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GRIZZLY BEAR HABITAT ANALYSIS

SECTION I

SUMMARY OF SECTIONS I, II, AND III

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SUMMARY OF SECTIONS I, II, AND III

The grizzly bear (Ursus arctos horribilis) is a carnivore; however, as much as 50 percent of its diet may be plant food. This report is confined entirely to describing and evaluating the vegetation components of the bear's habitat. The animal components will be treated in a separate report.

From 1972 through 1979 a study of grizzly bear habitat was conducted in the Scapegoat and Bob Marshall Wilderness areas of Montana to botanically describe the habitat, analyze the feeding habits of grizzlies, evaluate habitat in terms of bear food plants, and then integrate this information into a multispectral, computer-assisted imagery analysis that could be computer extrapolated to the entire wilderness ecosystem. The research was divided into three sections; a section-by-section summary follows.

Section I

Botanical Description of Grizzly Bear Habitat

Our objective in Section I was to present a holistic description of the vegetation composing grizzly bear habitat and then in Sections II and III to describe and emphasize those components most essential to the bear.

To accomplish this, the vegetation of one primary study area and two secondary study areas within the wilderness system was type-mapped and quantitatively described in terms of vegetation/land systems for alpine (above 7600 feet [2711 m]), subalpine (7000 feet to 7600 feet [2711 m to 2132 m]), and temperate (below 7000 feet [2132 m]) climatic zones. Forests were classified and mapped according to the forest habitat types of Daubenmire and Daubenmire (1968) and Pfister et al. (1977). A vegetation/landtype classification was developed for the grass-shrublands of the alpine, subalpine, and temperate zones based on the ecoclass method of Daubenmire (1952), Peterken (1970), Corliss and Pfister (1973), and Mueggler and Handl (1974).

Data derived from type mapping and from vegetation sampling enabled us to quantify bear food plants on a comparative basis. The data also served as ground truth for computer mapping the primary study area in the Scapegoat Wilderness and two secondary areas (Slategoat and Danaher in the Bob Marshall Wilderness) using LANDSAT multispectral imagery. The computer-modeled vegetation maps were tested against ground vegetation type maps for accuracy. The methods and results of this and the food plant analysis are summarized in Sections II and III.

In the Scapegoat study area, the alpine, subalpine, and temperate zones comprised 14, 42, and 44 percent respectively of the total land area. In the alpine zone, 94 percent of the area was non-forested, whereas only 7.3 percent non-forested area occurred in the subalpine zone and in the temperate zone. Twelve land units were delineated and botanically described in the alpine zone: Alpine Meadow, Alpine Meadow Krummholz, Slab-Rock Krummholz, Slab-Rock Steps, Glacial Cirque Basin, Mountain Massif, Vegetated Talus, Semi-Vegetated Talus, Fellfield, Parent Rock (limestone/argillite), Bare Talus (limestone/argillite), and Snowfield and Snowfield Sinks.

Five landtypes delineated and botanically described in the subalpine zone were Seral Stages (burns), Wet Forb-Grasslands, Dry Forb-Grasslands, Snowslides, and Ridgetop Glades. With the exception of Snowslides, the same landtypes were delineated and described in the temperate zone.

Forest habitat types of both the subalpine and temperate zones were grouped as xeric, mesic, or hydric types, and eight major habitat types included within these groupings were sampled for ground cover and botanically described in terms of grizzly bear food plants.

The abundance and distribution of grizzly bear food plants were determined by vegetation sampling of ecological landtypes and forest habitat types of the alpine, subalpine, and temperate zones respectively.

Ecological land units of the alpine zone varied considerably in their potential as plant energy sources for the grizzly bear. The most important land units, based on the percent abundance of food plants, were the Alpine Meadow, Alpine Meadow Krummholz, Glacial Cirque Basin, and Mountain Massif, all of which showed an abundance of bear food plants in excess of 50 percent. Within the alpine zone, 51 percent of the vegetation ground cover consisted of plant species or genera utilized by the grizzly as food. The most abundant and widely distributed of these were the grasses and sedges, *Arctostaphylos uva-ursi*, and species of *Vaccinium*, *Polygonum*, and *Lomatium*.

Ecological landtypes of the subalpine zone also varied in their potential as plant energy sources. Those with the greatest abundance of food plants were fire-caused Seral Stages, Dry Forb Grasslands, Snowslides, and Ridgetop Glades, all of which showed an abundance of food plants in excess of 50 percent of the total ground cover.

Within the grass-shrublands of the subalpine zone, 56 percent of the vegetation ground cover consisted of plant species or genera utilized by grizzlies as food. The most abundant and widely distributed of these were the grasses and sedges. Among the shrubs there were *Vaccinium scoparium*, *Vaccinium globulare*, and *Shepherdia canadensis*; and among the forbs, *Xerophyllum tenax*, *Fragaria virginiana*, *Equisetum arvense*, *Heracleum lanatum*, *Erythronium grandiflorum*, *Claytonia lanceolata*, *Lomatium cous*, and *Polygonum bistortoides*.

Forest habitat types of the subalpine zone had high potential as plant energy sources. Those with the greatest abundance of food plants were *Abies lasiocarpa/Luzula hitchcockii-Vaccinium scoparium* and *Abies lasiocarpa* (*Pinus albicaulis/Vaccinium scoparium*), both of which exceeded 60 percent. The poorest was *Abies lasiocarpa/Luzula* *hitchcockii*-*Menziesia ferruginea*.

Within the forest habitat types, 59 percent of the understory vegetation consisted of grizzly bear food plants. *Pinus albicaulis*, the only tree species providing food, averaged 17 percent of the subalpine forest canopy. *Vaccinium scoparium* was the most abundant and widely distributed food plant of the understory and, with *Xerophyllum tenax* and *Carex geyeri*, dominated the ground cover.

Within the subalpine zone, 57 percent of ground vegetation cover of the grass-shrublands and the coniferous forests combined was a potential energy source for the grizzly. The most abundant species were *Vaccinium scoparium*, *Xerophyllum tenax*, *Carex geyeri*, and *Festuca idahoensis*. The presence of *Pinus albicaulis* made the subalpine zone unique as an energy source for the grizzly.

Ecological landtypes of the temperate zone showed greater variation as energy sources than their equivalents in the subalpine zone. Seral Stages (burns) and Dry Forb Grasslands showed the highest potential based on food plant abundance with values exceeding 70 percent.

Within the grass-shrublands of the temperate zone, 61 percent of the vegetation ground cover consisted of plant species or genera utilized by grizzlies. The most abundant and widely distributed of these were species of *Festuca* and *Carex*. Among the shrubs were *Amelanchier alnifolia*, *Arctostaphylos uva-ursi*, *Shepherdia canadensis*, and *Symphoricarpos* albus; among the forbs, Xerophyllum tenax and Fragaria virginiana.

The highest bear food plant potential among all vegetation units measured were the forest habitat types of the temperate zone. Those with the greatest abundance of understory food plants were Abies lasiocarpa/Xerophyllum tenax-Vaccinium globulare, Abies lasiocarpa/Xerophyllum tenax-Vaccinium scoparium, and Pseudotsuga menziesii/Calamagrostis rubescens habitat types. Food plant abundance values for each of these habitat types exceeded 80 percent.

Within all of these forest habitat types, 72 percent of the understory vegetation consisted of grizzly bear food plants. The most abundant and widely distributed species were Vaccinium scoparium, Xerophyllum tenax, Calamagrostis rubescens, Vaccinium globulare, and Carex geyeri.

In the temperate zone bear food plants comprised 67 percent of the ground cover of the grass-shrublands and coniferous forests combined. The most abundant food plants were Vaccinium scoparium, Xerophyllum tenax, Calamagrostis rubescens, Festuca spp., and Carex spp.

Each climatic zone was evaluated as a potential energy source for the grizzly bear based on its food plant abundance and area percent values. The subalpine zone rated highest, the temperate zone second, and the alpine zone third, with values of 8, 31, and 30 respectively. The presence of Pinus albicaulis (the sole overstory species, limited to the subalpine zone) accounted for the subalpine zone's high rating. The resources of all three zones are essential to the grizzly, and all zones support habitat critical to the grizzly within the Scapegoat/Bob Marshall Wilderness areas. These potential habitat values for each climatic zone are based on the assumption that each of the many food plants utilized by grizzlies are equal in importance. However, grizzlies show decided preferences in their use, so in Section II the various food plants are evaluated by established criteria to determine their specific importance to the grizzly. The values obtained are then used to refine the climatic zone habitat ratings presented in Section I.

Section II

Evaluation of Grizzly Bear Food Habits, Food Plants, and Habitat

The food habits of grizzly bears were determined from the occurrence of plant items in fecal samples and from direct observation in the field.

The importance value percent (IVP) of food plants identified in scats was calculated for a number of food items. This expression of utilization of food plants, developed by Sumner and Craighead (1973), permits direct comparison between food-plant usage and food-plant abundance. The IVPs were ranked and used to describe dietary importance of individual food plants to the grizzly bear.

Scat analysis indicated four major plant energy sources for the grizzly bear in the alpine and subalpine zones: graminales, forbs, berries, and pine nuts with IVPs of 29.7, 37.6, 12.5, and 20.4 respectively.

Energy values (Kcal/g) were determined for the more important food plants. Available energy of specific food plants varied from a low of 1.91 Kcal/g in the roots of _Veratrum viride_ to 3.99 Kcal/g in whitebark pine nuts (_Pinus albicaulis_). Specific energy values were then related to each plant's abundance, distribution, and seasonal and annual availability.

IVP values for specific plants varied from 20.4 for pine nuts (_Pinus albicaulis_) to .1 for several forb species. A general relationship was found between grizzly bear use of grasses (Gramineae) and their relative abundance values in the grass-shrublands of the alpine and subalpine zones. The sedges (Cyperaceae) were not consumed in relation to their relative abundance values.

The high IVPs of specific forbs such as _Lomatium cous_ and _Claytonia megarhiza_ indicated that preference and a high order of selectivity, rather than relative abundance, determined the extent to which they were utilized by grizzlies.

Among the four major energy sources utilized by grizzlies, the graminales and forbs were chiefly spring and summer foods, berries were almost exclusively summer food, and pine nuts were primarily fall food except during years of exceptional seed production when they were consumed in spring as well.

The grasses, a highly stable energy source available during the entire foraging season, served as a "survival ration" to carry the bear through periods when other energy sources were low.

A food plant value percent (PVP) was calculated for most of the species and plant groups used by grizzlies. This was accomplished by utilizing a number of parameters that could be quantitatively expressed and compared. Based on the values calculated for each food plant, we concluded that the most important ones for the grizzly were: Gramineae, 1; *Pinus albicaulis*, 2; *Vaccinium* spp., 3; Cyperaceae, 4; *Lomatium cous*, 5; *Shepherdia canadensis*, 6; *Claytonia megarhiza*, 7; *Fragaria* spp., 8; and *Arctostaphylos uva-ursi*, 9. Other less important ones were also rated. Gramineae and Cyperaceae exhibited high PVPs, but individual species of grasses and sedges could not be rated.

Refined habitat ratings for the alpine, subalpine, and temperate zones were derived by adding the PVP values to obtain zonal food plant values. These were then combined with the potential energy source values derived in Section I to arrive at climatic zone habitat values. Based on these combined values the habitat ratings were: subalpine zone, 1; temperate zone, 2; and alpine zone, 3. Thus when all comparable parameters were considered in the evaluation process, the subalpine zone emerged unique as an energy source for grizzly bears.

Grizzlies confined much of their plant foraging to micro-habitats within the larger zonal and vegetation-type designations. Generally these were sites of high food plant abundance, either single high preference food plants or a combination of several. These relatively small foraging sites were distributed throughout all the major land units and forest habitat types in all three climatic zones. They are extremely important to the grizzly and should receive special site protection in areas where land use practices threaten them.

The zonal ratings show the relative values of each zone and further support an earlier conclusion that all three climatic zones are essential components of grizzly bear habitat. Destruction or adverse modification of habitat in any zone could constitute loss of critical habitat and a lack of compliance with Section 7 of the Endangered Species Act. *Vaccinium scoparium*, *Vaccinium ovalifolium*, and *Pinus albicaulis* were considered to be the most vulnerable of the major food sources and the most essential to the grizzly bear's long-term energy needs. These can be adversely affected or destroyed by poor land-use practices.

Section III

LANDSAT-1 Multispectral Imagery and Computer Analysis of Grizzly Bear Habitat

Multispectral imagery and computer analysis was employed to develop and perfect a system for mapping vegetation of extensive wilderness areas and relating this to grizzly bear habitat requirements. The satellite technology employed consists essentially of a satellite multispectral scanner in polar orbit that records spectral energy in four spectral bands. The intensity in each band is continuously recorded beneath the satellite path, converted to digital form, and stored on magnetic tape. An image or frame 110 x 110 miles (185 x 185 km) from any one of the spectral bands is composed of over 6 million picture elements or "pixels." Each pixel is a record of the brightness level of a portion of the earth's surface (scanned by the multispectral scanner) having an area of 1.12 acres (0.453 hectares). An entire LANDSAT frame, or any portion of it, can be computer-oriented and analyzed pixel by pixel. When the vegetation characteristics of grouped pixels of similar spectral values are known, then the vegetation can be computer mapped since similar vegetation tends to have similar spectral values and a number of unique spectral signatures characterized a wide range of vegetation. The accuracy of computer vegetation mapping depends to a large extent on the accuracy and detail of the ground truth data that can be correlated with the spectral values or signatures. The pixel-by-pixel analysis provides a unique system of classifying and inventorying vegetation over extensive land areas and continuously updating results by additional data input.

Using the vegetation ground map and data presented in Section I, broad vegetation classes were distinguished according to their spectral reflectance values established from LANDSAT-1 images of the land/vegetation associations and interpreted through the General Electric interactive multispectral image analysis system. Results of the computer modeling were then refined and (following each of 3 seasons of field testing and vegetation sampling) integrated into first-, second-, and third-generation computer maps with summary statistic readouts. The maps were field tested for accuracy. The technique of computer extrapolation of signature data to unmapped areas of the wilderness ecosystem was also field checked.

To obtain unique spectral signatures, a number of training areas for each vegetation theme were located in the field and recorded on orthophoto maps. These training sites were later positioned on the MMS imagery. By combining spectral signatures and signature polygons representing spacial zones, the number of color-encoded themes were increased with each new generation map. The final product consisted of 13 unique vegetation complexes, each represented by a color code and each botanically described in quantitative terms.

The effect of aspect, elevation, and canopy cover on spectral reflectance was examined by various sampling procedures.

Second- and third-generation thematic maps of the primary study area were checked for accuracy by comparing computer-assigned vegetation classses (spectral themes) with ground truth data. Test sites were examined pixel by pixel for agreement (or lack of it) between the computer modeling and ground truth for each class.

Once the level of accuracy had been determined for the thematic map of the Scapegoat study area, the spectral values (signatures) were extrapolated to the Slategoat and the Danaher study areas using multispectral imagery and the computer-processed spectral data. These maps were, in turn, checked for accuracy.

Accuracy of the primary area in the Scapegoat was tested with 336, 5.1-acre sites; the secondary Slategoat and Danaher areas were tested with 457, 2.8-acre sites and 140, 6.7-acre sites, respectively.

An examination of the role of aspect and canopy density in determining spectral values showed that the density of the forest canopy largely determined the gray-level values that characterized the two forest signatures. Canopy density, in turn, was to a large degree determined by moisture conditions governed by aspect. Therefore moisture and aspect designations were employed to describe the forest themes.

By employing spacial zoning at the 7000-foot and 7600-foot contours in the computer modeling, it was possible to differentiate vegetation with identical spectral values but very different species composition. Thus, both grass-shrubland and forest themes of the alpine, subalpine, and temperate zones were spacially delineated (subdivided) into vegetation complexes. The two forest themes were subdivided into four complexes; the grass-shrubland theme into three. These were sampled to establish their botanical composition.

Ten vegetation complexes were computer delineated and mapped to construct the second-generation map of Scapegoat. To describe the vegetation composition of each complex, the descriptive botanical data presented in Section I were re-organized to conform to the appropriate land units represented by each complex.

The vegetation complexes were first described by their percentage composition of land units, landtypes, and forest habitat types with respective area percentages. Each vegetation complex was then described in greater detail by quantifying percent cover and percent occurrence of ground vegetation cover and forest understory species. Finally, the specific food plants were rated and ranked and related to the vegetation complexes.

Thirteen vegetation complexes were computer delineated and mapped to construct the third-generation (final) map of Scapegoat, and the vegetation of each complex was described in quantitative terms. The same was done for the secondary study areas, Slategoat and Danaher. The thirteen complexes separated by spectral signatures and/or signature polygons were: Alpine Meadow, Vegetated Rock, Bare Rock I (lichens), Bare Rock II (lichens), Xeric *Pinus albicaulis* Forest, Mesic *Abies lasiocarpa*/*Pinus albicaulis* Forest, subalpine Parkland, *Equisetum* Seepage, Forested SCREE, Xeric *Abies lasiocarpa* Forest, Xeric *Pseudotsuga menziesia* Forest, Mixed Coniferous Temperate Forest, Temperate Parkland, and *Carex*-*Salix* Marsh.

The application of field test sites showed an average accuracy for the primary area of 91 percent for the alpine zone complexes, 88 percent for the subalpine zone, and 88 percent for the temperate zone complexes. The entire primary Scapegoat area was computer mapped with an overall accuracy of 89 percent.

When ecotone pixels that could be considered correct for more than one theme or complex were recorded as being correct for the theme or themes being tested, then the total pixels that could be recorded as correctly classified by the computer increased. Using this procedure, the overall numerical expression of accuracy increased to 93 percent.

Extrapolating data from Scapegoat to the two secondary areas and testing with field sites (with consideration of ecotone pixels) showed an average extrapolation accuracy for Slategoat and Danaher of 91 percent and 85 percent respectively.

A comparison of area statistics for the conventional vegetation type map (ground truth) of Scapegoat against the computer-modeled map of the same area showed close correlations when the inherent differences in the two classification systems were analyzed. This was considered positive evidence of the accuracy and feasibility of applying computer modeling to vegetation type mapping using LANDSAT multispectral imagery. Within the three study areas, we found that a strong correlation existed between spectral classes and the vegetation types (ELUs, ELTs, and FHTs) that composed them. This was interpreted as further evidence that computer extrapolation of grouped vegetation types, using spectral classes spacially zoned, was feasible and accurate. The final result of computer-mapping was three thematic maps, each botanically described in terms of ecologically classified vegetation types, with area statistics for each computer-derived complex and with quantitative expressions of the percentages of bear food plants and food-plant groupings for each complex. The vegetation complexes were then numerically rated to express habitat quality.

The significance of this is fourfold. First, large geographical areas of ecologically similar habitat within the Scapegoat and Bob Marshall Wilderness areas can be computer type-mapped by extrapolation with a degree of accuracy and statistical detail comparable to that demonstrated for the study areas. This can be accomplished without additional field data, using the spectral signatures and the spatial zoning technique already discussed. Second, grizzly bear habitat for large geographic areas can be computer-mapped and quantitatively described in terms of plant foods and energy sources. Third, it is predictable that reliable population estimates of grizzly bears and other large mammals can be made in the future for the entire wilderness area by relating animal numbers on the study area to specific vegetation complexes (habitat) and then computer-extrapolating the ratio of animal numbers to vegetation complexes. The same procedure will also provide statistics on animal distribution. Fourth, the computer mapping procedures and quantitative descriptive methods discussed in the text constitute a rapid, precise wilderness resource inventory system that can be continuously improved and updated by computer input and applied to wilderness, land, and wildlife management problems. In addition to the vegetation data, soils, terrain, and hydrologic parameters can be merged with LANDSAT imagery through the user-interactive computer to make an integrated multipurpose analysis. Application of such a system by state and federal resource agencies could greatly enhance land planning, land usage, and resource predictions for the nation's large wilderness and wildland areas.

