quadrats--pellets were of unknown age).

Transect	Mean pellet-groups per hectare ± SE (n)*	
	Elk	Mule Deer
41	400±169 (20)	450±185 (20)
42	600±152 (20)	1,300±363 (20)
43	650±209 (20)	300±105 (20)
44	300±128 (20)	150±109 (20)
45	550±223 (20)	300±164 (20)
46	150±82 (20)	50±50 (20)
47	100±100 (20)	0±0 (20)
48	150±82 (20)	50±50 (20)
49	300±105 (20)	350±167 (20)
50	250±99 (20)	650±254 (20)
Combined	345±46 (200)	360±61 (200)

*n = Number of 10 m^2 (108 ft^2) quadrats.

Appendix Table II-5 Road counts of mule deer, elk, and mountain sheep, 1979.*

West of Gunnison				East of Gunnison			
Mile Interval	Deer	Elk	Sheep	Mile Interval	Deer	Elk	Sheep
1				1			
2				2			
3				3	166		
4	38			4	170		
5	15			5	48		
6	65			6	109	27	
7	33			7	81		
8	6			8	144		
9	13			9	65	13	
10	3			10	24	36	
11	16	70		11			
12	10			12		43	
13	66			13	32	4	
14	8			14	104		
15				15	3		
16	4			16	19	71	
17	71			17	2		
18	1			18			
19	23	1		19			
20	35	9	8	20			
Totals	407	80	8		967	194	0

Total observed over 40 miles of highway: mule deer = 1,374
elk = 274
mountain sheep = 8

*Numbers are animals observed on 25 February 1979 within 500 m (0.3 mi) of Highway 50. Counts west of Gunnison were begun at the Gunnison River bridge; counts east of Gunnison were begun at Adams Street.

Appendix Table II-6 Age class composition of mule deer and elk wintering near Gunnison, 1979.

Location	Age Class Composition*		
MULE DEER	Fawns		Adults
East of Gunnison	5		316
West of Gunnison	19		565
Ratio of fawns:adults = 2.7 fawns:100 adults (n = 905)			
ELK	Calves	Cows	Bulls
East of Gunnison	34	78	15
West of Gunnison	2	5	4
Ratio of calves:cows = 43.4 calves:100 cows (n = 138)			

*Counts were made from Highway 50, 20 miles east and 20 miles west of Gunnison, on 24 February 1979.

Appendix Table II-7 Numbers and locations of elk observed during monthly aerial counts. Elevations are approximate.

Date	No. of Elk Observed	Location and Habitat*
28 June 78	33	Anthracite Range, NW quarter, 9,000 ft., conifer-aspen-montane meadow habitat
	20	Flat Top, east side, 9,400 ft., aspen-montane meadow habitat
27 July 78	24	Anthracite Range, south side, 10,000 ft., conifer-montane meadow habitat
	16	Flat Top, east side, 9,200 ft., aspen-montane meadow habitat
24 Aug. 78	21	Anthracite Range, south side, 10,000 ft., conifer-montane meadow habitat
	15	Red Mt., NE quarter, 10,000 ft., aspen-montane meadow habitat
	27	Red Mt., NW quarter, 11,000 ft., conifer-montane meadow habitat
21 Sept. 78	25	Anthracite Range, south side, 10,000 ft., conifer-montane meadow habitat
	2	Red Mt., west side, 10,500 ft., conifer-montane meadow habitat
	3	Whetstone Mt., west side, 10,000 ft., conifer-montane meadow habitat
	2	The Castles, east side, 10,400 ft., conifer-montane meadow habitat
28 Oct. 78	15	Mt. Axtell, Gibson Ridge, 10,600 ft., aspen-montane meadow habitat
	13	Flat Top, SE quarter, 9,800 ft., aspen-montane meadow habitat
17 Nov. 78	3	Whetstone Mt., south side, 10,200 ft., conifer-montane meadow habitat
	1	Red Mt., SW quarter, 10,800 ft., aspen-montane meadow habitat
	5	Flat Top, east side, 9,500 ft., aspen-montane meadow habitat
29 Nov. 78	120	Alkali Basin, sections 20 and 21, 9,200 ft., aspen-sagebrush habitat
	41	North of Copper Gulch (SE of Almont Triangle), 9,600 ft., aspen-sagebrush habitat

Appendix Table II-7 - cont. Numbers and locations of elk observed during monthly aerial counts.