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GRIZZLY BEAR HABITAT ANALYSIS

Section I

VEGETATION DESCRIPTION OF GRIZZLY BEAR HABITAT IN THE SCAPEGOAT WILDERNESS (Ground Truth)

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INTRODUCTION

The number of grizzly bears (*Ursus arctos horribilis*) in the United States, excluding Alaska, has declined rapidly since the early 1800s. Recent drops in population levels have caused concern for the survival of the species. Craighead et al. (1974) demonstrated a 44.5 percent decline of grizzly bears in the five million acre Yellowstone ecosystem from 1967 to 1974. Evidence suggests the population may not yet be stabilized. A viable population probably does not exist in the 1.6 million acre (.65 million ha) Selway-Bitterroot Wilderness ecosystem of Idaho and Montana where grizzlies were once fairly abundant. The population status of the species in the extensive Bob Marshall and Lincoln-Scapegoat Wilderness areas of Montana has not yet been documented scientifically. The number now inhabiting the contiguous 48 states may not exceed 600 or 700 (Craighead et al. 1974). The historical, as well as the more recently documented, decline of the grizzly bear in the western United States has resulted from the species' low reproductive rate and its inability to cope with severe man-induced mortality and drastic habitat changes (Craighead et al. 1974). The grizzly has been able to survive only where spacious habitat has insulated it from excessive mortality.

Evidence of a decline of grizzlies in Yellowstone, combined with aroused public concern for the fate of this powerful carnivore in the contiguous 48 states, prompted the director of the U.S. Fish and Wildlife Service, following scientific and public review, to declare the grizzly bear a threatened species subject to the rules and regulations of the Endangered Species Act of 1973. Evidence suggested the grizzly bear was threatened by over-utilization from sport hunting, illegal kills, over-reactive control measures, increasing human use of its habitat, lack of effective state and federal cooperative management programs, and present or future destruction, modification, and curtailment of grizzly bear habitat. These potentially destructive forces (J. J. Craighead, in press) and the species' low reproductive rate (Craighead et al. 1974, 1976) emphasize the importance of critically defining and analyzing components of grizzly bear habitat and relating this information to numbers and distribution of this threatened species.

The grizzly bear has survived through the past decade primarily because suitable habitat was preserved by the Wilderness Act of 1964, which established a National Wilderness Preservation System. This system now includes much of the spacious, mountainous habitat where grizzly bears are found and where they presumably can survive in the future. The habitat is largely confined to three grizzly bear "ecosystems"--the Yellowstone, the Selway-Bitterroot, and the Bob Marshall-Lincoln-Scapegoat. In one, and probably two, of the three ecosystems, grizzly bears occur as geographically and genetically isolated populations. In the third, the Bob Marshall-Lincoln-Scapegoat and adjacent areas, the population can be reinforced genetically and numerically by movement and interchange of individual bears from adjacent occupied habitat in Canada.

The Endangered Species Act prohibits federal agencies from jeopardizing a threatened or endangered species by disturbing or destroying critical habitat. However, critical habitat has been scientifically defined only in the Yellowstone region (J. J. Craighead 1978). Clearly, it will be necessary to describe, analyze, and map wilderness habitat occupied by grizzly bears before critical habitat subject to land use modification can be defined precisely. We believe that the initial step in delimiting critical habitat should be to classify land areas that are: (1) in wilderness status and currently supporting viable grizzly bear populations; (2) occupied by grizzly bears but are (or will be) subject to high priority land use conflicts; (3) wilderness or _de facto_ wilderness no longer supporting viable grizzly bear populations, but having the habitat potential to do so. The broad habitat classifications should then be intensively studied and scientifically described.

Our efforts have been to describe and map habitat that previous experience suggests may be prime for the species and which currently supports viable bear populations.

We surveyed grizzly bear habitat in the Lincoln-Scapegoat Wilderness in 1972 (Sumner and Craighead 1973) and experimented with habitat mapping using ERTS multispectral imagery (Varney et al. 1973). We also delineated critical habitat in the Yellowstone region in terms of movement data, death statistics of marked and unmarked animals, as well as from information on habitat and spatial needs of the species and competition between bear and man for the same space and habitat (J. J. Craighead 1978).

Various aspects of grizzly bear habitat south of Canada have been described by Shaffer (1971); Craighead and Craighead (1972); Sumner and Craighead (1973); Varney, Craighead, and Sumner (1973); Mealey (1975, 1976); Roop (1975); U.S. Forest Service (1975); Craighead, Sumner, and Varney (1976); and J. J. Craighead (1978). This literature deals with habitat surveys establishing criteria for evaluating habitat, developing habitat rating systems, developing habitat-typing and mapping techniques, analyzing distribution and occurrence of plant foods, and relating food habits of grizzly bears to habitat types and generalized vegetative complexes. It is difficult to compare the literature because a standardized habitat classification and terminology have not yet been developed. In order to develop such a standard, we adopted the forest habitat classifications of Pfister (1977) and the grassland classifications of Mueggler and Handl (1974). We applied these classifications, and our own classification of alpine vegetation, to a specific study area in the Scapegoat Wilderness of Montana. The result was a vegetation description of all components of bear habitat between elevations of 4000 and 9000 feet (1218 and 2742 m). The description and the vegetation-cover map provide the ground truth data necessary for accomplishing the objectives cited in Sections II and III. It was assumed, and later verified by field sampling, that the Scapegoat study area was representative of much larger areas. Thus, the Scapegoat served as the basic land unit for our descriptions of grizzly bear habitat. Secondary study areas, Slategoat and Danaher, are described in Section III, along with an explanation of the contribution of each to the overall habitat analysis. The relationship of the three areas is shown is Fig. 1a.

This report on grizzly bear habitat is divided into three sections. The first is a description of grizzly bear habitat; the second describes the utilization of habitat by the grizzly bear and proposes a habitat rating system; the third presents results of applying LANDSAT imagery and computer technology to mapping grizzly bear habitat.

Specific objectives were:

Section I

1. To present a holistic description of the vegetation composing grizzly bear habitat by defining and describing land units, habitat types, plant communities, plant

foods, and climatic zones utilized by grizzly bears in the Lincoln-Scapegoat Wilderness.

2. To produce a ground truth vegetation map of a 79-square-mile (205 km^2) study area in the Lincoln-Scapegoat Wilderness by classifying the vegetation into ecological land units, landtypes, and habitat types.
3. To relate the abundance and distribution of grizzly bear food plants to the abundance and distribution of other plants in the bears' environment.
4. To develop a quantitative botanical description of grizzly bear habitat that can be refined with additional data input and that will serve as a scientific basis for comparing, evaluating, and rating such habitat.

Section II

1. To analyze grizzly bear food habits and relate the data to relative abundance and availability of food plants in the study area.
2. To develop climatic zone habitat rating indices.
3. To evaluate specific grizzly bear food plants and food-plant categories.
4. To correlate all resulting ecological data with observed grizzly bear behavior and habitat use in order to describe and evaluate grizzly bear habitat requirements.

Section III

1. To utilize satellite multispectral imagery and ecological

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ground truth data to construct a thematic, computerized vegetation type map.

2. To group ecologically similar vegetation units described in Section I into broad vegetation complexes that can be computer mapped from multispectral imagery themes.
3. To describe each computer-mapped vegetation complex in quantitative terms that can be related to the abundance and distribution of specific grizzly bear food plants.
4. To evaluate classification accuracy of the computer-generated thematic map.
5. To test the efficacy of extrapolating the classification criteria to locations outside the study area in order to map vegetation for a much larger geographic area.
6. To produce a biotic resource monitoring and inventory system based on satellite multispectral imagery which can be continuously updated with computer science.

PRIMARY STUDY AREA

The primary study area lies in the center of the 240,500-acre (97,368 ha) Lincoln-Scapegoat Wilderness located 75 miles (121 km) northeast of Missoula and 75 miles west of Great Falls, Montana, in the Lolo National Forest (Figs. 1a, b, c, and d). The 950,000-acre (384,615 ha) Bob Marshall Wilderness borders the study area on the northwest. The Lolo National Forest lies to the south and west, Flathead National

Fig. 1a. Satellite photograph showing 12,100 square mile area with location of study sites.

1 = Scapegoat--primary study area
3 = Danaher--secondary study area
4 = Slategoat--secondary study area
2 = Area of ecologic similarity

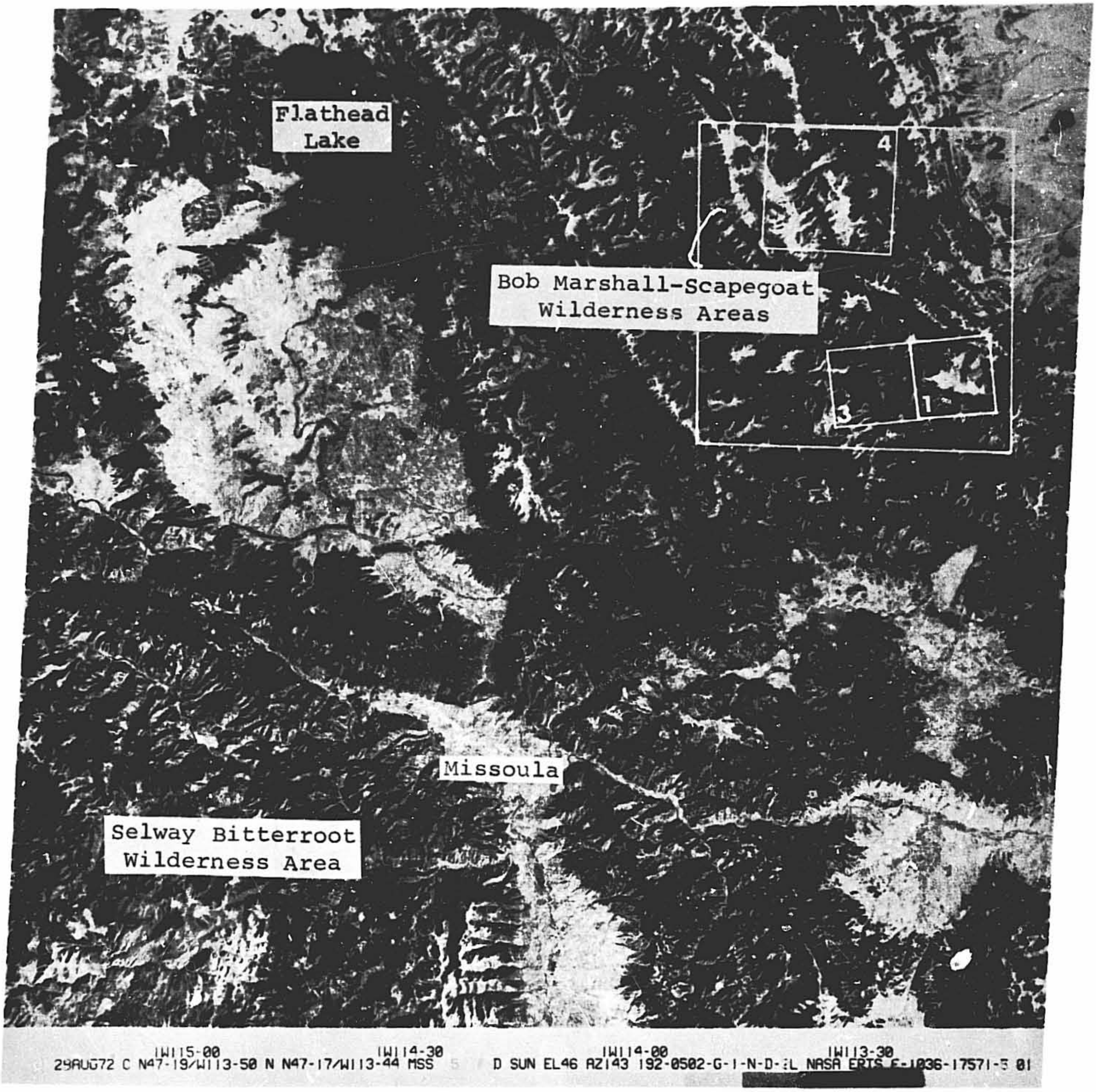
Flathead
Lake
Bob Marshall-Scapegoat
Wilderness Areas
4
2
3
1
Missoula
Selway Bitterroot
Wilderness Area
1W115-00
1W114-30
1W114-00
1W113-30
29AUG72 C N47-19/W113-50 N N47-17/W113-44 MSS D SUN EL46 AZ143 192-0502-G-1-N-D-2L NASA ERTS E-1036-17571-5 01

Fig. 1b. Oblique view looking east over the Scapegoat Study Area. The timbered area in the foreground represents the upper limits of the subalpine zone. Above the 1000-foot headwall lies the Scapegoat Plateau of approximately 8000 acres with Scapegoat Mountain centrally located. Alpine Meadows, Glacial Cirque Basins, krummholz islands and talus are discernible.

Photo courtesy of U.S. Forest Service

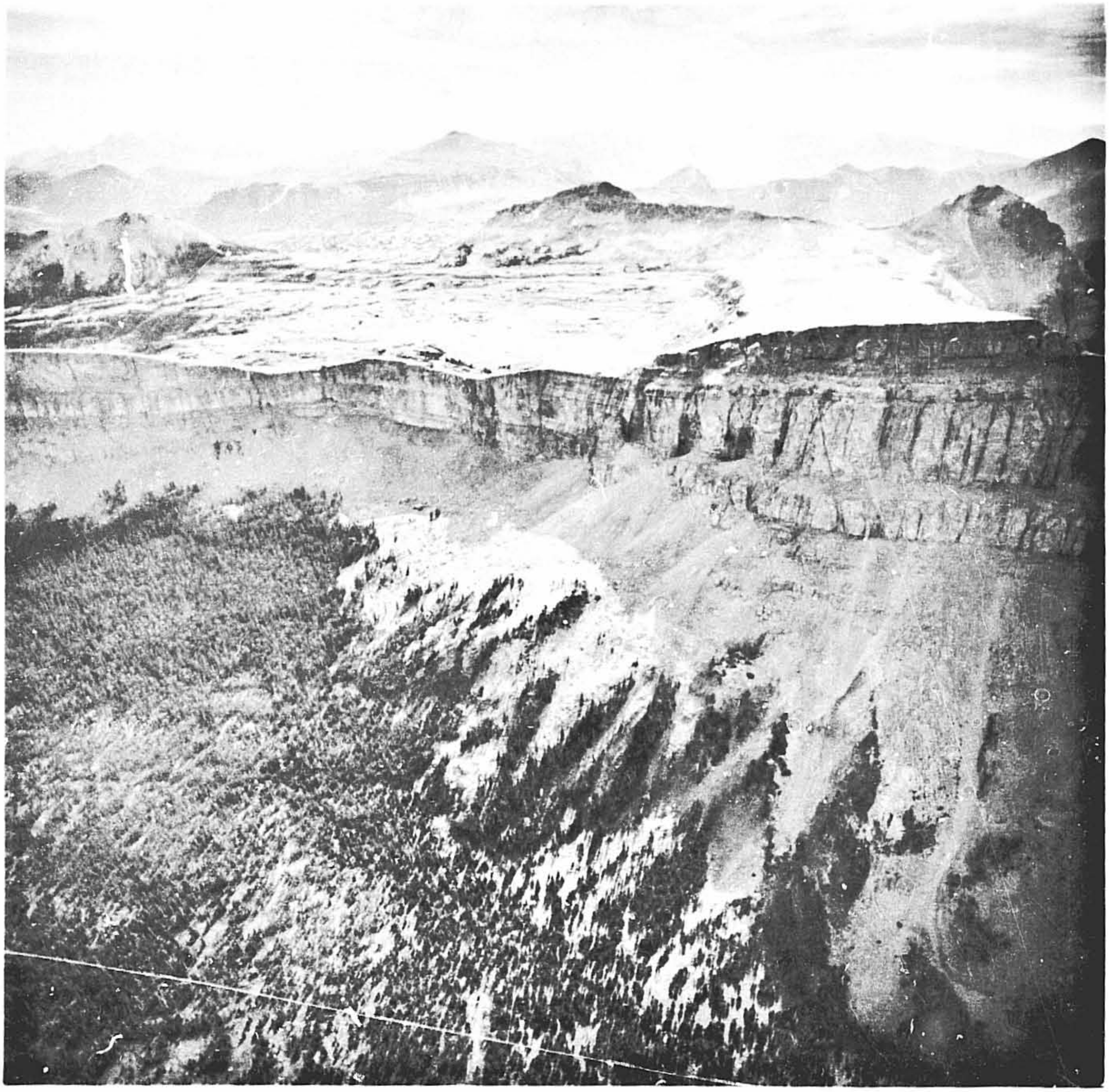

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Fig. 1c. Oblique view looking northeast over the Scapegoat study area. To the left is the high alpine meadow ridge known as Flint Mountain; to the right, Goat Peak. Both subalpine and temperate forests are visible in the foreground. The subalpine forests are interspersed with grass-shrublands.

Photo courtesy of U.S. Forest Service

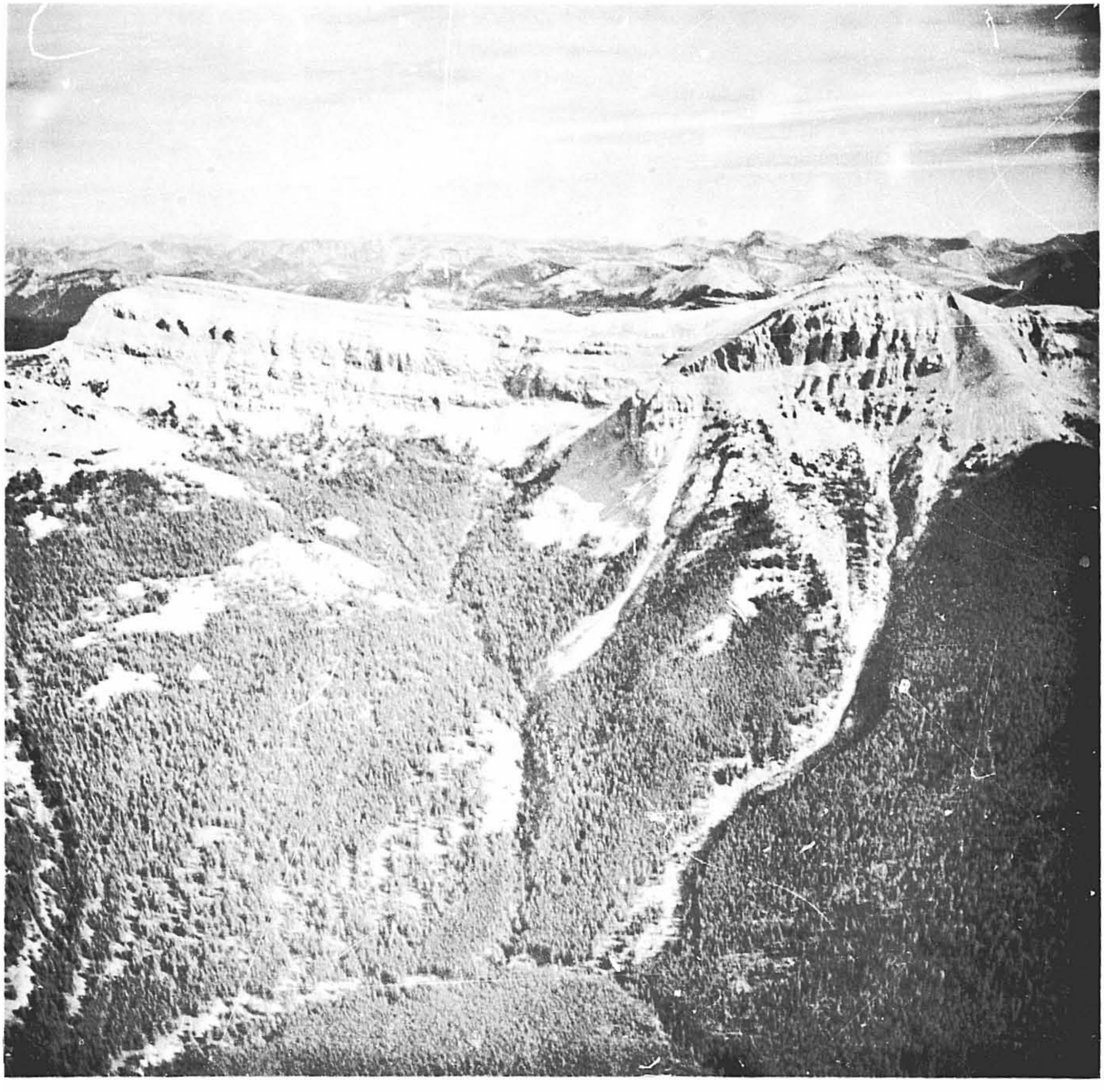

Fig. 1d. Oblique view looking southwest over the Scapegoat study area. To the left, within the subalpine zone, lies Halfmoon Park. A long, narrow, precipitous landform separates Halfmoon Park from the Green Fork of Straight Creek and extends southerly to terminate in Scapegoat Mountain. In the near distance lies Evans Peak. Directly north of this peak is a broad glacial cirque basin that drops abruptly from the alpine zone to the upper limits of the temperate zone. The sheer limestone cliffs characterize both the Scapegoat and Bob Marshall wilderness areas. They help provide the isolation and privacy so essential to the grizzly bear.

Photo courtesy of U.S. Forest Service

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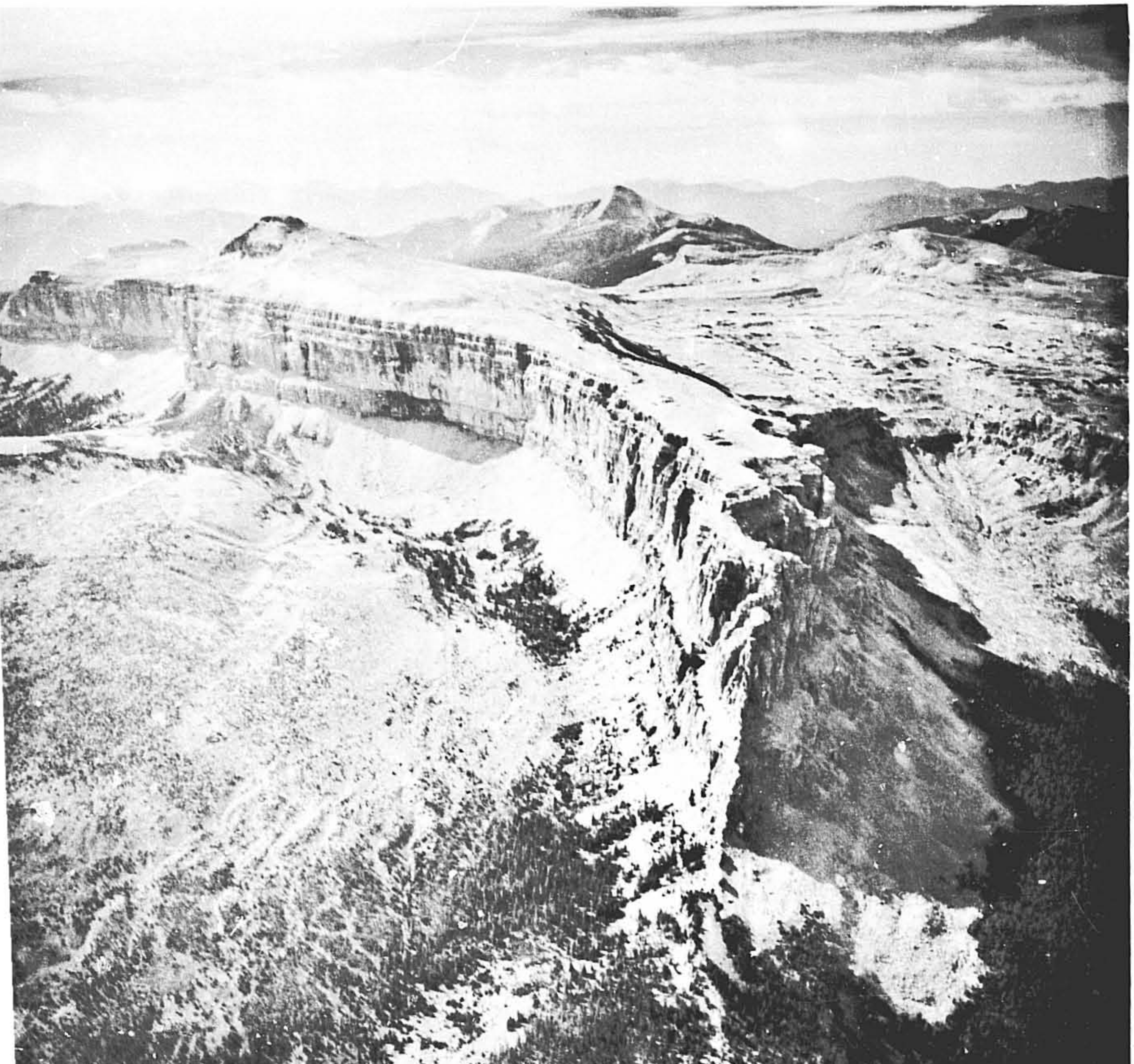
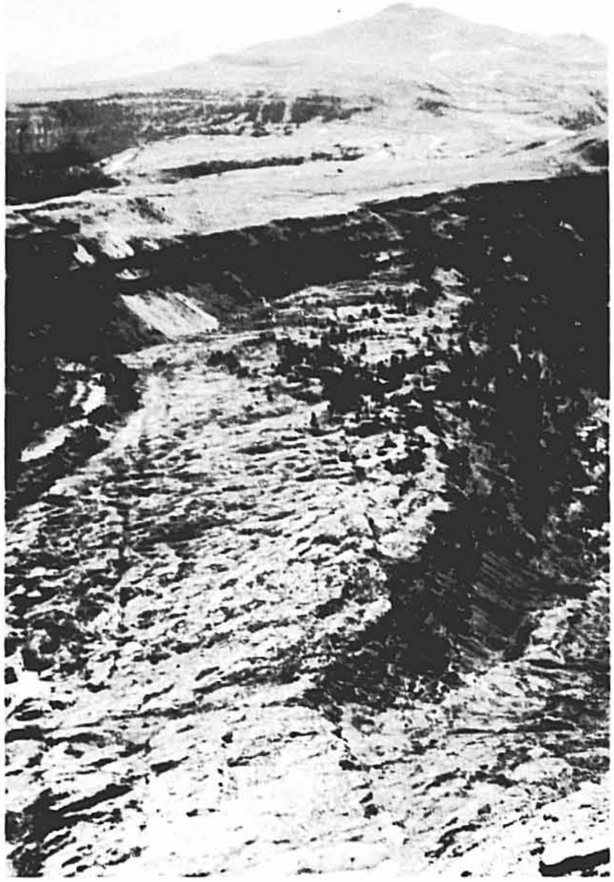


Forest to the northwest, Lewis and Clark National Forest to the north and east, and Helena National Forest to the southeast.

The limestone and argillite topography is extremely rugged with topographic features shaped by glaciation. Scapegoat Peak and Flint Mountain rise over 9000 feet (2742 m); Evans, Nighthawk, and several other prominent peaks are over 8500 feet (2589 m). Scapegoat Plateau rises abruptly 1000 to 1500 feet (304 to 457 m) above the timbered valleys and lies mainly within the alpine zone (Fig. 2). The lower valleys of the Cabin, Dry Fork, and Dobrota Creeks drain into the North Fork of the Blackfoot River south of the study area. To the northeast, Halfmoon Creek flows into the Dearborn River. The Green Fork of Straight Creek and the South Fork of the Sun River flow to the north and northwest, respectively. The 7746-acre (3136 ha) Scapegoat Plateau extends north of the Continental Divide from 2 miles (3 km) southeast of Scapegoat Mountain west to Observation Point. The average elevation of the Plateau is approximately 8000 feet (2437 m).

Timberline occurs at about 7600 feet (2771 m) with variations due primarily to changes in aspect and exposure. The transition from timberline to alpine vegetation is gradual and often ill defined, with alpine tundra first appearing at about 8000 feet (2437 m). At elevations below 7600 feet (2771 m), the alpine flora is replaced by subalpine

Fig. 2. Photographs showing landscape typical of Scapegoat Plateau; identified clockwise from lower left: Fellfield; talus slopes; Glacial Cirque Basin; timberline.



vegetation.

Approximately 15 percent of the study area lies in the alpine zone and 85 percent in the subalpine and the temperate forest zones. Four climax series are represented: grass-sedge, grass-shrubs, *Abies lasiocarpa*, and *Pseudotsuga menziesii*.

GRIZZLY BEAR HABITAT CRITERIA

Studies of bear-man relationships (J. J. Craighead and F. C. Craighead, 1971), and food habits and habitat requirements of grizzly bears in the Yellowstone ecosystem (J. J. Craighead 1978; Craighead, Craighead, and Sumner, in prep.) have defined a number of environmental characteristics essential to the maintenance of a grizzly bear population. These are:

1. Space

   Movements of grizzly bears may exceed 50-60 airline miles (81-97 km) and their home ranges encompass an area of 1000 to 1500 square miles (2590 to 3885 km) with altitudinal changes of over 5000 feet (1524 m) or more; therefore, large wilderness and *de facto* wilderness areas of national parks and national forests are essential.

2. Isolation

   Because grizzlies conflict with man and with his uses of the land, their habitat must be isolated from developed areas and should receive only light recreational, logging, and livestock use. Intensity of livestock and recreational use must be more precisely defined in order to classify critical habitat. Also, criteria must be developed for zoning or restricting land uses in occupied habitat. Roading tends to degrade the habitat, as does excessive trail use.

3. Sanitation

Grizzly bears are omnivorous and are attracted to "artificial" food sources; therefore, sanitary disposal of garbage and other edible refuse at recreational sites and by communities adjacent to grizzly habitat is an essential habitat criterion. Bears become man-conditioned when they feed on refuse in the presence of humans. This conditioning greatly reduces their natural fear of man and is the major cause of tragic bear-man encounters.

4. Food

An abundance of natural foods must be available from April to November and be sufficiently varied so that an annual deficiency in one or more major food sources does not drastically limit the total available food and jeopardize the grizzly population. Basic foods are carrion, ungulates, rodents, berries, pine nuts, green vegetation, bulbs, and tubers, and, in some situations, fish. This broad range of essential foods fluctuates in abundance from year to year. The lower limits tend to determine carrying capacity.

5. Den Sites

In the Rocky Mountain regions, grizzlies normally den at altitudes ranging from 7000 to 9000 feet (2132 to 2742 m) in areas of heavy snowfall. Most wilderness and primitive areas provide the specific denning requirements of topography, aspect, snow depth, and soil types. Isolation appears to be the most essential denning criterion.

6. Vegetation Types

A wide range of vegetational types characterizes prime grizzly bear habitat. Vegetation diversification provided by mountain parks, grasslands interspersed with timber, alpine meadows, and talus slopes are necessary for feeding as well as social activities. Alder thickets, lodgepole "downfalls," and other dense vegetation are preferred bedding sites. The relative importance of specific habitat types and vegetation complexes is unknown, and thus provides the subject of this investigation.

7. Safety

Protection against human depredation and competitive use of habitat is essential. Except for man, the grizzly has no enemies that restrict its use of habitat. It has been amply demonstrated that the species requires precise management and protection; otherwise, the man-caused death rate rapidly exceeds the birth rate and jeopardizes the population.

These briefly defined environmental characteristics were used as criteria for selecting a representative grizzly bear habitat study area in the Lincoln-Scapegoat Wilderness area. They will also be utilized and referenced in developing a holistic concept of that habitat and its use by the species. The Lincoln-Scapegoat Wilderness area meets all essential habitat criteria. It is spacious and secluded, with no developments except Forest Service cabins and lookouts. The area now receives little recreational use in comparison to the heavily travelled Bob Marshall Wilderness However, greatly increased use can be anticipated in the future. Alpine meadows and subalpine parklands interspersed with extensive stands of timber provide the grizzly with places to forage, socialize, breed, and den.

The least-understood environmental requirements are the types of food essential for grizzly bears, the amount and distribution of these foods, and their availability temporally and spatially. Subject matter of Section I is confined entirely to a botanical description of grizzly bear habitat. It will serve as the basis for an overall description and evaluation of the habitat requirements of the species in the Scapegoat-Bob Marshall Wilderness areas.

METHODS

Landform Classification

Although systems for habitat typing of forests (Daubenmire and Daubenmire 1968; Pfister et al. 1974, 1977) and grass-shrublands (Mueggler and Handl 1974) were known, no comparable system existed prior to this study for typing alpine vegetation. We developed a vegetation classification for the alpine environment based, in part, on the "ecoclass method" of Daubenmire (1952) and Corliss and Pfister et al. (1973) that would provide an ecological framework for describing and evaluating grizzly bear habitat. Unique repetitive features and patterns of the landscape having similar geomorphic origins were recognizable on the ground and from maps and aerial photographs. These units of land (e.g., rock ridges and mountain peaks, taluses, glacial cirque basins, and limestone escarpments) were classifiable and termed "landforms." Landforms tended to have characteristic soils and, therefore, distinctive plant communities patterned along topographical and environmental gradients. The landform and its associated vegetation were classified and mapped as a discrete unit termed an "ecological land unit" (ELU). The ELU was the basic unit used in characterizing the vegetation/land systems of the alpine zone.

Unlike the alpine environment, the vegetation/land systems at lower elevations were a combination of grass-shrubland and forested areas. The grass-shrublands were analyzed and categorized using a modification of the methods of Mueggler and Handl (1974). The basic descriptive parcel was the "ecological landtype" (ELT), which, though distinctive and identifiable in terms of landform and associated vegetation, was usually larger and somewhat less discrete and cohesive than were the ELUs used in the alpine areas. The forested areas of the lower elevations were described and categorized according to methods based, in part, on the work of Pfister et al. (1977). The basic working unit was the "habitat type," a delineation in terms of the climax and/or dominant species of the canopy and understory.

Riparian communities were evaluated as microhabitats within the ELU, ELT, or habitat type. While the vegetation was usually indicative of that found in the general surroundings, variations that occurred along the xeric to hydric gradient were a function of plant forms characteristic of areas having high water tables.

The ELUs, ELTs, and forest habitat types were ideal units of classification because they could be related precisely to grizzly bear ecology and applied reliably to management of the species. Because they tended to intergrade along environmental gradients to form larger geomorphic and biotic land/vegetation complexes, the ELUs, ELTs, and forest habitat types could be further combined into larger, perceivable units of the landscape that supported ecologically similar biotic resources. These were termed "vegetation complexes." These complexes formed the basis for computer mapping and will be described in Section III. The forest habitat types tended to be definable in terms of elevation, aspect, and moisture. They were categorized as to xeric, mesic, or hydric sites and combined into four groups on the basis of elevation and distinctive species of the canopy and understory. The four groups were of practical importance in relation to grizzly bear food sources and habitat, but less directly related to vegetational lines of distinction important in determining complexes.

The hierarchical sequence of land/vegetation classification was extended further by combining the vegetation complexes into climatic zones. The three zones, alpine (above 7000 feet [2132 m]), subalpine (7000 to 7600 feet [2132 to 2771 m]), and temperate (below 7000 feet [2132 m]) were distinguished along lines of obvious vegetational transitions according to elevation. The characterization and delineation of the zones is treated in greater depth in the presentation of results for this section and in Section III.

Our description of discrete ELUs, ELTs, and habitat types will become more precise with additional data, but we believe them sufficiently accurate now to define ecologically and to describe quantitatively the habitat of grizzly bears. More data can be obtained for any of the basic descriptive units as their management significance becomes apparent. The flexibility of the classification system provides for continual scientific input and, thus, for its gradual perfection. For example, though we have not attempted to define habitat types within ELUs, these could be identified with further sampling by designating dominant and co-dominant species and/or those species indicating recognizable environmental variations.

Photointerpretation

Aerial photographs of the Scapegoat study area were taken on a flight line at a scale of 1:15840 (four inches to the mile) using Kodak 2445 color negative film. Contact prints 9 inches by 9 inches (23 cm x 23 cm) and 2x enlargements were used to delineate the major landforms and to compare landforms mapped in the field with landforms as they appeared on orthophotos. The landforms were the basis for describing land units, landtypes, and landtype associations. Aerial maps were used also as reference for forest habitat typing and for determining "gray values" of vegetation using a microdensitometer. Gray values were valuable in correlating densities of plant cover with specific ecological land units in the alpine zone.

Vegetation Sampling

Subalpine and temperate forest habitat types were sampled and mapped using the classifications and techniques of Pfister et al. (1977). We sampled alpine and subalpine grass-shrubland vegetation employing an ocular estimate technique suggested by P. Stickney (personal communication 1975). Percent vegetative cover in the grass-shrublands was estimated to the 5 percent level on sample plots of 1156 square feet (108 m^2) (34 feet x 34 feet [10 m x 10 m]). Values for vascular plants representing less than 5 percent cover were lumped together. Cover estimates were assigned to species when known and to genera when species identifications were questionable or [illegible]fied for lack of mature identifying characters. Ground[illegible] status was assigned in two categories: (1) non-vegetated, consisting of loose or anchored rock or of soil and rock with moss and/or lichens; and (2) vegetated, having vascular vegetation. In making ocular estimates, percent non-vegetated area was determined first; then percent vegetation was estimated and the two values compared. Next, percent cover estimates were made for the more abundant species, followed by estimates for the less abundant. In mono-layer plant communities, ocular estimates of cover totaled 100 percent. In multi-layered communities, the estimates of total vegetation cover could exceed 100 percent. However, the total coverage within the ground-layer vegetation always totaled 100 percent.

Plots were located within representative plant communities or ELUs. Representative plots were photographed in color and some were marked with stone cairns. "Ephemerals" were recorded early in the growing season. Plots established before the full development of the vegetation were revisited and re-estimated late in the season to account for phenological changes.

Estimated values recorded at the 5 percent coverage interval represented an estimated range of ground coverage. A plant species with a recorded value of 5 percent cover could have had an actual coverage that ranged from 3 percent through 7 percent. Similarly, a recorded coverage value of 10 percent could represent a range of 8 percent through 12 percent; 15 percent, a range of 13 percent through 17 percent, and so on.

To describe the vegetation, 300 sample plots were evaluated between June 27 and August 17. Plot data for each ecological land unit were consolidated and then averaged by dividing the total percent cover for each species by the total percent cover for all species. Species averaging 2 percent or more of the total cover recorded in all plots for any ELU were listed in the tables.

Species showing values less than 2 percent were lumped. Table 1 illustrates the method used to record data from the sample plots, while Fig. 3 illustrates the method of summarizing percent vegetative cover. Four dominant and co-dominant genera are used in the illustration, but the same procedure was also applied to secondary species occurring at the 5 percent level or greater. For example, within the Alpine Meadow ecological land unit, <u>Carex</u> spp. in Plot

Table 1. Method of Recording Percent Occurrence and Percent Vegetative Cover in 39 Sample Plots of the Alpine Meadow Ecological Land Unit.