Date	No. of Elk Observed	Location and Habitat*
13 Dec. 78	130	Lost Canyon, north rim, 9,000 ft., aspen-sagebrush habitat
	30	Cement Creek, west end, 9,500 ft., conifer-aspen-sagebrush habitat
	20	Flat Top, east side, 9,500 ft., aspen-montane meadow habitat
17 Jan. 79	20	Lost Canyon, 10,000 ft., aspen-sagebrush habitat
	3	Antelope Creek, 4 mi. S of Mill Creek, 8,400 ft., sagebrush habitat
	48	Almont Triangle, 8,400 ft., sagebrush habitat
	180	Flat Top, south side, 8,200 ft., sagebrush habitat
	99	West of Gunnison near road, 8,100 ft., sagebrush-agricultural habitat
26 Feb. 79	24	Lost Canyon, 10,000 ft., aspen-sagebrush habitat
	2	North of Copper Gulch (SE of Almont Triangle), 9,600 ft., aspen-sagebrush habitat
	48	Almont Triangle, 9,000 ft., conifer-sagebrush habitat
	2	Flat Top, east side, 9,000 ft., aspen-sagebrush habitat

*Flight paths during summer and early fall included the following mountains and their associated valley systems: Mount Emmons, Anthracite Range, Mt. Axtell, Whetstone Mt., Carbon Peak, the eastern slopes of the West Elk Mountains, Red Mt., and Flat Top. Winter flight paths included Red Mt., Flat Top, Round Mt., the Almont Triangle, Lost Canyon and Antelope Creek drainages, and the generally south-facing slopes north of Highway 50 approximately five miles to the east and to the west of Gunnison.

Appendix Table II-8. Relative numbers of bird species observed among sampling locations, 1978. Numbers are the average number of birds observed during one-hour observation periods conducted at each location along 100m x 800m transects. The number of one-hour observation periods is shown in parentheses.

Species	Location Number* 1 (6)	2 (6)	3 (5)	4 (6)	5 (4)	6 (5)	7 (2)	8 (5)	9 (5)	10 (2)	11 (4)	12 (6)	13 (8)	14 (6)
WATERFOWL:														
Mallard	1.83		0.40						0.20					1.33
HAWKS,EAGLES,FALCONS:														
American kestrel	0.33	0.17	0.40											
Red-tailed hawk							0.50	0.20	0.20		0.25			
GALLINACEOUS BIRDS:														
Blue grouse				0.50							0.17			
White-tailed ptarmigan						1.00								
SHOREBIRDS:														
Killdeer	0.83	0.17	0.20											
Common snipe	0.17													
Spotted sandpiper	0.17		0.20						0.60					1.83
DOVES:														
Mourning dove		0.33	0.40	0.33										
CAPRIMULGIDS:														
Common nighthawk			0.20											
SWIFTS,HUMMINGBIRDS:														
Broad-tailed hummingbird	2.17	1.83	8.60	0.50				2.20			0.75		3.75	6.50
WOODPECKERS:														
Common flicker	1.17	0.17	0.60		0.25							0.50	0.63	
Yellow-bellied sapsucker	0.17		0.20					0.60					0.38	0.17

Appendix Table II-8. - cont. Relative numbers of bird species observed among sampling locations, 1978.

Species	Location Number* 1 (6)	2 (6)	3 (5)	4 (6)	5 (4)	6 (5)	7 (2)	8 (5)	9 (5)	10 (2)	11 (4)	12 (6)	13 (8)	14 (6)
Hairy woodpecker												0.17		
PERCHING BIRDS:														
Western wood pewee					0.50					0.50	1.75		0.50	
Willow flycatcher	0.17		0.40										3.50	2.50
Hammond's flycatcher													0.88	1.17
Dusky flycatcher	0.83		1.00	0.17							0.50			
Western flycatcher							1.00		0.20			0.17		
Olive-sided flycatcher											0.25	0.33	1.13	0.33
Horned lark				1.83		0.40								
Cliff swallow	0.67													
Violet-green swallow	0.17	0.50	0.80		0.25								2.13	4.50
Tree swallow	0.17							0.20	0.20	2.00	0.25		7.88	8.67
Steller's jay									0.40		0.25			
Gray jay							0.50	0.80	0.40	0.50		1.50		
Black-billed magpie	2.00		1.40											
Common raven													0.25	0.17
Black-capped chickadee													0.13	
Mountain chickadee					1.75	0.20	5.50	0.20		5.00	2.00	3.33	1.00	0.50
Dipper														0.17
White-breasted nuthatch											0.25		0.13	
Red-breasted nuthatch							3.00			2.50	0.50	0.33	0.50	0.17
Brown creeper					0.50					0.50		1.17		
House wren	0.50		0.40								0.75		3.00	
Rock wren		0.33		0.17										
American robin	2.17	0.50	3.20	0.33	0.25	0.60	1.50	2.60	3.00	1.00	2.00	1.33	6.00	6.67
Hermit thrush					1.00	0.20	0.50			1.00	0.75	1.83	0.50	0.33
Swainson's thrush					0.25			0.60			0.25	0.17	0.38	0.67
Gray-cheeked thrush												0.17		
Mountain bluebird		1.17				0.40							0.13	0.50
Ruby-crowned knight					0.75	1.00	1.00			8.00		5.33	0.88	2.00
Golden-crowned knight												0.67		
Water pipit						3.80								
Starling	0.67		0.80											
Warbling vireo			0.20		5.75						4.75		7.13	
Yellow warbler	1.17		2.00					0.60	0.20				3.00	5.00
Yellow-rumped warbler					2.00	1.00	2.50			1.50	3.00	1.17	3.50	0.33

Appendix Table II-8. - cont. Relative numbers of bird species observed among sampling locations, 1978.

Species	Location Number* 1 (6)	2 (6)	3 (5)	4 (6)	5 (4)	6 (5)	7 (2)	8 (5)	9 (5)	10 (2)	11 (4)	12 (6)	13 (8)	14 (6)
MacGillivray's warbler	0.50		0.60					0.40	0.40		0.25		0.25	0.83
Wilson's warbler					0.75			0.20	1.40		0.75	1.33	0.13	3.00
Western meadowlark	1.50	3.17	0.40	0.50										
Red-winged blackbird	4.17		1.80											0.17
Brewer's blackbird	2.67	2.50	0.80	3.17										0.67
Brown-headed cowbird	1.00		1.60					0.60					0.25	1.00
Western tanager							0.50				0.25	0.67	0.13	0.17
Black-headed grosbeak								0.20			0.25		0.75	1.83
Cassin's finch					0.25	1.00				1.00		0.50	0.63	0.17
Pine grosbeak					0.25							0.50		
Gray-crowned rosy finch						1.60								1.50
Pine siskin	0.33		0.40		3.00	1.20	3.50	7.60	0.60	5.50	3.75	6.83	3.50	2.83
Red crossbill												3.83		
Green-tailed towhee	0.67	2.67	0.20	0.67			0.50	0.20	0.40		0.25			
Vesper sparrow	0.50	2.83	0.20	7.50										
Gray-headed junco					5.75	0.40	0.50	0.60	1.20	0.50	4.25	3.50	2.00	
Chipping sparrow						0.80								
Brewer's sparrow	0.17	2.17		1.50										
White-crowned sparrow						4.00		1.20	1.80				0.13	3.50
Lincoln's sparrow	0.17		1.20					0.20	1.00					0.33
Song sparrow	0.67		0.60						0.60					3.00