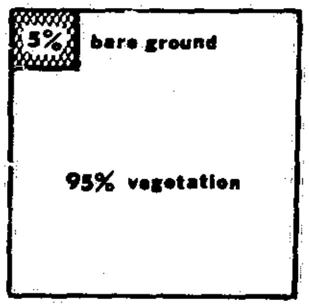
Alpine Vegetation	Plot Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	Range of Percent Cover
Achillea millefolium					5												15				5			T				5		T								5		5-15
Anemone multifida												10												5																5-10
Anemone parviflora																																		5						5-5
Antennaria spp.																								15				5	25											5-25
Arabis nuttallii								10																																10-10
Arctostaphylos uva-ursi													5						85	5		75	10								75				60					5-85
Arenaria spp.																								5				10												5-10
Astragalus spp.																								5	35															5-35
Caltha leptosepala					15						35																			5										5-35
Carex spp.	25	45	25			30	10	60	50	20	15	55	15	40	60	20		50	5	10	20	5	20			35	25		20	45			10	10	10	5	75		10	5-75
Delphinium bicolor																																						5		5-5
Douglasia montana	20																																							20-20
Dryas octopetala						30			50				15	10				25	5				50			15							60	40					55	5-60
Erigeron simplex					5		5																	5	10															5-10
Erigeron speciosus																																						10		10-10
Eritrichium nanum	5			30			10									10		5																						5-30
Festuca idahoensis	15		25	10			50			55		10					35					5		25	30	15	15	60		35					10	65		35		5-65
Gramineae				10	40		5					5			5					5	25									10	10		10							5-40
Hedysarum spp.					5	T							15			5		10	5		5	10				5		5			5		10	5						5-15
Juncus parryi																													15											5-15
Lloydia serotina										5																														5-5
Lomatium spp.			5				T								5		20													T										5-20
Oxytropis campetris			5			T	5	10						10	10	5	5	5						10			20					40				10	10			5-40
Pedicularis spp.											10	5																												5-10
Phlox pulvinata	30	40	30	40			10	10				10		10		5	10				5			10			30					40				10	10		10	5-40
Physaria didymocarpa																5																								5-5
Polygonum spp.	T	15	T		T		5		T	5		T	5	10			T		T	T	15	5	T	5	T	T				T			T	T	5	T		5	T	5-15
Potentilla diversifolia				5	5					10														5	10													10		5-10
Potentilla fruiticosa													5		5						15					5	10				10									5-15
Ranunculus eschscholtzii					20						5														10				25											5-25
Salix spp.											10		30							70						25														10-70
Senecio megacephalus															10																									10-10
Solidago multiradiata																					10																			10-10
Trace Forbs																10																								10-10
Valeriana edulis																																						5		5-5
Ground Cover	95	100	90	95	95	60	100	90	100	95	75	95	90	80	95	60	85	95	100	90	100	100	80	90	95	100	100	85	85	95	100	80	90	60	85	90	95	75	75	
Bare Ground	5	0	10	5	5	40	0	10	0	5	25	5	10	20	5	40	15	5	0	10	0	0	20	10	5	0	0	15	15	5	0	20	10	40	15	10	5	25	25	

Fig. 3. Method of summarizing percent vegetation composition.

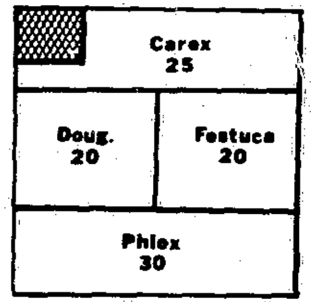
Figure 3, Method of Summarizing Percent Vegetative Composition

Step I - One Plot in the Alpine Meadow Land Unit

Plot Size



Vegetative Cover to Bare Ground



Percent Cover of Four Major Plant Species

1) Phlox pulvinata 30%

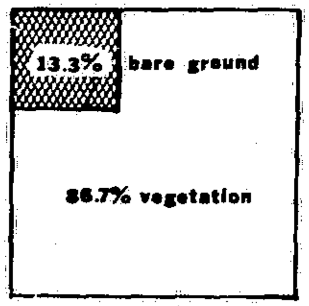
2) Carex spp. 25%

3) Festuca idahoensis 20%

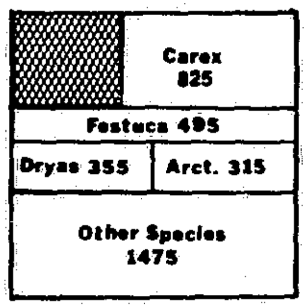
4) Douglasia montana 20%

Step II - Total Plots in Alpine Meadow Land Unit

Plot Size



Vegetative Cover to Bare Ground



Total Percent Cover of Four Major Plant Species

1) Carex spp. 825%/3465 = 23.8%

2) Festuca idahoensis 495%/3465 = 14.2%

3) Dryas octopetala 355%/3465 = 10.2%

4) Arctostaphylos uva-ursi 315%/3465 = 9.1

5) Other species 1475%/3465 = 42.6%

No. 1 were recorded as 25 percent of the cover (Step 1). Next the percent cover by species for Plot No. 1 was added to the percent cover of 38 other plots taken in the Alpine Meadow land unit. Carex spp. totaled 825 percent (Step II). The total of 825 was then divided by the total percent cover for all plant species (825/3465), thus showing Carex spp. to have comprised 23.8 percent of the total vegetation. It is this value to which "percent vegetation" refers in all tables. A similar procedure was used in developing tables to show "percent occurrence" of plant species in each ELU. If a species represented 5 percent or more of the cover, it was counted as occurring in a plot. The total percent occurrence for a species was then calculated by dividing the total number of plots taken in the ELU into the number of plots in which the species occurred. These procedures enabled us to focus on the major components of the vegetation. Minor components were recorded, however (see Appendix I), and some of these, important to the grizzly bear, will be discussed in Section II.

Plant Identification

Plant species of uncertain identity were collected and later identified in the laboratory. Klaus Lockschewitz, Department of Botany, University of Montana, and Peter Stickney, U.S. Forest Service, identified the more difficult ones. A total of 266 species representing 154 genera were identified and recorded (nomenclature follows Hitchcock and Cronquist 1973). A species list is presented in Table 20,

Appendix I. Almost without exception, vegetation sampling was accomplished in pristine areas free from the presence of domestic livestock.

Species taxonomically difficult to separate were identified in the field only to genus. Grasses and sedges in varied developmental stages were lumped under the generalized terms of Gramineae or Cyperaceae or, when feasible, identified to genus and species. This simplified vegetation sampling during the early growth period. Although many of the grasses and sedges were later identified to species by specialists, the "lumped category" was retained in terms of percent cover and percent occurrence; we lacked both time and manpower necessary to re-estimate the plots at the end of the growing season for species of grasses and sedges that individually composed less than 5 percent of the total cover. In most instances, sedges other than *Carex geyeri* and grasses other than *Festuca idahoensis* composed less than 2 percent of the total cover.

RESULTS

Research has shown that grizzly bears inhabiting mountanous terrain in Wyoming and Montana required large seasonal and home ranges and that they foraged over a wide range of landforms varying in elevation from 4000 to over 11,000 feet (1218 to over 3352 m) (Craighead, F.C., Jr. 1976 and Craighead, J.J. 1978). Vegetation zones were used seasonally as preferred food became available. In order to obtain a holistic description of grizzly bear habitat and an understanding of the use of habitat by the bear, we elected to study and describe the entire altitudinal range of habitat occupied by grizzly bears within the Scapegoat study area. We recognized limitations to this approach but accepted these as preferable to limitations imposed if we studied and described only a portion of the habitat. To facilitate vegetation classification, we applied the climatic zone concept.

Climatic Zones

The study area is represented by three climatic zones, the alpine, subalpine, and temperate, each characterized by distinct climax vegetation. The demarcations between zones were discernible in the field though they varied several hundred feet in elevation with differences in slope, aspect, soil depth, and other ecological parameters. The alpine zone extended from the lower limit of timberline to the tops of the highest peaks at elevations over 9000 feet (2742 m). Timberline was a rather narrow ecotone varying several hundred feet in elevation according to aspect, slope, and soil conditions. It was located between the variable upper limit of contiguous forests and lower limit of shrub-like trees, generally at an elevation of about 7600 feet (2771 m). Thus, for practical purposes, we designated 7600 feet (2771 m) as timberline--the break between alpine and subalpine vegetation. The alpine zone was broadly characterized by fir-spruce-whitebark pine krummholz (*Pinus albicaulis*-*Abies lasiocarpa* habitat type). Intrusions of subalpine forest habitat types, *Abies lasiocarpa* (*Pinus albicaulis*)/*Vaccinium scoparium* and *Abies lasiocarpa*/*Luzula hitchcockii*-*Vaccinium scoparium* were also present, as well as alpine meadows and sparsely vegetated rock valleys, basins, slopes, and ridges. The zone was exposed to severe geomorphic processes which limited vegetation growth and shaped the ecology.

The subalpine zone was characterized by forests of subalpine fir and whitebark pine interspersed with grass-forblands and grass-shrublands. The gradation between forest and grassland types formed a highly variable ecotonal zone of open-canopied forests and grass-forb-shrub vegetation. This, in conjunction with early seral fire stages, gave a park-like appearance to large areas of the subalpine zone not covered with extensive forests. The zone extended from timberline at about 7600 feet to 7000 feet (2771 to 2132 m), where a discernible change in vegetation types occurred. At about 7000 feet (2132 m), subalpine vegetation intergraded into the temperate zone vegetation. The elevation at which the change occurred varied several hundred feet with aspect, soil, and slope conditions; but for practical purposes we designated 7000 feet (2132 m) as the lower climatic limit of the subalpine zone and the upper climatic limit of the temperate zone. The demarcation in the contiguous forest areas was characterized by the absence, or near absence, of whitebark pine and the replacement of this species by Douglas-fir, an ecological equivalent. The demarcation between subalpine and temperate zones in the grass-shrublands was less discernible. However, quantifiable changes in percent cover and percent occurrence of grass-shrub habitat types, as well as species, did occur at about the 7000-foot (2132 m) level. Therefore, this elevation provided a practical and logical break in the natural vegetation patterns for grass-shrublands, as well as for forest types.

The temperate zone extended from about 7000 feet (2132 m) to the lower valley floors at about 4000 feet (1218 m). It was characterized by large, dense stands of forests composed principally of habitat types of the subalpine fir and Douglas-fir series, with the spruce series usually represented on moist sites along the valley floors. The most distinctive change in forest composition between subalpine and temperate forests was the replacement of whitebark pine by Douglas-fir on xeric sites. The upper limit of the temperate zone was defined by the lower climatic limit of whitebark pine and the upper climatic limit of Douglas-fir.

Vegetation Classification of the Alpine Zone

Twelve identifiable units of landscape composed of specific combinations of classified vegetation and land were located within the alpine zone of the Scapegoat study area. These ecological land units (ELU) are geomorphically discrete but intergrade along environmental gradients from lichen-bearing rock to climax vegetation. Landforms used to delineate boundaries of the ecological land units were readily discernible as to their size, shape, and distribution. The vegetation associated with land unit classifications, however, exhibited local variations and intergradations between units, forming mosaics that were defined to be gradient-variable vegetation complexes of species whose percent cover and frequency of occurrence varied with soil depth, moisture, aspect, slope, exposure, elevation, and geomorphic processes. Plant species were distinctive of a unit, but were not exclusive to that unit. Therefore, we adopted Pfister's philosophy (1977) that, although a vegetation continuum may exist, the objective of sampling and classifying was to develop a logical classification that reflects the natural vegetation patterns found on the landscape and that can be readily and practically applied by resource managers.

We present an ELU classification for the alpine zone that, with further study and the acquisition of more data, will permit modification and perfecting. Although the classification was ecologically oriented, it was not confined only to land units supporting vascular vegetation because "non-vegetated" landforms were known to play an important role in soil formation, in creating microclimates, and in regulating water flow to vegetated landforms.

Description of Vegetation in Terms of Ecological Land Units

The vegetation descriptions for each ELU were confined to dominant and co-dominant genera (those species most heavily represented as plant cover and/or with the highest frequency of occurrence). Sedges were lumped under *Carex* spp. for purposes of vegetation description; however, detailed species listings may be found in Appendix I, Table 20.

The land and vegetation description of each ecological land unit was as follows:

Alpine Meadow (Tundra)

Altitudinal range: Hi-8840 feet (2694 m), Lo-8000 feet (2437 m), Avg.-8420 feet (2566 m). Land unit is characterized by relatively deep limestone soil (rooting depth 1-4 feet /30-122 cm/) and gentle topographic gradients. Geomorphic processes gradually modify the topography, slope, and the associated vegetation. Major vegetation types are *Carex* turf, *Festuca*-forb meadow, cushion plant turf, *Salix*, *Arctostaphylos*, and *Dryas* mats, *Potentilla fruiticosa* thickets, and *Juncus* swales. Krummholz is rare or absent. Dry meadows on southerly exposures are characterized by cushion turfs of *Phlox pulvinata*, *Silene acaulis*, *Eritrichium nanum*, *Douglasia montana*, *Draba* spp., *Physaria didymocarpa*, and *Arenaria* spp. Wet meadows are characterized by *Caltha* leptosepala, Ranunculus eschscholtzii, and Pedicularis groenlandica.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Carex spp.	23.8	Carex spp.	76.9
Festuca idahoensis	14.2	Festuca idahoensis	43.6
Dryas octopetala	10.2	Phlox pulvinata	43.6
Arctostaphylos uva-ursi	9.1	Oxytropis campetris	33.3
Phlox pulvinata	8.9	Hedysarum spp.	30.8

Alpine Meadow Krummholz

Altitudinal range: Hi-8440 feet (2571 m), Lo-7600 feet (2771 m). Avg.-8020 feet (2443 m). Land unit and vegetation are similar to Alpine Meadow, characterized by gentle to steep slopes, deep to shallow soil (rooting depth 3-20 inches /8-50 cm/) with deep soil occurring in pockets and crevices. Topography is rougher and more varied than Alpine Meadow with vegetation similar, but distinctive. Krummholz is common in pockets and crevices of deep soil with characteristic Luzula and Thalictrum undergrowth. This land unit represents the highest altitudinal advance of forest habitat types.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Festuca idahoensis	33.3	Festuca idahoensis	63.6
Carex spp.	18.0	Carex spp.	36.4
Luzula hitchcockii	7.5	Luzula hitchcockii	32.0
Vaccinium scoparium	4.6	Potentilla diversifolia	32.0
Thalictrum occidentale	4.2	Thalictrum occidentale	27.3
	Krummholz		
Abies lasiocarpa	67.4	Abies lasiocarpa	46.7
Pinus albicaulis	28.3	Pinus albicaulis	40.0
Picea engelmannii	4.3		

Slab-Rock Krummholz

Altitudinal range: Hi-7840 feet (2388 m), Lo-7600 feet (2771 m), Avg.-7720 feet (2352 m). Land unit is characterized by flat, creviced bedrock interspersed with precipitous to gentle slopes, very shallow soil (1-6 inches [3 to 15 cm]), rough topography, and deep limestone sinks. Krummholz is common along rock fractures. Slab-Rock Krummholz represents a developmental stage toward Alpine Meadow Krummholz.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Luzula hitchcockii	25.9	*Luzula hitchcockii*	62.5
Carex spp.	17.9	*Thalictrum occidentale*	50.0
Thalictrum occidentale	8.9	*Arnica latifolia*	25.0
Erythronium grandiflorum	8.0	*Carex* spp.	25.0
Festuca idahoensis	8.0	*Valeriana sitchensis*	25.0
Krummholz			
Abies lasiocarpa	76.4	*Abies lasiocarpa*	50.0
Pinus albicaulis	12.7	*Pinus albicaulis*	50.0
Picea engelmannii	10.9	*Picea engelmannii*	25.0

Slab-Rock Steps (Escarpment)

Altitudinal range: Hi-8320 feet (2535 m), Lo-7600 feet (2771 m), Avg. 7760 feet (2425 m). Land unit is characterized by steep glacial rock steps with flat to gently sloping ledges. Soil is deep to shallow over bedrock. Ledges are often moist and krummholz is very common. This land unit is a transitional landform between Glacial Cirque Basins and other landforms. Glacial headwalls are included in the land unit.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Carex spp.	20.0	Carex spp.	57.1
Thalictrum occidentale	19.1	Thalictrum occidentale	42.9
Anemone parviflora	8.0	Potentilla fruiticosa	28.6
Valeriana sitchensis	5.8	Valeriana sitchensis	28.6
Dryas octopetala	5.3		
	Krummholz		
Abies lasiocarpa	75.9	Abies lasiocarpa	61.9
Pinus albicaulis	23.4	Pinus albicaulis	57.1

Glacial Cirque Basins

Altitudinal range: Hi-8560 feet (2608 m), Lo-7600 feet (2771 m), Avg.-8080 feet (2461 m). Land unit is characterized by flat, boulder-strewn slab-rock with approximately 50 percent exposed rock surface and 50 percent soil covered surface. Soil mantle is shallow except in crevices and swales where rooting depth is sufficient to support turf and, rarely, krummholz.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Festuca idahoensis	20.7	Carex spp.	46.9
Carex spp.	14.3	Festuca idahoensis	37.5
Salix spp.	10.6		
Phyllodoce empetriformis glanduliflora	8.0		
Dryas octopetala	7.0		
	Krummholz		
Abies lasiocarpa	40.0	Abies lasiocarpa	6.3
Pinus albicaulis	40.0	Pinus albicaulis	6.3
Picea engelmannii	20.0		

Mountain Massif

Altitudinal range: Hi-9200 feet (2803 m), Lo-7720 feet (2352 m), Avg.-8460 feet (2577 m). Land unit is characterized by large, relatively uniform expanses of bare or very shallow-soiled bedrock elevated above the surrounding land area. Slopes are gentle to precipitous, occasionally with small permanent snowfields. Snowmat-krummholz reaches the highest altitudes for tree growth. Relatively few plant species are represented, generally as unpatterned ground cover of low mat and cushion plants.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Dryas octopetala	38.6	*Carex* spp.	50.0
Carex spp.	29.5	*Dryas octopetala*	50.0
Arctostaphylos uva-ursi	21.6	*Arctostaphylos uva-ursi*	33.3
Potentilla fruiticosa	4.5		
Krummholz			
Abies lasiocarpa	72.6	*Abies lasiocarpa*	41.7
Pinus albicaulis	27.4	*Pinus albicaulis*	33.3

Vegetated Talus

Altitudinal range: Hi-7800 feet (2376 m), Lo-7600 feet (2771 m), Avg.-7700 feet (2346 m). Land unit is formed at the base of rock faces and characterized by steep slopes of fragmented rock varying in size and composition from boulders to gravel and rocky soil. Steep to gentle slopes of stabilized soil and rock fragments support a relatively rich flora of dense vegetation; frequently merge into avalanche slopes and subalpine parkland.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Festuca idahoensis	14.3	*Achillea millefolium*	75.0
Astragalus bourgovii	10.0	*Gentiana calycosa*	75.0
Dryas octopetala	10.0	*Astragalus bourgovii*	50.0
Gentiana calycosa	10.0	*Carex* spp.	50.0
Achillea millefolium	7.1		
Krummholz			
Pinus albicaulis	75.0	*Picea engelmannii*	25.0
Picea engelmannii	25.0	*Pinus albicaulis*	25.0

Semi-Vegetated Talus

Altitudinal range: Hi-8200 feet (2498 m), Lo-7600 feet (2771 m), Avg.-7900 feet (2407 m). Small rock components and gravel form gentle to steep slopes; vegetated portions tend to be stable.

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Dryas octopetala	18.2	*Dryas octopetala*	50.0
Claytonia megarhiza	10.9	*Carex* spp.	30.0
Arabis spp.	7.3	*Claytonia megarhiza*	30.0

Fellfield

Altitudinal range: Hi-9080 feet (2767 m), Lo-7820 feet (2383 m), Avg.-8450 feet (2575 m). Land unit is characterized by wind-shaped rocky surfaces; ground patterned with low mat and cushion plants (*Dryas* islands).

Vegetation Description

Species	% Vegetation	Species	% Occurrence
Dryas octopetala	68.6	*Dryas octopetala*	81.8
Carex spp.	24.3	*Carex* spp.	45.5
		Saxifraga spp.	9.0

Parent Rock (limestone/argillite)

Altitudinal range: Hi-9200 feet (2803 m), Lo-7600 feet (2771 m), Avg.-8400 feet (2559 m). Land unit is composed of bedrock, boulder fields, rock ridges, peaks, precipitous slopes, and cliffs, all devoid of soil and vascular vegetation; lichens present. Land unit greatly dissected and eroded; may be portions of mountain massif or isolated rock structures.

Bare Talus (limestone/argillite)

Altitudinal range: Hi-9080 feet (2767 m), Lo-7600 feet (2771 m), Avg.-8340 feet (2541 m). Land unit is composed of large rocks forming very steep unstable slopes. Soil and vegetation are sparse or absent.

Snowfield and Snowfield Sink

Altitudinal range: Hi-8000 feet (2437 m), Lo-7800 feet (2376 m), Avg.-7900 feet (2407 m). Land unit is characterized by steep slopes overlain by permanent snowfields draining into precipitous limestone rifts and sinks. Shallow, water-saturated soil or snowflush is located at the base of snowfields where vegetation is absent or greatly retarded by late growing season.

A more detailed description of the 9 vegetated ELUs listing percent vegetation of secondary species was prepared (Appendix I, Tables 1-9) to provide for species comparisons with characterizations of alpine communities by other workers. A final compilation of total percents vegetation and total percents occurrence for all species found in the alpine zone was used for relative comparisons between the nine vegetated ELUs (Appendix I, Tables 10-13). Also, the relative percent of bare ground to vegetated ground was evaluated for the vegetated ELUs (Appendix I, Tables 14 and 15). For visualization and future reference, black-and-white photographs were taken that depicted landform-vegetation patterns and relative amounts of vegetation cover for each of the nine vegetated and three nonvegetated ELUs (Figs. 4-8).

In order to synthesize a vegetation classification for practical application and for interpretive purposes, the 12 alpine ELUs were consolidated into 4 groupings, each possessing distinctive ecological characteristics. These groupings have been numbered from I through IV and will be discussed in detail in Section III. Other groupings will be made as the text progresses, resulting in a final classification of 9 vegetation groups within 3 climatic zones that will be the basis for mapping, describing, and interpreting grizzly bear habitat.

Vegetation Classification of the Subalpine Zone

To map vegetation of the subalpine zone, we employed the grass-shrubland classification (with modifications) of

Fig. 4. Photographs in the alpine zone of Scapegoat Plateau showing: top, Alpine Meadow (foreground), Mountain Massif (background); bottom, Parent Rock with talus slope below and Scapegoat Mountain (9200 feet [2803 m]) above.

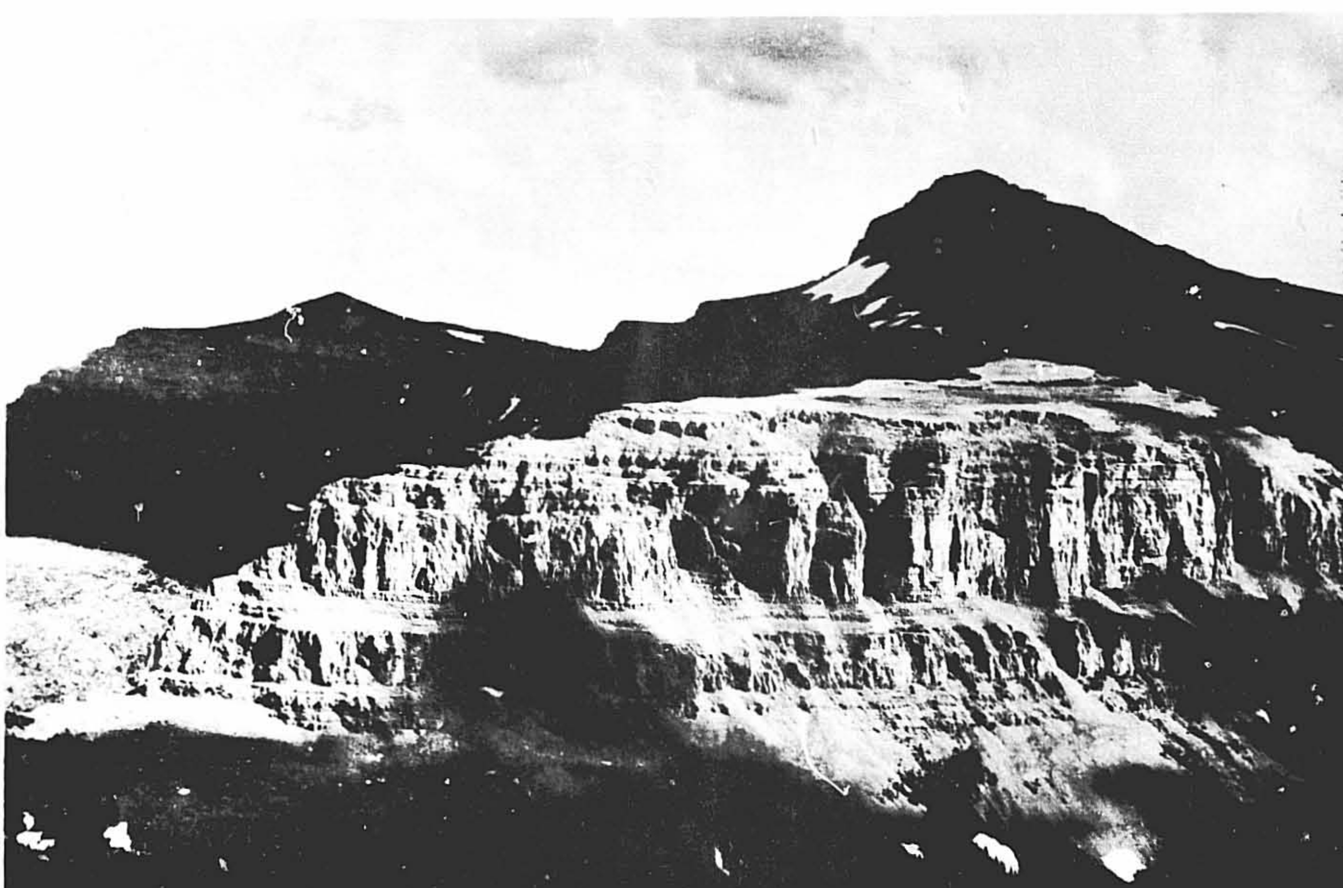


Fig. 5. Photographs in the alpine zone of Scapegoat Plateau showing: top, Alpine Meadow Krumholz (foreground), Slab-Rock Steps (background); bottom, Snowfields and Snowfield Sinks lying below Alpine Meadow.

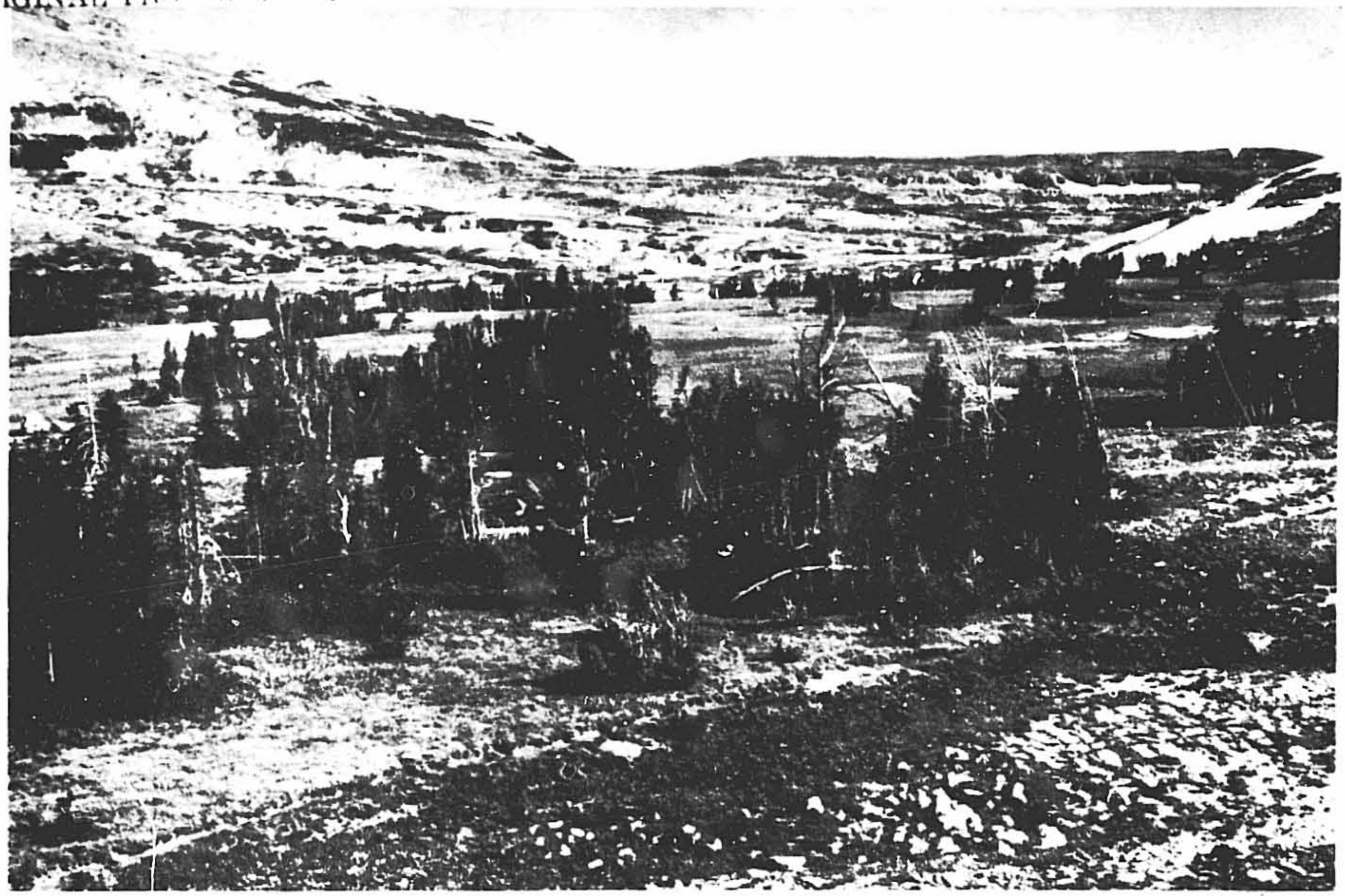


Fig. 6. Photographs in the alpine zone of Scapegoat Plateau showing: top, Fellfields with matted krummholz in the background; bottom, Glacial Cirque Basin surrounded by krummholz.

Fig. 7. Photographs showing ecological land units in the alpine zone of Scapegoat Plateau, identified clockwise from lower left: Semi-Vegetated Talus; Fellfield, Vegetated Talus foreground and Bare Talus background, and Vegetated Talus merging into Bare Talus.

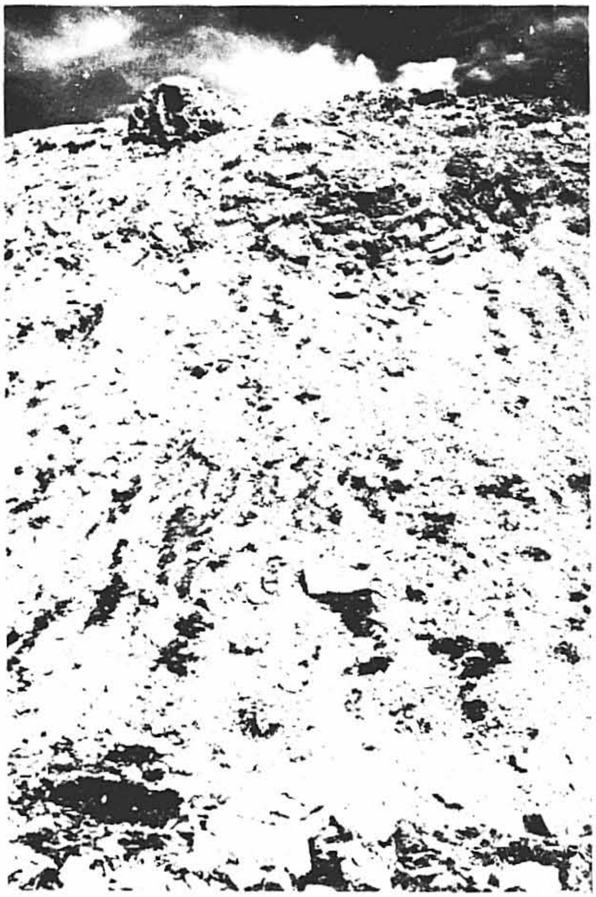


Fig. 8. Photographs in the alpine zone of Scapegoat Plateau showing: top, Alpine Meadow with Bare Talus and Parent Rock in foreground; bottom, Parent Rock, and Talus Slopes with island krummholz.

Mueggler and Handl (1974) and the forest habitat classification of Pfister et al. (1977). Grass-shrublands (nonforested areas) of the subalpine zone, therefore, were divided into ecological land types (ELT), while forested areas were distinguished in terms of habitat types.

Description of the Grass-Shrubland Ecological Landtypes

Vegetation was sampled using the same techniques applied in the alpine zone. The purpose of the sampling was to obtain a quantitative description of the vegetation in each landtype that would be general, yet sufficiently specific to separate one landtype from another and indicate similarities as well as differences. Ecological landtypes identified were various early Seral Stages (burns), hydric to mesic Forb-Grasslands (*Heracleum lanatum*-*Pedicularis groenlandica* meadows and glades), Dry Forb-Grasslands (*Xerophyllum tenax*-*Festuca idahoensis* meadows), Snowslides (*Carex* spp.-*Xerophyllum tenax*), and Ridgetop Glades (*Carex* spp.-*Festuca* spp.) (Fig. 9). Percent vegetation cover by species (Table 2) and percent species occurrence (Table 3) were determined for each of the 5 ELTs using the tabulations of total percent vegetative cover and percent occurrence by plots as illustrated in the appendix, Tables 16 through 19.

It should be noted that the snowslides and recent burns were in seral transitions that will require long periods to progress to climax communities; due to periodic

Fig. 9. Photographs showing vegetated landtypes in the subalpine zone: top, Burns (seral stages); bottom, Snowslide (far left), Ridgetop Glade (left center), Dry Forb-Grasslands (center).

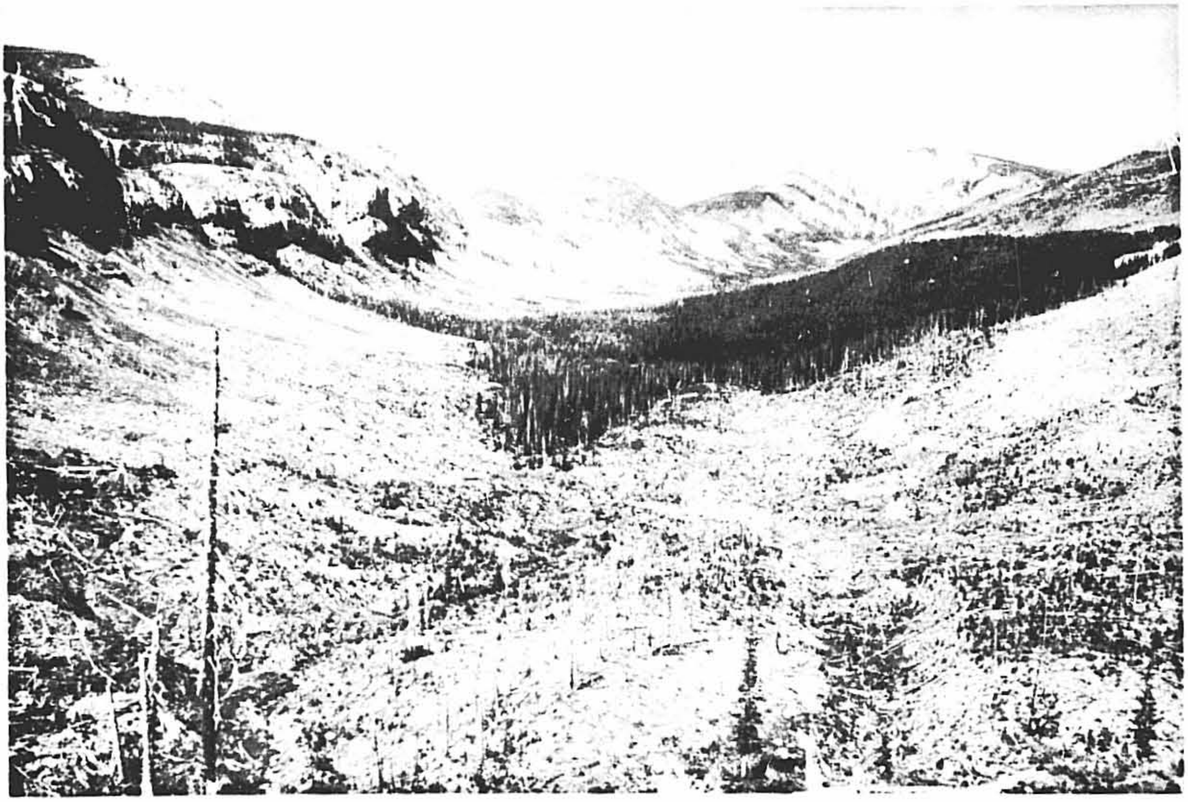


Table 2. Percent vegetation cover in five ecological landtypes in the Subalpine Zone. (123 plots, 142,188 square feet).

Vegetation	Seral Stages (Burns) (42 plots)	Wet Forb Grasslands (13 plots)	Dry Forb Grasslands (23 plots)	Snowslides (29 plots)	Ridgetop Glades (16 plots)
Xerophyllum tenax	19.0	.8	17.1	10.5	
Trace forbs*	13.0	14.1	6.2	3.3	8.9
Carex spp. (geyeri predominant)	12.1	15.7	9.3	16.8	6.3
Vaccinium scoparium	7.6		4.7	.7	
Calamagrostis rubescens	4.8		1.6	1.1	
Lupinus argenteus	4.5		1.6	6.8	
Aster sp.	3.2				
Fragaria virginiana	3.0	2.0	.3	1.2	
Anemone parviflora	2.4				4.5
Shepherdia canadensis	1.9				
Gramineae**	1.9	13.3	7.0	3.0	18.8
Astragalus vexilliflexus	1.9				
Heracleum lanatum	1.7	2.8		.7	
Festuca idahoensis	1.5	.4	11.1	10.0	25.9
Festuca scabrella	1.3				
Thalictrum occidentale	1.1	3.2	.8	6.8	
Arnica cordifolia	.9		.3	.7	
Agropyron spp.	.9				
Vaccinium globulare	.9			1.1	
Luzula hitchcockii	.6		.3		
Achillea millefolium	.6		.5	.7	
Antennaria umbrinella	.6				
Juncus parryi	.6				
Senecio spp.	.6				
Antennaria spp.	.4	.4	4.1		
Solidago spp.	.4				
Phleum pratense	.4				
Bromus sp.	.4				
Balsamorhiza sagittata	.4		.3		
Vaccinium myrtillus	.4				
Pedicularis contorta	.2				
Amelanchier alnifolia	.2				
Anaphalis margaritacea	.2				
Artemisia ludoviciana	.2				
Castilleja spp.	.2				
Galium boreale	.2				
Matricaria matricarioides	.2				
Sibbaldia procumbens	.2		1.0		
Parnassia fimbriata	.2	1.6			
Anemone multifida	.2		1.0	.4	
Phyllodoce empetriformis	.2		1.8		
Hackelia micrantha	.2		1.0		
Cirsium scariosum	.2				
Rubus parviflorus	.2				
Senecio triangularis	.2	3.2	4.4	12.3	
Hedysarum sulphurescens	.2				
Erythronium grandiflorum	.2	.4	1.3	1.4	2.7
Equisetum arvense		8.0		.2	
Bryophyta		6.4			
Astragalus bourgovii		2.4	2.6	1.4	1.8
Zigadenus elegans		1.6			
Pedicularis groenlandica		1.2			
Taraxacum officinale		.8	.3		
Cicuta sp.		.8			
Osmorhiza occidentalis		.4	2.6	.9	
Polygonum bistortoides		.4	1.0	.2	

Table 2. Percent vegetation cover in five ecological landtypes in the Subalpine Zone. (123 plots, 142, 188 square feet). (Continued)

Vegetation	Seral Stages (Burns) (42 plots)	Wet Forb Grasslands (13 plots)	Dry Forb Grasslands (23 plots)	Snowslides (29 plots)	Ridgetop Glades (16 plots)
Galium spp.		.4	.5		
Haplopappus lyallii		.4			
Gentiana calycosa		.4		.2	
Dodecatheon spp.		.4			
Habenaria dilitata		.4			
Potentilla diversifolia		1.2	1.8		
Geranium spp.		2.4			
Sium suave		1.6			
Vicia villosa					1.8
Veronica spp.		2.0			
Allium schoenoprasum		9.6		.2	
Calamagrostis canadensis				6.8	
Agastache urticifolia				.7	
Fraseria speciosa				.2	
Veratrum sp.				.7	
Penstemon spp.				1.1	
Arenaria spp.			1.3	.5	
Menziesia ferruginea				4.6	
Lonicera involucrata				.4	
Senecio canus					.9
Eriogonum spp.			.3	.4	.9
Geranium viscosissimum				.4	
Salix spp.		1.2	1.3	2.3	
Penstemon ellipticus			.5		
Lomatium dissectum			1.0		
Senecio megacephalus			.3	.4	3.6
Arctostaphylos uva-ursi			.3		
Spirea betulifolia			.3		
Lomatium spp.			.3		8.0
Pedicularis spp.			.8		
Saxifraga spp.			.3		
Caltha leptosepala			.3		
Solidago multiradiata			.5		
Cerastium arvense			.3		
Melica spectabilis			.5		
Sedum spp.			.3		
Claytonia lanceolata			3.6		
Juncus spp.			1.6		
Ranunculus eschscholtzii			.5		
Veratrum veride			.3		
Arnica longifolia			.3		
Erigeron peregrinus			1.0		
Hedysarum occidentale			.3	.4	
Valariana sitchensis				.2	
Eackelia sp.				.9	
Arnica spp.					1.8
Poa spp.					2.7
Oxytropis spp.					6.3
Potentilla fruiticosa					2.7
Erigeron compositus					1.8
Juniperus communis					.9
Trace shrubs and trees ***	6.5				
Pinus albicaulis reproduction	.2				
Picea engelmannii reproduction	.2				
Total	99.3	99.9	100.7	100.6	100.3

*Includes identified forbs that occurred at less than the 5% level of cover.
**Gramineae includes grasses that could not be identified when the plots were taken because of immature stages. These were later keyed by Klaus Lockschenwitz at the University of Montana herbarium and appear in the species lists.
***Includes trees and shrubs that occurred at less than the 5% level of cover.