*Location Number

1 = Lower Alkali Basin : Riparian (sec 21, 22, 23)
2 = " " " : Sage (sec 22)
3 = " " " : Riparian (sec 21, 22)
4 = Upper Alkali Basin : Sage (sec 24, 25)
5 = Carbon Creek Drainage: Conifer-aspen (sec 32, 33, 19)
6 = Mount Emmons : Alpine (sec 31)
7 = " " : Conifer (sec 5, 6)
8 = " " : Riparian (sec 4)
9 = " " : Riparian (sec 5, 6)
10 = Washington Gulch : Conifer (sec 15, 16)
11 " " " : Aspen (sec 15, 16, 22)
12 = Anthracite Creek : Conifer
13 = " " " : Aspen
14 = " " " : Riparian

Appendix Table II-9. Relative numbers of bird species observed among sampling locations, 1979. Numbers are the average number of birds observed during 6 one-hour observation periods conducted at each location along 100 m x 800 m transects.

Species	Location Number*																		
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
WATERFOWL:																			
Mallard									2.00			0.67				0.50	0.33		3.50
Gadwall												0.33							
Green-winged teal																			0.50
Common merganser												0.17							
HAWKS, EAGLES, FALCONS:																			
Goshawk																		0.17	
Cooper's hawk																	0.17		
Sharp-shinned hawk							0.17												
Red-tailed hawk						0.17					0.17	0.50							
American kestrel		0.17		0.17		0.67	0.17		0.17										0.17
GALLINACEOUS BIRDS:																			
Blue grouse						0.17		0.17											
Sage grouse			1.17	0.33															
White-tailed ptarmigan													0.17						
HERONS:																			
Black-crowned night heron									0.50										
SHOREBIRDS:																			
Killdeer	1.00	0.33																	
Spotted sandpiper		0.33							0.50	3.00		0.17						0.17	3.83
Wilson's phalarope																			0.33
Common snipe		0.83							0.50										1.33
DOVES:																			
Mourning dove	0.17		0.67	0.17		0.17	0.33	1.00	0.67	0.33		0.17							

Appendix Table II-9 - cont. Relative numbers of bird species observed among sampling locations, 1979.

Species	Location Number*																		
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
OWLS:																			
Great horned owl		0.17																	
CAPRIMULGIDS:																			
Common nighthawk				0.50								0.33							
SWIFTS, HUMMINGBIRDS:																			
White-throated swift									0.83										
Broad-tailed hummingbird	3.67	4.00		0.50	0.50	5.67	0.83	0.67	1.50	4.83	0.17	4.33			2.00	0.67	0.67	1.17	0.17
KINGFISHERS:																			
Belted kingfisher												0.17							
WOODPECKERS:																			
Common flicker	0.50	0.33	0.17			0.83	0.17	0.33	0.67	0.17	0.22	0.17			0.83			0.33	
Yellow-bellied sapsucker		0.17			0.17		0.33	0.67	0.83	0.33		0.83			0.50			0.17	
Williamson's sapsucker															0.17		0.17		
Hairy woodpecker														0.33	0.17		0.17		
Downy woodpecker															0.17				
PERCHING BIRDS:																			
Willow flycatcher		0.83						0.17	1.17			0.67						0.17	
Hammond's flycatcher					0.17		0.17		0.33						0.67	0.67	0.17	0.17	
Dusky flycatcher	0.17	0.33				0.17													
Western flycatcher					0.17				0.17	0.67						0.33	0.17		
Western wood pewee					0.83		0.83	3.17				1.33			1.83			0.17	
Olive-sided flycatcher							0.83							0.33		1.50	0.33		

Appendix Table II-9 - cont. Relative numbers of bird species observed among sampling locations, 1979.