Table 3 . Percent occurrence of plant species in five ecological landtypes in the Subalpine Zone. (123 plots, 142,188 square feet).

Vegetation	Seral Stages (Burns) (42 plots)	Wet Forb Grasslands (13 plots)	Dry Forb Grasslands (23 plots)	Snowslides (29 plots)	Ridgetop Glades (16 plots)
Trace forbs	90.5	84.6	60.9	31.0	31.3
Carex spp. (geyeri predominant)	71.4	76.9	43.5	55.2	12.5
Xerophyllum tenax	50.0	7.7	34.8	17.2	
Calamagrostis rubescens	31.0		8.7	10.3	
Fragaria virginiana	23.8	23.1	4.3	17.2	
Vaccinium scoparium	23.8		13.0	3.4	
Lupinus argenteus	19.0		17.4	20.7	
Shepherdia canadensis	19.0				
Aster sp.	19.0				
Gramineae **	14.3	38.5	47.8	20.7	37.5
Festuca idahoensis	11.9	7.7	26.1	41.4	43.7
Arnica cordifolia	9.5		4.3	6.9	
Anemone parviflora	9.5				6.3
Thalictrum occidentale	9.5	15.4	4.3	41.4	
Heracleum lanatum	7.1	15.4		10.3	
Luzula hitchcockii	7.1		4.3		
Festuca scabrella	7.1				
Senecio spp.	7.1				
Antennaria spp.	4.8	7.7	13.0		
Achillea millefolium	4.8		8.7	10.3	
Vaccinium myrtillus	4.8				
Amelanchier alnifolia	2.4				
Anaphalis margaritacea	2.4				
Solidago spp.	2.4				
Artemisia ludoviciana	2.4				
Castilleja spp.	2.4				
Phleum pratense	2.4				
Bromus sp.	2.4				
Agropyron spp.	2.4				
Balsamorhiza sagittata	2.4		4.3		
Galium boreale	2.4				
Matricaria matricarioides	2.4				
Sibbaldia procumbens	2.4		4.3		
Parnassia fimbriata	2.4	23.1			
Anemone multifida	2.4		4.3	6.9	
Antennaria umbrinella	2.4				
Juncus parryi	2.4				
Phyllodoce empetriformis	2.4		8.7		
Astragalus vexilliflexus	2.4				
Pedicularis contorta	2.4				
Hackelia micrantha	2.4		8.7		
Cirsium scariosum	2.4				
Rubus parviflorus	2.4				
Senecio triangularis	2.4	30.8	8.7	31.0	
Hedysarum sulphurescens	2.4				
Vaccinium globulare	2.4			3.4	
Erythronium grandiflorum	2.4	7.7	4.3	13.8	12.5
Equisetum arvense		23.1		3.4	
Bryophyta		38.5			
Astragalus bourgovii		7.7	4.3	3.4	6.[illegible]
Zigadenus elegans		15.4			
Pedicularis groenlandica		23.1			
Taraxacum officinale		7.7	4.3		
Cicuta spp.		15.4			
Osmorhiza occidentalis		7.7	4.3	6.9	
Polygonum bistortoides		7.7	17.4	3.4	
Galium spp.		7.7	8.7		
Haplopappus lyallii		7.7			
Gentiana calycosa		7.7		3.4	

Table 3 . Percent occurrence of plant species in five ecological landtypes in the Subalpine Zone. (123 plots, 142,188 square feet). (Continued)

Vegetation	Seral Stages (Burns) (42 plots)	Wet Forb Grasslands (13 plots)	Dry Forb Grasslands (23 plots)	Snowslides (29 plots)	Ridgetop Glades (16 plots)
Dodecatheon spp.		7.7			
Habenaria dilitata		7.7			
Potentilla diversifolia		15.4	26.1		
Geranium spp.		15.4			
Sium suave		7.7			
Vicia villosa					6.3
Veronica sp.		15.4			
Allium schoenoprasum		30.8		3.4	
Calamagrostis canadensis				17.2	
Agastache urticifolia				6.9	
Fraseria speciosa				3.4	
Veratrum sp.				3.4	
Penstemon spp.				6.9	
Arenaria spp.			4.3	3.4	
Menziesia ferruginea				6.9	
Lonicera involucrata				3.4	
Senecio canus					6.3
Eriogonum spp.			4.3	3.4	6.3
Geranium viscosissimum				6.9	
Salix spp.		7.7	8.7	6.9	
Penstemon ellipticus			4.3		
Lomatium dissectum			8.7		
Senecio megacephalus			4.3	3.4	18.8
Arctostaphylos uva-ursi			4.3		
Spirea betulifolia			4.3		
Lomatium spp.			4.3		50.0
Pedicularis spp.			8.7		
Saxifraga spp.			4.3		
Caltha leptosepala			4.3		
Solidago multiradiata			4.3		
Cerastium arvense			4.3		
Melica spectabilis			8.7		
Sedum spp.			4.3		
Claytonia lanceolata			13.0		
Juncus spp.			13.0		
Ranunculus eschscholtzii			4.3		
Veratrum veride			4.3		
Arnica longifolia			4.3		
Erigeron peregrinus			4.3		
Hedysarum occidentale			4.3	6.9	
Valariana sitchensis				3.4	
Hackelia sp.				13.8	
Arnica spp.					12.5
Poa spp.					18.8
Oxytropis spp.					12.5
Potentilla fruiticosa					18.8
Erigeron compositus					6.3
Juniperus communis					6.3
Trace shrubs and trees***	61.9				
Pinus albicaulis reproduction	2.4				
Picea engelmannii reproduction	2.4				

*Includes identified forbs that occurred at less than the 5% level of cover.
**Gramineae includes grasses that could not be identified when the plots were taken because of immature stages. These were later keyed by Klaus Lockschenwitz at the University of Montana herbarium and appear in the species lists.
***Includes trees and shrubs that occurred at less than the 5% level of cover.

disruptions, climax may never be attained.

Seral Stages (Burns)

Ground cover of early successional stages following burns closely resembled that of the other landtypes in the subalpine grass-shrublands. Thus, for practical purposes of sampling and recording of data, the Seral Stages were treated as ecological landtypes. However, because of successional trends and projected climaxes, the Seral Stages were classified on the ground map as forest habitat types. Burns were characterized by the predominance of *Xerophyllum tenax*, trace forbs, and species of *Carex*, with *Carex geyeri* predominating. With the exception of *Calamagrostis rubescens*, grasses played little part in the vegetation. This was in marked contrast to the percent cover and percent occurrence of grasses in the other landtypes of the subalpine grass-shrublands (Tables 2 and 3). A higher percentage of *Vaccinium scoparium*, *Fragaria virginiana*, and *Shepherdia canadensis* occurred in burns than in the other subalpine grass-shrubland landtypes and, as indicated by percent occurrence, were also more widely distributed. The data suggest that these species, all food plants well represented in the forest habitat types utilized by grizzly bears, were also abundant in the early seral stages. Burns were further differentiated from the grass-shrublands by the presence of forest reproduction (Fig. 9).

Wet Forb-Grasslands

The Wet Forb-Grasslands composed a very small percentage of the subalpine grass-shrublands. They were associated with seepage areas, swales, ponds, and stream banks and exhibited a preponderance of grasses, forbs, and sedges. The Wet Forb-Grasslands gradually integrated into the Dry Forb-Grasslands on southerly slopes. *Carex* and grasses were predominant. *Heracleum lanatum*, *Equisetum arvense*, *Parnassia fimbriata*, *Pedicularis groenlandica*, and *Allium schoenoprasum*, generally indicators of a high water table, were well represented in the plant cover (Tables 2 and 3). *Caltha leptosepala* and *Potentilla fruiticosa* also fall into this class, but did not occur on the sample plots.

Dry Forb-Grasslands

The Dry Forb-Grasslands were more extensive than the other landtypes found in the subalpine grass-shrublands. They were characterized by a predominance of *Xerophyllum tenax*, *Festuca idahoensis*, and *Carex geyeri*. *Balsamorhiza sagittata* and *Lomatium* spp. were indicator species (Tables 2 and 3). In late June and early July, *Claytonia lanceolata*, *Erythronium grandiflorum*, and *Anemone parviflora* represented as much as 20-40 percent of the plant cover on some sites. However, these and other effervescents comprised progressively less of the total cover as new vegetation emerged. By mid-August, *C. lanceolata* and *E. grandiflorum* were relatively scarce on plots where earlier they had been abundant.

Snowslides

Snowslides, for practical purposes of sampling, were treated as landtypes of subalpine grass-shrublands, but were actually seral stages of forest habitat types of the *Abies lasiocarpa* series. Specimens of *Picea engelmannii*, *Abies lasiocarpa*, *Pinus albicaulis*, and rarely, *Pinus contorta* were represented as broken mature trees or as seedlings. Because of long histories of disturbances (often annual), normal tree growth could not occur and slide areas existed as grass-shrubland communities. The communities varied with altitude and aspect, and by whether the slide had followed a riparian or non-riparian path down the mountain slope. Plant composition of individual slides varied widely, but, in general, included *Carex geyeri* and *Xerophyllum tenax* as predominant cover plants, with *Senecio triangularis* abundant in riparian habitats (Tables 2 and 3). The ecotone between slide and forest frequently supported relatively heavy stands of *Vaccinium scoparium* and *V. globulare*, with the lower reaches of the slide often terminating in thickets of *Alnus sinuata*.

Ridgetop Glades

Ridgetop Glades were defined to be linear land formations of shallow rocky soil at the upper limits of timberline (approximately 7800-8200 feet [2376-2498 m]) and were frequently ecotones between the alpine and subalpine zones. The predominant plant cover was *Carex geyeri*, *Festuca* *idahoensis*, and various other species of grasses. *Xerophyllum tenax* was absent. *Potentilla fruiticosa*, *Senecio canus*, and *Oxytropis* spp. distinguished the Ridgetop Glades from the Dry Forb-Grasslands. The predominant tree species bordering the Ridgetop Glades were *Abies lasiocarpa*, *Pinus albicaulis*, and in some situations, *Larix lyallii*, all of which are important components of the alpine fir habitat types. The ridgetop flora was exposed to more severe winds and greater frost action than were grass-shrublands at the lower elevations. Considerably more sampling will be required to determine whether Ridgetop Glades should more appropriately be classified as a subalpine ELT or as an ELU of the alpine zone. For classification purposes, we have tentatively designated them as an ELT within the subalpine zone.

SCREE

The difficulty of describing SCREE by using the forest habitat types has already been discussed by Pfister et al. (1977). The broad environmental range, the scattered distribution or absence of trees, and the low coverage of undergrowth species preclude using the forest habitat types. Therefore, we have tentatively included the SCREE in our landtype classification because the landtype designates a distinct landform and an area less specific than that occupied by habitat types. The vegetation associated with

SCREE is less distinctive than that found in the other five ELTs of the subalpine zone. A quantitative description similar to that for the five major landtypes was not possible without a substantial amount of additional sampling.

Description of Subalpine Forest Vegetation in Terms of Grouped Habitat Types

In accordance with the methods of Pfister et al. (1977), 19 forest habitat types were recorded in the subalpine and temperate zones. To facilitate interpretation in terms of grizzly bear ecology, the habitat types were distributed into four groups according to moisture, vegetation, and elevation. Since 4 vegetation groupings have been designated and numbered for the alpine zone, the 4 subalpine and temperate forest habitat groupings will be designated Groups V, VI, VII, and VIII with the subalpine and temperate grass-shrublands forming Group IX. These numbered groupings will facilitate both discussion and interpretation. Group V consisted entirely of the _Abies lasiocarpa_ series above 7000 feet (2132 m) and was the only group considered within the subalpine zone. On xeric sites, _Pinus albicaulis_ was a major component of the forest and, occasionally, was the predominant tree species. It was also a major habitat component on mesic sites except in the _Menziesia ferruginea_ phase of the _Abies lasiocarpa_/_Luzula hitchcockii_ habitat type and in the _Larix lyallii_-_Abies lasiocarpa_ habitat type. _Vaccinium scoparium_ was generally a common undergrowth plant in all of the Group V habitat types. The characterization of Group V, including numerical designations in parentheses according to Pfister et al. (1977), was as follows:

Group V

Forest habitat types at 7000-7600 feet (2132-2771 m) with *Abies lasiocarpa* dominant and *Pinus albicaulis* a major component. *Vaccinium scoparium* usually common.

A. Xeric sites

(831) *Abies lasiocarpa/Luzula hitchcockii-Vaccinium scoparium*
(850) *Pinus albicaulis-Abies lasiocarpa*
(820) *Abies lasiocarpa (Pinus albicaulis)*/Vaccinium scoparium
(870) *Pinus albicaulis*

B. Mesic sites

(832) *Abies lasiocarpa/Luzula hitchcockii-Menziesia ferruginea*
(831) *Abies lasiocarpa/Luzula hitchcockii-Vaccinium scoparium*
(850) *Pinus albicaulis-Abies lasiocarpa*
(860) *Larix lyallii-Abies lasiocarpa*

Description of Specific Forest Habitat Types of the Subalpine Zone

The forest habitat types listed under Group V are described in greater detail for latter reference.

Abies lasiocarpa/Luzula hitchcockii-Vaccinium scoparium (ABLA/LUHI-VASC)

This was the most abundant forest type in the subalpine zone where it occurred on all but the most northerly aspects (Table 7). *Abies lasiocarpa* and *Pinus albicaulis* dominated the overstory while *Xerophyllum tenax*, *Vaccinium* scoparium, and Luzula hitchcockii were the major undergrowth species.

Abies lasiocarpa (Pinus albicaulis)/
Vaccinium scoparium (ABLA(PIAL)/VASC)

Although ecologically equivalent to ABLA/LUHI-VASC, ABLA(PIAL)/VASC was separately delineated because it was found extensively represented on xeric southerly exposures. Abies lasiocarpa and Pinus albicaulis were major components of the forest canopy with Vaccinium scoparium, Xerophyllum tenax, and Carex geyeri dominating the undergrowth.

Abies lasiocarpa/Luzula hitchcockii-
Menziesia ferruginea (ABLA/LUHI-MEFE)

This was the major forest type on moist northerly aspects in the subalpine zone. Abies lasiocarpa, Picea engelmannii, and Pinus albicaulis dominated the overstory. The ground vegetation was dominated by Menziesia ferruginea, Xerophyllum tenax, and Vaccinium scoparium.

Pinus albicaulis-Abies lasiocarpa
(PIAL-ABLA)

This habitat type was predominantly associated with the high elevations along ridgetops at or near timberline. Pinus albicaulis, Picea engelmannii, and Abies lasiocarpa were the predominant trees with the latter often occurring in "krummholz." The major undergrowth plants were Vaccinium scoparium, Xerophyllum tenax, Carex geyeri, and Phyllodoce empetriformis.

C2

Vegetation Classification of the Temperate Zone

The temperate zone was mapped using the same methods and landtype/forest habitat type classifications employed in the subalpine zone. Four of the 6 subalpine landtypes were identified in the temperate zone, viz., Burns, Wet Forb-Grasslands, Dry Forb-Grasslands, and SCREE. Ridgetop Glades and Snowslides were not present at the low temperate zone elevations.

Description of the Grass-Shrubland Ecological Landtypes

Seral Stages (Burns)

Xerophyllum tenax and *Carex geyeri* were the predominant plant species in the burns. The most abundant grasses were *Phleum pratense*, *Agropyron spicatum*, and *Bromus* spp. (Table 4). Shrubs were common in the temperate zone, comprising over 12 percent of the vegetation. The most abundant forbs, each comprising over 2 percent of the vegetation, were *Fragaria virginiana*, *Lupinus* spp., and *Epilobium angustifolium*. Additional plots are needed before we can make more precise listing of the plants and their vegetative percentages. The distribution of species in the temperate burns is summarized as percent occurrence in Table 5.

Wet Forb-Grasslands

The Wet Forb-Grasslands were extensive; large expanses of wet meadow were located in the Danaher Valley along

Table 4 . Percent vegetation cover in four ecological landtypes in the Temperate Zone. (41 plots, 47,396 square feet).

Vegetation	Seral Stages (Burns) (11 plots)	Wet Forb Grasslands (7 plots)	Dry Forb Grasslands (19 plots)	Scree (4 plots)
Xerophyllum tenax	16.9			
Carex geyeri	15.4		2.5	
Trace forbs	13.8	3.3	9.3	22.0
Phleum pratense	7.7		3.3	
Agropyron spicatum	4.6		6.8	6.0
Fragaria virginiana	4.1	5.4		4.0
Bromus sp.	4.1			2.0
Carex spp.	3.6	21.2	2.7	
Lupinus sp.	3.1		.3	
Amelanchier alnifolia	3.1		1.1	2.0
Spirea betulifolia	2.6			
Symphoricarpos albus	2.1			2.0
Epilobium angustifolium	2.1			
Gramineae	2.1	1.6	1.4	
Shepherdia canadensis	1.5			6.0
Vaccinium scoparium	1.5			
Trace shrubs and trees	1.5		.3	16.0
Juniperus communis	1.0			
Lonicera utahensis	1.0			
Antennaria spp.	1.0			
Potentilla gracilis	1.0	1.1		
Smilacina stellata	1.0			
Hieracium gracile	1.0			
Poa spp.	1.0			
Arenaria spp.	.5			
Galium boreale	.5			
Apocynum sp.	.5			
Potentilla fruiticosa	.5	13.0	5.2	
Luzula hitchcockii	.5			
Festuca scabrella	.5		36.4	
Betula glandulosa		26.1		
Salix spp.		26.1		8.0
Swertia perennis		1.6		
Achillea millefolium		.5		
Festuca idahoensis			15.6	8.0
Artemisia tridentata			7.7	
Deschampsia cespitosa			2.2	
Poa pratensis			1.4	
Arctostaphylos uva-ursi			.8	4.0
Danthonia unispicata			.8	
Calamagrostis rubescens			.5	
Rosa sp.			.3	
Tragopogon dubius			.3	
Geum triflorum			.3	
Trifolium sp.			.3	
Perideridia gairdneri			.3	
Phleum alpinum			.3	
Juniperus scopulorum				10.0
Acer glabrum				4.0
Prunus virginiana				4.0
Sedum spp.				2.0
Total	99.8	99.9	100.1	100.0

Table 5 . Percent occurrence of plant species in four ecological landtypes in the Temperate Zone (41 plots, 47,396 square feet.)