Species	Location Number*																		
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
PERCHING BIRDS cont:																			
Horned lark			5.00	0.83									1.33						
Barn swallow	0.33								0.17			0.33							1.67
Cliff swallow	5.33	4.33		0.17		0.67			2.00			0.33							1.50
Violet-green swallow	2.33	5.33				0.67	2.50	0.17	0.17	0.17		0.83			0.33		0.17		
Tree swallow	0.17	0.17				0.33		3.17	2.33	1.83		1.50			3.83	1.00			0.67
Steller's jay															0.17		0.17		
Gray jay							1.00				0.67			0.17		0.50		0.33	
Black-billed magpie	0.33	0.67	0.17						0.50			0.33			0.33				1.00
Clark's nutcracker								0.33					0.17		0.17				
Common raven	0.17		0.17																
Common crow																			0.33
Black-capped chickadee					0.50			1.00	0.17			0.33		0.33			0.17		
Mountain chickadee		0.33					2.33	0.17			5.17			5.00	2.00	2.33	0.17	0.67	
White-breasted nuthatch								0.50											
Red-breasted nuthatch							0.17	0.67							0.17	0.33			
Brown creeper								0.17								0.50			
House wren					2.50		1.17	3.17	1.33	0.67		2.17			1.67		0.17		
Rock wren	0.17		0.17																
Sage thrasher			0.17																
American robin	0.67	4.83	0.17		2.83	4.50	8.33	5.83	13.17	6.83	3.17	14.00		0.33	5.17	1.67	3.83	5.00	0.33
Townsend's solitaire					0.50									0.17		0.17			
Veery									0.33			0.33							
Hermit thrush					0.83		0.83	0.50	0.17		1.00		0.33	0.33	0.33	0.50	0.50		
Swainson's thrush							0.17	0.17		0.17	0.17				0.50		0.17	0.17	
Mountain bluebird	0.50		0.33		0.17			0.33					1.17		0.17				
Ruby-crowned kinglet							4.67	1.83		1.17	7.33			3.00	1.67	5.00	0.17	0.50	
Water pipit													2.83						
Starling		1.67						0.50	0.50			0.83							
Solitary vireo		0.33																	
Warbling vireo		0.17			12.17		6.17	6.50		1.00		0.83		0.50	5.33	0.33		0.17	

Appendix Table II-9 - cont. Relative numbers of bird species observed among sampling locations, 1979.

Species	Location Number*																		
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
PERCHING BIRDS cont:																			
Orange-crowned warbler							0.17												
Yellow warbler		1.33			0.17	0.17	0.17	1.00	11.33	1.83		14.00			0.83				3.67
Yellow-rumped warbler					2.67		0.83	2.83		0.33	1.83			3.33	5.00	3.33	1.17	0.50	0.17
MacGillivray's warbler		1.33			0.17	0.33				1.33		0.17					0.50	0.50	
Wilson's warbler		0.67							1.33	0.17		0.33		1.50	1.00	1.83	0.33	4.00	
Western meadowlark	0.67	0.33	1.50	1.50															
Red-winged blackbird	0.17	6.83							5.83	0.17		0.33							10.00
Brewer's blackbird	3.33	2.33	4.17	4.83		3.00			8.17	0.17		0.83							0.83
Brown-headed cowbird								0.33	0.17			1.67			0.33	0.17			0.17
Western tanager							0.17	0.33			0.67			1.33	1.17	0.17		0.67	
Black-headed grosbeak										0.33					0.33				
Cassin's finch							0.17	0.67			0.17	0.17			1.00	1.67	0.33		0.50
Pine grosbeak											0.17			0.33	0.33	0.67			
Gray-crowned rosy finch													1.17						
Pine siskin		0.50	1.00	0.17	1.33	2.00	3.33	1.00	4.67	3.33	3.17	2.67	0.33	0.50	1.83	5.83	6.67	1.50	8.83
Red crossbill														1.17		0.33		0.33	
Green-tailed towhee	0.17	0.33	1.83	1.00		6.33	1.00			2.83						0.17	0.17		0.17
Savannah sparrow		0.17							2.17			0.50							7.67
Vesper sparrow	3.50	0.17	4.67	2.50		0.50													0.17
Gray-headed junco					2.33		2.67	4.50			3.17		1.67	0.83	3.83	3.17	0.67	0.33	
Chipping sparrow					0.17										0.33	0.50			0.17
Brewer's sparrow	2.33	0.67	3.33	1.83		0.67													
White-crowned sparrow						1.17	0.17	0.50	0.83		0.67	1.67	8.00	0.17	0.50	0.67	0.83	1.50	4.67
Lincoln's sparrow		1.33					0.67		1.00	2.00		0.33	0.50			3.50	0.83	1.83	1.50
Song sparrow		0.50					0.17	0.33	3.83	0.67		2.17			0.17	0.17	0.17	0.67	0.67

*Location Number
15 = Lower Alkali Basin : Sage (sec 22)
16 = Lower Alkali Basin : Riparian (sec 21, 22)
17 = Upper Alkali Basin : Sage (sec 24, 25)

Appendix Table II-9 - cont. Relative numbers of bird species observed among sampling locations, 1979.

*Location Number - cont.	18 = Upper Alkali Basin	:	Sage (sec 19, 20, 30)
	19 = Upper Alkali Basin	:	Aspen (sec 28, 29)
	20 = Carbon Creek Drainage	:	Sage (sec 17)
	21 = Carbon Creek Drainage	:	Conifer-Aspen (sec 32, 33)
	22 = Carbon Creek Drainage	:	Aspen (sec 32, 33)
	23 = Carbon Creek Drainage	:	Riparian (sec 17, 20)
	24 = Carbon Creek Drainage	:	Riparian (sec 5, 32)
	25 = Ohio Pass	:	Conifer (no section available)
	26 = Ohio Creek	:	Riparian (sec 18, 19, 20, 29)
	27 = Mount Emmons	:	Alpine (sec 31)
	28 = Mount Emmons	:	Conifer (sec 5, 6)
	29 = Mount Emmons	:	Aspen (sec 5, 6, 32)
	30 = Mount Emmons	:	Bog (sec 6)
	31 = Mount Emmons	:	Riparian (sec 4)
	32 = Mount Emmons	:	Riparian (sec 5, 6)
	33 = Mount Emmons	:	Riparian (sec 34, 35)

The probability level for rejection of null hypotheses was $\alpha = 0.05$ for all tests.

Analyses of Large Mammal Populations.

Comparisons of elk pellet-group counts in the five winter range locations (Table II-1) were made using a Student-Newman-Keuls (SNK) multiple range test, following a significant F-test ($F = 6.76$; $df = 4, 43$) from a single-factor analysis of variance. Degrees of freedom are based on number of transects, not number of quadrats, i.e., an unweighted analysis of means was used. The conventional double asterisk notation indicating significance at $\alpha = 0.01$ was omitted to simplify presentation.

The correlation coefficient quantifying the association between elk and deer pellet-group distributions on winter range was weak but significant ($r = 0.33$; $df = 46$; $p<0.05$). An unweighted analysis of means was again employed.

Nonsignificance of differences between years for both elk and deer pellet-group densities was based on paired t-tests. Independent tests were made for Alkali Basin and for the Flat Top study area. Also, a test was made combining data from all transects that were operable both years. Correlations of elk and deer pellet-group densities with big sagebrush utilization were highly significant in spite of the meager amount of utilization detected. An arcsine transformation was used on the percent utilization data. Data pairs were transect means, not quadrat values. The correlation coefficient for elk pellet-groups and percent utilization was $r = 0.64$, $df = 21$, $p<0.001$; for deer pellet-groups and percent utilization, $r = 0.69$, $df = 21$, $p<0.001$.