Vegetation	Seral Stages (Burns) (11 plots)	Wet Forb Grasslands (7 plots)	Dry Forb Grasslands (19 plots)	Scree (4 plots)
Trace forbs	100.0	85.7	100.0	100.0
Carex geyeri	54.5		15.8	
Xerophyllum tenax	45.5			
Fragaria virginiana	27.3	28.6		25.0
Gramineae	27.3	28.6	21.1	
Trace shrubs and trees	27.3		5.3	100.0
Carex spp.	18.2	100.0	21.1	
Amelanchier alnifolia	18.2		5.3	25.0
Spirea betulifolia	18.2			
Agropyron spicatum	18.2		21.1	50.0
Bromus sp.	9.1			25.0
Lupinus sp.	9.1		5.3	
Symphoricarpos albus	9.1			25.0
Epilobium angustifolium	9.1			
Shepherdia canadensis	9.1			50.0
Vaccinium scoparium	9.1			
Juniperus communis	9.1			
Lonicera utahensis	9.1			
Antennaria spp.	9.1			
Potentilla gracilis	9.1	14.3		
Smilacina stellata	9.1			
Hieracium gracile	9.1			
Poa spp.	9.1			
Arenaria spp.	9.1			
Galium boreale	9.1			
Apocynum sp.	9.1			
Potentilla fruiticosa	9.1	100.0	26.3	
Luzula hitchcockii	9.1			
Festuca scabrella	9.1		94.7	
Phleum pratense	9.1		21.1	
Betula glandulosa		85.7		
Salix spp.		100.0		50.0
Swertia perennis		28.6		
Achillea millefolium		14.3		
Festuca idahoensis			84.2	25.0
Artemisia tridentata			15.8	
Deschampsia cespitosa			10.5	
Poa pratensis			10.5	
Arctostaphylos uva-ursi			10.5	25.0
Danthonia unispicata			10.5	
Calamagrostis rubescens			5.3	
Rosa sp.			5.3	
Tragopogon dubius			5.3	
Geum triflorum			5.3	
Trifolium sp.			5.3	
Perideridia gairdneri			5.3	
Phleum alpinum			5.3	
Juniperus scopulorum				50.0
Acer glabrum				25.0
Prunus virginiana				25.0
Sedum spp.				25.0

the South Fork of the Flathead River. Salix spp., Potentilla fruiticosa, Carex spp., and Betula glandulosa characterized the vegetation. These species exhibited the highest percent vegetation and the widest distribution (Tables 4 and 5). Grasses and forbs composed a smaller portion of the total vegetation, but were widely distributed.

Dry Forb-Grasslands

The grasses formed the largest percentage of vegetation in the temperate Dry Forb-Grassland; dominant species were Festuca scabrella, F. idahoensis, and Agropyron spicatum (Tables 4 and 5). Potentilla fruiticosa and Artemisia tridentata were the prevalent shrubs in terms of percent vegetation and percent occurrence. Forb species were numerous but did not individually comprise a high percentage of the vegetation. Common forbs were Lupinus spp., Geum triflorum, Trifolium spp., and Perideridia gairdneri.

SCREE

The vegetational composition of the SCREE varied considerably in the sample plots. Generally the ratio of trees and shrubs to graminales and forbs was higher than in other temperate grass-shrubland landtypes. Juniperus scopulorum, Salix spp., and Shepherdia canadensis were the most abundant shrubs. The dominant graminales were Festuca idahoensis and Agropyron spicatum. Most forbs occurred at low vegetative percentages (Table 5). More research effort is needed before adequate vegetation descriptions of the SCREE can be presented.

Description of Temperate Forest Vegetation in Terms of Grouped Habitat Types

Of the 19 forest habitat types recorded in the sub-alpine and temperate zones using the methods of Pfister et al. (1977), 13 were found in the temperate zone and constituted the last three groupings of habitat types aligned in terms of grizzly bear ecology. Groups VI, VII, and VIII included forest habitat types at 7000 feet (2132 m) and below and were composed of the _Abies lasiocarpa_ and the _Pseudotsuga menziesii_ series. _Pinus albicaulis_, an important grizzly bear food source, was absent. Habitat types of the _Abies lasiocarpa_ series (Groups VI and VIII) were present on xeric and mesic sites. _Vaccinium scoparium_ and _V. globulare_ were common (Group VI) or variable (Group VIII) components of the understory. Xeric forest habitat types (Group VII) were dominated by _Pseudotsuga menziesii_ with _Vaccinium_ spp. generally absent. The characterization of Groups VI, VII, and VIII, including numerical designations in parentheses according to Pfister et al. (1977), was as follows:

Group VI

Forest habitat types below 7000 feet (2132 m) with _Abies lasiocarpa_ dominant but without _Pinus albicaulis_. _Vaccinium_ spp. common.

A. Xeric sites

(691) _Abies lasiocarpa/Xerophyllum tenax-Vaccinium globulare_

(692) Abies lasiocarpa/Xerophyllum tenax-Vaccinium scoparium
(690) Abies lasiocarpa/Xerophyllum tenax

B. Mesic sites

(670) Abies lasiocarpa/Menziesia ferruginea
(691) Abies lasiocarpa/Xerophyllum tenax-Vaccinium globulare
(692) Abies lasiocarpa/Xerophyllum tenax-Vaccinium scoparium
(730) Abies lasiocarpa/Vaccinium scoparium
(731) Abies lasiocarpa/Vaccinium scoparium-Calamagrostis rubescens

Group VII

Xeric forest habitat types with Pseudotsuga menziesii dominant, low water table. No Vaccinium spp.

(320) Pseudotsuga menziesii/Calamagrostis rubescens
(330) Pseudotsuga menziesii/Carex geyeri
(360) Pseudotsuga menziesii/Juniperus communis
(750) Abies lasiocarpa/Calamagrostis rubescens

Group VIII

Hydric to mesic forest habitat types with Abies lasiocarpa dominant, high water table. Vaccinium spp. variable.

(650) Abies lasiocarpa/Calamagrostis canadensis
(660) Abies lasiocarpa/Linnaea borealis
(780) Abies lasiocarpa/Arnica cordifolia

Description of Specific Forest Habitat Types of the Temperate Zone

The forest habitat types listed under Groups VI through VIII are characterized by the descriptions that follow.

Abies lasiocarpa/Xerophyllum tenax-Vaccinium globulare (ABLA/XETE-VAGL)

Within the temperate zone this habitat type of the

VAGL phase comprised the major forest growth on relatively xeric exposures in the Scapegoat study area. Abies lasiocarpa dominated the forest canopy with Pinus contorta and Pseudotsuga menziesii occurring less frequently. Vaccinium globulare, Xerophyllum tenax, and V. scoparium were major components of the undergrowth.

Abies lasiocarpa/Xerophyllum tenax-
Vaccinium scoparium (ABLA/XETE-VASC)

Although similar to the ABLA/XETE habitat type VAGL phase, the ABLA/XETE habitat type VASC phase generally occurred on less xeric sites. Abies lasiocarpa and Pinus contorta were, again, the dominant trees with Vaccinium scoparium and Xerophyllum tenax dominating the ground vegetation.

Abies lasiocarpa/Menziesia ferruginea
(ABLA/MEFE)

This, the most abundant forest habitat type of the temperate zone, occurred on moist sites on northerly aspects (Table 7). Abies lasiocarpa and Picea engelmannii were the major overstory components with Menziesia ferruginea a preponderant member of the ground vegetation. Xerophyllum tenax and Vaccinium spp. were other undergrowth plants.

Pseudotsuga menziesii/Calamagrostis rubescens-
Calamagrostis rubescens (PSME/CARU-CARU)

This habitat type, CARU phase, generally occurred on xeric southerly exposures where Pseudotsuga menziesii and *Pinus contorta* dominated the forest canopy. The major undergrowth components were *Calamagrostis rubescens* and *Carex geyeri*.

Vegetation Type Map

A vegetation type map constructed from field mapping and vegetation sampling (Fig. 10a) shows the distribution of ELUs, ELTs, and forest habitat types within the 50,365-acre (20,391-ha) Scapegoat study area. The type map describes grizzly bear habitat in terms of plant succession and vegetation cover types for the region. Recorded on the map are 9 groupings of 41 vegetation types of which 25 are displayed in color. These extend from approximately 4000 feet to over 9000 feet (1218 m to over 2742 m); most have ecological significance for the grizzly bear. Some are more important than others, and the different types vary greatly in size and distribution, but together they characterize grizzly bear habitat. They have been botanically described earlier in the text, but for easy reference to the map the vegetation types are grouped and listed as follows:

Alpine Ecological Land Units
(J. J. Craighead)

Group I

1. Alpine Meadow (Tundra)--*Carex*-*Festuca*-*Phlox*
2. Alpine Meadow Krummholz (*Pinus albicaulis*-*Abies lasiocarpa*) h.t. with - *Festuca*-*Carex*-*Luzula* meadow
3. Slab Rock Krummholz (*Pinus albicaulis*-*Abies lasiocarpa*) h.t. with - *Luzula*-*Carex* meadow

Fig. 10a. Ground vegetation type map of grizzly bear habitat on Scapegoat Plateau and adjacent areas. The distribution of the ELUs, ELTs, and grouped forest habitat types are readily apparent. Acreage and percentage statistics are presented in Tables 6, 7, and 8. This map with vegetation descriptive data is used as ground truth for constructing the computerized thematic maps described in Section III.

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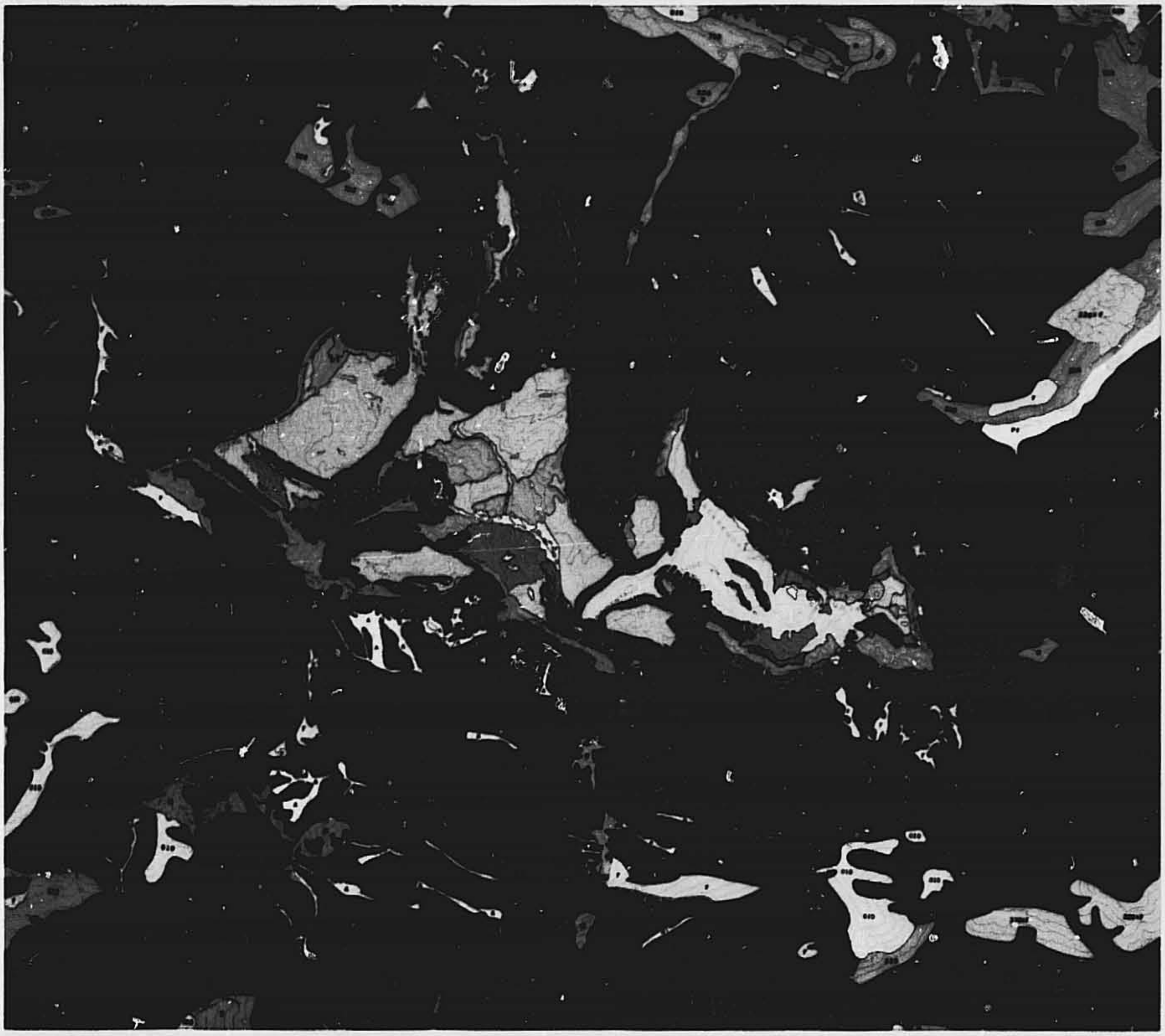

Vegetation Type Map
GRIZZLY BEAR HABITAT
Lincoln Scapegoat Wilderness

ALPINE ECOLOGICAL LAND UNITS AND LANDTYPES*

SUBALPINE AND TEMPERATE FOREST HABITAT TYPES**

SUBALPINE AND TEMPERATE GRASS-SHRUBLAND LANDTYPES***

4. Slab Rock Steps Krummholz (Pinus albicaulis-Abies lasiocarpa) h.t. with - Carex-Thalictrum meadow
5. Vegetated Talus - Gentiana-Carex

Group II

6. Glacial Cirque Basin - Carex-Festuca
7. Mountain Massif - Carex-Dryas
8. Fellfield - Dryas
9. Semi-Vegetated Talus - Dryas-Claytonia megarhiza

Group III

10. Parent Rock-Lichens (limestone/argillite)

Group IV

11. Bare Talus-Lichens (limestone/argillite)
12. Snowfield and Snowfield Sinks

Subalpine and Temperate Forest Habitat Types
(After R. Pfister 1977)

Group V

Abies lasiocarpa series above 7000 feet (2132 m) with Pinus albicaulis a major component and Vaccinium scoparium usually common.

870 Pinus albicaulis
860 Larix lyallii-Abies lasiocarpa
850 Pinus albicaulis-Abies lasiocarpa
832 Abies lasiocarpa/Luzula hitchcockii-Menziesia ferruginea
831 Abies lasiocarpa/Luzula hitchcockii-Vaccinium scoparium
820 Abies lasiocarpa(Pinus albicaulis)/Vaccinium scoparium
010 SCREE (with Pinus albicaulis adjacent to forest types where P. albicaulis is a major component)

Forest Mosaic, with Pinus albicaulis of 831 or 832 or 820 with Abies lasiocarpa/Calamagrostis canadensis

Mosaic of SCREE (rock adjacent to and interspersed with forest types where Pinus albicaulis is a major component.

Group VI

Abies lasiocarpa series at 7000 feet (2132 m) and below without Pinus albicaulis. Vaccinium spp. common.

691 Abies lasiocarpa/Xerophyllum tenax-Vaccinium globulare
692 Abies lasiocarpa/Xerophyllum tenax-Vaccinium scoparium
690 Abies lasiocarpa/Xerophyllum tenax (with Vaccinium globulare and/or Vaccinium scoparium)
670 Abies lasiocarpa/Menziesia ferruginea
730 Abies lasiocarpa/Vaccinium scoparium
731 Abies lasiocarpa/Vaccinium scoparium-Calamagrostis rubescens

Forest Mosaic of 670 or 691 with 650

Group VII

Xeric forest of Abies lasiocarpa or Pseudotsuga menziesii series. No Vaccinium spp.

750 Abies lasiocarpa/Calamagrostis rubescens
330 Pseudotsuga menziesii/Carex geyeri
320 Pseudotsuga menziesii/Calamagrostis rubescens

Forest Mosaic of 320 and rock
Forest Mosaic of 320 and Festuca meadow

Group VIII

Hydric to mesic forest of Abies lasiocarpa series. Vaccinium spp. variable.

650 Abies lasiocarpa/Calamagrostis canadensis
660 Abies lasiocarpa/Linnaea borealis
780 Abies lasiocarpa/Arnica cordifolia

Subalpine and Temperate Grass-Shrubland Landtypes
(Modified after Mueggler and Handl 1974)

Group IX

Subalpine and temperate grass-shrubland landtypes. Vaccinium spp. variable.

Dry Forb-Grasslands--Festuca-Xerophyllum-Carex
Ridgetop Glades--Festuca-Carex-Lomatium
Wet Forb-Grasslands--Potentilla-Pedicularis-Carex
Snowslides (Avalanche)--Xerophyllum-Carex-Senecio
SCREE (without Pinus albicaulis and Vaccinium spp.)

The vegetation map (Fig. 10a) can be interpreted in terms of climatic zones by referencing Fig. 10b. The landtypes and landtype/habitat types are divided into the 9 major vegetation groupings, separated by altitudinal parameters. Representative plant communities and forest habitat types are shown for each zone.

Habitat Acreage

The Scapegoat study area represented by the habitat map (Fig. 10a) comprised 50,365 acres (20,391 ha).

The alpine zone, excluding 489 acres (198 ha) of subalpine forest intrusion, comprised 7256 acres (2938 ha), or 15 percent of the entire study area. The subalpine and temperate zones comprised 20,879 acres (8453 ha) (42 percent) and 21,739 acres (8801 ha) (43 percent), respectively.

Acreages of Alpine Zone Ecological Land Units

In the alpine zone, Bare Talus was the largest ecological land unit aggregate with 1277 acres (517 ha), followed by Glacial Cirque Basins with 1145 acres (464 ha) and Parent Rock with 1047 acres (424 ha) (Table 6). The smallest acreages were in permanent Snowfields and Snowfield Sinks.

Land units having similar landforms and soil characteristics were grouped into 4 landtypes: Alpine Meadows,

Table 6. Acreage of ecological land units that comprise landtypes in the Alpine Zone (ground map).

Vegetation Landtypes	Acreage	Percent Landtype to Total Acreage	Percent ELU to Landtype
Group I			
Alpine Meadow Landtype			
Slab-Rock Steps	493.1		24.5
Alpine Meadow Krummholz	359.5		17.9
Alpine Meadow	336.3		16.7
Vegetated Talus	328.5		16.3
Slab-Rock Krummholz	295.1		14.7
Island Krummholz	201.1		10.0
Total	2013.6	27.8	100.1
Group II			
Vegetated Rock Landtype			
Glacial Cirque Basin	1144.8		41.4
Semi-Vegetated Talus	676.6		24.5
Mountain Massif	550.0		19.9
Fellfield	392.7		14.2
Total	2764.1	38.1	100.0
Groups III and IV			
Bare Rock Landtype			
Bare Talus	1276.7		51.5
Parent Rock	1047.2		42.3
Snowfield Sink	86.6		3.5
Permanent Snowfields	67.9		2.7
Total	2478.4	34.2	100.0
GRAND TOTAL	7256.1	100.1	
With Subalpine Forest Intrusion	7746.0		

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Vegetated Rock, Bare Rock and Talus, and Snowfields. The Vegetated Rock landtype was found to be the largest, comprising 38 percent of the alpine area; Bare Rock and Talus and the Alpine Meadow landtype comprised 34 percent and 28 percent respectively (Table 6).

In the Alpine Meadow landtype, the Slab-Rock Step was the largest land unit, comprising 24.5 percent; the Glacial Cirque Basin was the largest in the Vegetated Rock landtype (41.4 percent); and Bare Talus occupied the greatest area in the Bare Rock landtype (51.5 percent). Two landtypes, the Alpine Meadow (I) and the Vegetated Rock (II), both used extensively by grizzly bears, comprised 65.9 percent of the entire alpine zone. The importance of this relatively small land area to the ecology of the grizzly bear will be discussed in Sections II and III.