Analyses of Small Mammal Populations.

Statistical analyses of cricetid data (Table II-7) employed single-factor analysis of variance and SNK multiple range testing procedures. Results were $F = 15.7$, $df = 12, 377$; 59 percent of the variance was accounted for among groups and 41 percent within groups.

The correlation of habitat affinities for long-tailed and montane voles was weak but significant ($r = 0.58$; $df = 11$; $p<0.05$).

The nonsignificance obtained for testing whether small mammal populations were higher in 1979 employed paired t-tests, the pairs being the locations sampled in both years.

The nonsignificance of differences over successive trapping days for each of four habitats (two sagebrush, one aspen, and one conifer-aspen) was determined using independent F-tests.

The nonsignificance of differences comparing results of snap traps and live traps was determined using a G-test ($G = 0.39$; $df = 1$; $n = 126$). Sufficient data were only available for deer mice and red-backed voles in the riparian habitat of Coal Creek.

An analysis of the small mammal baseline data of 1979 was performed for purposes of evaluating the feasibility of future monitoring. The population of deer mice in Alkali Basin, based on results from transects moved on consecutive days, was found to be randomly distributed. The test for a Poisson distribution followed Zar (1974); $X^2 = 2.04$; $df = 4$. Given the variation encountered, a 900 trap-night effort would have permitted the detection, on the average, of a 60 percent decrease in a localized segment of the deer mouse population due to causes other than natural variation.

Analyses of Bird Populations.

The correlation coefficient for quantifying the association between S diversities and average diversities was $r = 0.92$; $df = 19$.

Differences in average breeding bird diversities throughout Alkali Basin were evaluated using a single-factor analysis of variance. Results were $F = 3.20$; $df = 4, 25$. Significance among categories could only be determined for the riparian compared to each of the upper Alkali Basin sagebrush sites, using SNK multiple range test procedures. On an *a priori* basis, differences between the riparian habitat and adjacent sagebrush habitat of lower Alkali Creek were tested using a t-test. Results were nonsignificant ($t = 1.66$; $df = 10$). Richness, or S diversities, were evaluated using G-tests (Sokal and Rohlf 1969). Results were basically the same using this diversity parameter. Namely, only the riparian habitat of lower Alkali Basin was significantly different from the remaining areas sampled. Testing over the five categories of 1979 data resulted in $G = 9.57$; $df = 4$; $p<0.05$. The riparian habitat tested against the remaining four habitats gave $G_{adj} = 13.19$; $df = 1$; $p<0.001$. The difference between the riparian and adjacent sagebrush was nonsignificant ($G_{adj} = 3.16$; $df = 1$).

Results of a significant F-test for average breeding bird diversities in the Mount Emmons area ($F = 13.34$; $df = 6, 35$) were again followed by SNK tests. Comparisons of S diversities, however, gave somewhat different results than those reported for average diversities. Namely, differences were nonsignificant among the bog, conifer, and the three riparian habitats, but the aspen and alpine habitats had significantly higher and lower diversities respectively ($G = 54.5$ for aspen; $G = 117.0$ for alpine; both with $df = 1$).

In the Carbon Creek drainage, the F-test for average diversities during 1979 was $F = 3.39$; $df = 4, 25$. While a significant difference was

obtained for the sagebrush habitat in terms of average diversities, no significant differences were obtained for S diversities ($G = 4.42$; $df = 4$).

The significant increase in breeding bird diversities from 1978 to 1979 for S diversities could not be demonstrated for average diversities. A t-test for paired comparisons was used for both diversity parameters. Results were $t = 3.55$ for S diversities, and $t = 1.36$ for average diversities; both with $df = 7$.