Acreage of Subalpine and Temperate Zone Forest Habitat Types, Forest Groupings, and Non-Forested Landtypes

The subalpine and temperate forests and grass-shrublands constituted 82 percent of the study area (Tables 7 and 8). Including bare rock and talus slopes (3.0 percent), the subalpine and temperate zones totaled 42,618 acres (17,254 ha), or approximately 85 percent of the study area, as compared to 15 percent for the Alpine Zone.

Forest habitat types above 7000 feet (2132 m), with whitebark pine a major component (Group V), comprised

Table 7. Acreage of Subalpine and Temperate Forest Habitat Types. Groups V-VIII.

Forest Groupings by Habitat Types	Acres	Percent of Total	Percent Habitat Type To Grouping
Group V ABIES LASIOCARPA FOREST WITH PINUS ALBICAULIS A MAJOR COMPONENT VACCINIUM SCOPARIUM USUALLY COMMON			
831 Abla/Luhi-Vasc	5460.8	13.8	29.8
820 Abla(Pial)/Vasc	3976.2	10.1	21.7
850 Pial-Abla	2212.8	5.6	12.1
010 Scree, containing Pial, adjacent to 800s h.t.	2116.3	5.4	11.5
832 Abla/Luhi-Mefe	1701.6	4.3	9.3
860 Laly-Abla	911.5	2.3	5.0
010 x R Scree, containing Pial with large exposures of rock	893.8	2.3	4.9
831 x 650 Mosaic, Abla/Luhi-Vasc with Abla/Caca	672.7	1.7	3.7
832 x 650 Mosaic, Abla/Luhi-Mefe with Abla/Caca	275.5	.7	1.5
820 x 650 Mosaic, Abla(Pial)/Vasc with Abla/Caca	99.6	.3	.5
870 Pinus albicaulis	9.6	.0	.1
Subtotal	18330.4	46.5	100.1
Group VI ABIES LASIOCARPA FOREST WITHOUT PINUS ALBICAULIS VACCINIUM SPP. COMMON			
670 Abla/Mefe	6354.9	16.1	34.0
691 Abla/Xete-Vagl	5692.3	14.4	30.5
692 Abla/Xete-Vasc	4971.1	12.6	26.6
690 Abla/Xete	858.7	2.2	4.6
670 x 650 Mosaic, Abla/Mefe with Abla/Caca	722.1	1.8	3.9
691 x 650 Mosaic, Abla/Xete-Vagl with Abla/Caca	71.9	.2	.4
730 Abla/Vasc	13.7	.0	.1
Subtotal	18684.7	47.3	100.1
GROUP VII DRY FOREST WITH VACCINIUM SPP. ABSENT			
750 Abla/Caru	877.3	2.2	42.7
320 x F Mosaic, Psme/Caru with Festuca meadow	512.2	1.3	24.9
320 Psme/Caru	369.2	.9	18.0
360 Psme/Juco	283.7	.7	13.8
320 x R Mosaic, Psme/Caru with Rock	12.4	.0	.6
Subtotal	2054.8	5.1	100.0
GROUP VIII WET FOREST WITH VACCINIUM SPP. VARIABLE			
650 Abla/Caca	287.2	.7	65.0
780 Abla/Arco	123.2	.3	27.9
660 Abla/Libo	31.2	.1	7.1
Subtotal	441.6	1.1	100.0
Total	39511.5	100.0	

Table 8. Acreage of Subalpine and Temperate Non-forested Land Types (Group IX).

Land Types	Acres	Percent Land Type to Grouping	Percent of Non-Forested Types	Percent of Forested and Non-Forested Types
Group IX				
Meadows, Glades, Snowslides and SCREE				
F Festuca Meadows	790.5	43.0	25.4	1.8
SCREE (Without Pinus albicaulis and Vaccinium spp.)	557.4	30.3	17.9	1.3
A Avalanche (Snowslides)	347.4	18.9	11.2	.8
Pf Potentilla fruiticosa meadows	138.3	7.5	4.5	.3
H Heracleum meadows	5.1	.3	.2	0
Subtotal	1838.7	100.0	59.2	4.2
Group III and IV				
Rock and Talus				
T Talus	667.5	52.7	21.5	1.6
R Rock	600.1	47.3	19.3	1.4
Subtotal	1267.6	100.0	40.8	3.0
Total Non-forested Land Types	3106.3			
Total Forested Habitat Types	39511.5			
GRAND TOTAL of Subalpine and Temperate Forested and Non-Forested Types	42,617.8			
Total Acreage in Study Area	50,365			

46 percent of the entire forest on the study area. Forests below 7000 feet (2132 m) and largely devoid of whitebark pine (Group VI) were similar in area (47 percent). Less than 50 percent of the forests contained major representations of whitebark pine, but 94 percent of the forest types (alpine excluded) supported Vaccinium spp. as a common component of the understory (Table 7). Forest types lacking whitebark pine and with species of Vaccinium spp. absent or variable (Groups VII and VIII) comprised only 6.3 percent of the forest area. Practically all of this was in temperate forests below 7000 feet (2132 m). Meadows, glades, snowslides, and SCREE (Group IX) represented 4.2 percent of the study area (Table 8).

Group V forests were largely confined to ridges and slopes above 7000 feet (2132 m), while the forest types lacking whitebark pine (Groups VI, VII, and VIII) were found on the lower slopes and in the valleys of the study area. Thus, whitebark pine was limited in distribution, but Vaccinium spp. were widely dispersed and common throughout the forests. The temperate zone was not fully represented within the Scapegoat study area; nevertheless, it is obvious that land within the subalpine and temperate zones comprised a large percentage (85 percent) of the total grizzly bear habitat. Certain forest habitat types and certain grass-forb landtypes supported more bear foods than others and were used more intensively by grizzly bears. The acreages of specific forest habitat types are presented in Table 7. The significance of specific habitat types and vegetation landtypes to the ecology of the grizzly bear will be treated in Section II.

Accuracy of Ground Type-Map

Accuracy in mapping ecological land units of the alpine zone approached 100 percent. Landforms delineating the ELUs were visible on orthophotos and aerial color photographs and, thus, were precisely mapped utilizing a combination of physical, geomorphic, and ecologic boundaries. The entire alpine area was mapped on the ground without recourse to extrapolative techniques. Vegetation descriptions for the land units and landtypes were developed through vegetation sampling as described in the Methods section (page 18).

Forest habitat types were mapped in the field from transects and vegetation plots. A model of habitat type distribution that was developed from the field data was then used to extrapolate to the entire subalpine forested area (Pfister et al. 1977). Estimated map accuracy for any given point is 80 percent.

Grizzly Bear Food Plants

Studies in the Yellowstone ecosystem from 1959 through 1970 showed that grizzly bears are extremely efficient omnivores that feed on a wide range of plant and animal foods (J. J. Craighead, in press; J. J. Craighead and Sumner, unpubl. data). Herbaceous vegetation such as clovers (Trifolium spp.), dandelion (Taraxacum officinale), horsetail (Equisetum arvense), elk thistle (Cirsium scariosum), sedges (Carex spp.), and succulent grasses (Gramineae) were preferred "greens." These and other succulent, nutritious forage plants were generally abundant and widely distributed in the alpine meadows and the subalpine and temperate grass-shrubland parks. They constituted a large proportion of the plant foods consumed by grizzlies but were not necessarily preferred, nor were they, in themselves, reliable indicators of prime habitat.

Plant foods high in protein and carbohydrates, such as tubers, nuts, and berries, were also major energy sources. A wide variety of tubers, bulbs, and corms were available in the grass-shrublands, while nuts of the whitebark pine and a variety of berries were abundant in the forest types.

The same food sources utilized within the Yellowstone ecosystem were present and were observed to be utilized by grizzlies in the Scapegoat study area of western Montana. The general plant food base is composed of a diverse assemblage of species (Table 9).

Specific Food Plant List

Specific food plants were identified through direct observations, identification of plant foods in digging areas,

Table 9: Grizzly bear food plants identified in the Scapegoat Study Area.

Scientific Name	Common Name
BERBERIDACEAE	
Berberis repens	Oregon grape
CAPRIFOLIACEAE	
Lonicera involucrata	Twinberry
L. utahensis	Red twinberry
Symphoricarpos albus	Snowberry
COMPOSITAE	
Agoseris spp.	Mountain dandelion
Cirsium scariosum	Elk thistle
Taraxacum officinale	Dandelion
CORNACEAE	
Cornus canadensis	Bunchberry dogwood
C. stolonifera	Red-osier dogwood
*CYPERACEAE	
Carex albonigra	Black-and-white scaled sedge
C. filifolia	Thread-leaved sedge
C. geyeri	Elk sedge
C. hoodii	Hood's sedge
C. scirpodia	Sedge
Carex spp.	Sedges
ELAEAGNACEAE	
Shepherdia canadensis	Buffalo-berry
EQUISETACEAE	
Equisetum arvense	Horsetail
E. hyemale	Scouring-rush
ERICACEAE	
Arctostaphylos uva-ursi	Kinnikinnick
Vaccinium caespitosum	Dwarf huckleberry
V. globulare	Blue huckleberry
V. myrtillus	Dwarf bilberry
V. scoparium	Grouse whortleberry

Table 9: Grizzly bear food plants identified in the Scapegoat Study Area (Continued).

Scientific Name	Common Name
*GRAMINEAE	
Agropyron spicatum	Wheatgrass
Bromis inermis	Brome grass
Calamagrostis canadensis	Bluejoint
C. rubescens	Pine grass
Festuca baffinensis	Fescue-grass
F. idahoensis	Fescue-grass
F. scabrella	Fescue-grass
Melica bulbosa	Oniongrass
M. spectabilis	Purple oniongrass
Phleum alpinum	Timothy
P. pratense	Timothy
Poa alpina	Bluegrass
P. fendleriana	Bluegrass
P. sandbergii	Bluegrass
P. spp.	Bluegrasses
GROSSULARIACEAE	
Ribes lacustre	Gooseberry
Ribes spp.	Currents
JUNCACEAE	
Juncus parryi	Parry's rush
LEGUMINOSAE	
Hedysarum occidentale	Sweetvetch
H. sulphurescens	Sweetvetch
Trifolium repens	Clover
LILIACEAE	
Allium cernuum	Wild Onion
A. schoenoprasum	Chives
Erythronium grandiflorum	Glacier Lily
Xerophyllum tenax	Beargrass
PINACEAE	
Pinus albicaulis	Whitebark Pine
P. flexilis	Limber pine

Table 9: Grizzly bear food plants identified in the Scapegoat Study Area (Continued).

Scientific Name	Common Name
POLYGONACEAE	
Oxyria digyna	Mountain sorrel
Polygonum bistortoides	American bistort
P. viviparum	Serpent grass
PORTULACEAE	
Claytonia lanceolata	Spring beauty
C. megarhiza	Spring beauty
ROSACEAE	
Amelanchier alnifolia	Serviceberry
Fragaria vesca	Strawberry
F. virginiana	Strawberry
Prunus virginiana	Chokecherry
Rubus parviflorus	Thimbleberry
Sorbus scopulina	Mountain ash
Rosa spp.	Rose
UMBELLIFERAE	
Angelica dawsonii	Angelica
Heracleum lanatum	Cow-parsnip
Lomatium cous	Biscuit-root
L. dissectum	Biscuit-root
L. macrocarpum	Biscuit-root
L. sandbergii	Biscuit-root
Perideridia gairdneri	Yampa

*Grasses and sedges were not identified to species in the scat analyses. Those listed as food plants were identified by closely observing grizzlies grazing and then examining the grazed sites for evidence of cropping.

and by scat analysis. The numerous species listed in Table 9 were distributed throughout a wide altitudinal range and a variety of habitats. Grizzlies used only a few of these species intensively. Additional long-term observations will no doubt indicate greater use of some of them and infrequent use of others. Also, further refinement of scat analysis and methods for making direct observations of bear feeding habits will reveal the use of additional plants as bear foods. Because we have described the grizzly bear environment in percentages of total ground vegetation (at the 5 percent level), the abundance and distribution values for newly recognized or newly reported bear food plants can be obtained from the vegetation descriptions presented earlier in this section or in the appendix. For example, we have not recorded the Indian paintbrushes (Castilleja spp.) as bear food plants. However, should future evidence indicate use of this genus by grizzlies, its abundance and distribution values in the grass-shrublands of the subalpine zone can be determined from data presented in Tables 2 and 3.

Abundance and Distribution Values of Grizzly Bear Food Plants

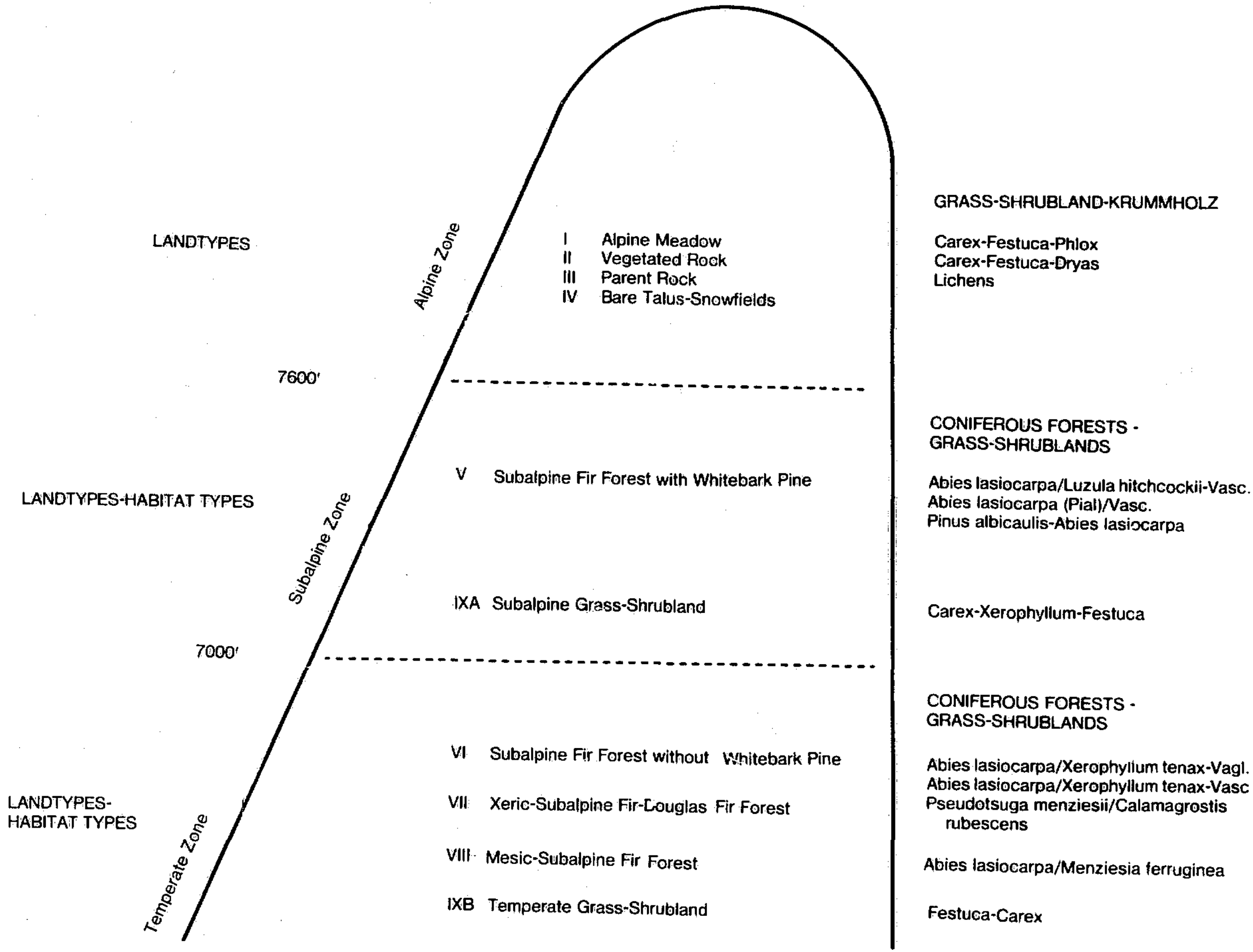
Our major consideration in this section, so far, has been to describe the abundance and distribution of plants as they occurred in sample plots in the alpine, subalpine, and temperate zones of the Scapegoat study area. With this as a foundation, we will now put the bear food plants in ecological perspective by showing how they relate to vegetation categories and to the total vegetation complex. Then each climatic zone will be evaluated and rated as a source of energy for grizzlies. By segregating the values for percent vegetative cover (abundance) and percent occurrence (distribution) of each food plant or food category from the values recorded for all other plants in sample plots, general abundance and distribution values for the bear food plants can be expressed as percentages. For example, _Carex_ spp. comprised 19.9 percent of the total ground vegetation in the forb-grasslands of the alpine zone and occurred in 52.2 percent of the plots (Table 12). Sedges thus had high abundance and distribution values, but nevertheless were not heavily utilized by grizzlies. On the other hand, _Lomatium cous_, which was heavily utilized by grizzlies, comprised only 0.7 percent of the total vegetation in the forb-grasslands of the alpine zone and had a distribution value of only 6.3 percent. Thus, comparative ranking of food plants and food-plant categories in terms of percent vegetation (abundance) within each of the three climatic zones provides comparative ecological measurements for the evaluation of bear habitat.

To evaluate each climatic zone, we first evaluated specific segments of the habitat. In the alpine zone, these components were the ecological land units (ELUs). In the subalpine and temperate zones, they were the ecological landtypes (ELTs) of the grass-shrublands and the forest habitat types of the coniferous forests. Each zone was then evaluated in terms of specific food plants and the food plant categories. Fig. 10b shows the zoning with examples of the landtypes/habitat types and their diagnostic vegetation. By referencing Figs. 10a and b the reader can put individual bear food plants in perspective within the entire classification system.

Ecological Land Units in the Alpine Zone

The relative abundance of bear food plants as they occur in 9 ecological land units are representative of the entire alpine zone within the Scapegoat study area (Tables 10 and 11). The percent of total bear food plants recorded for each alpine land unit (Fig. 11), and for other vegetation units or vegetation types to be discussed later, are measurements of the potential of each unit as a source of energy for grizzly bears. Some of the food plant species are more nutritious than others and some are more readily utilized by grizzlies because of their distribution patterns or seasonal occurrence. Thus, the potential values indicated by abundance and distribution are later modified in Section II. For example, in the Alpine Meadow unit (Table 10), bear food plants represent 56.8 percent of the total ground vegetation; however, 38.1 percent of this is *Carex* and *Festuca*, neither highly preferred bear foods. On the other hand, the Semi-Vegetated Talus unit (Table 11) shows a total

Fig. 10b. Elevational zoning for landtypes and forest habitat types with diagnostic vegetation groupings.


LANDTYPES
Alpine Zone
I Alpine Meadow
II Vegetated Rock
III Parent Rock
IV Bare Talus-Snowfields
GRASS-SHRUBLAND-KRUMMHOLZ
Carex-Festuca-Phlox
Carex-Festuca-Dryas
Lichens
7600'
LANDTYPES-HABITAT TYPES
Subalpine Zone
V Subalpine Fir Forest with Whitebark Pine
IXA Subalpine Grass-Shrubland
CONIFEROUS FORESTS - GRASS-SHRUBLANDS
Abies lasiocarpa/Luzula hitchcockii-Vasc.
Abies lasiocarpa (Pial)/Vasc.
Pinus albicaulis-Abies lasiocarpa
Carex-Xerophyllum-Festuca
7000'
LANDTYPES-HABITAT TYPES
Temperate Zone
VI Subalpine Fir Forest without Whitebark Pine
VII Xeric-Subalpine Fir-Douglas Fir Forest
VIII Mesic-Subalpine Fir Forest
IXB Temperate Grass-Shrubland
CONIFEROUS FORESTS - GRASS-SHRUBLANDS
Abies lasiocarpa/Xerophyllum tenax-Vagl.
Abies lasiocarpa/Xerophyllum tenax-Vasc
Pseudotsuga menziesii/Calamagrostis rubescens
Abies lasiocarpa/Menziesia ferruginea
Festuca-Carex

... and occurrence of grizzly bear food plants by ecological land units in the Alpine Zone (94 plots, 108,664 square feet).

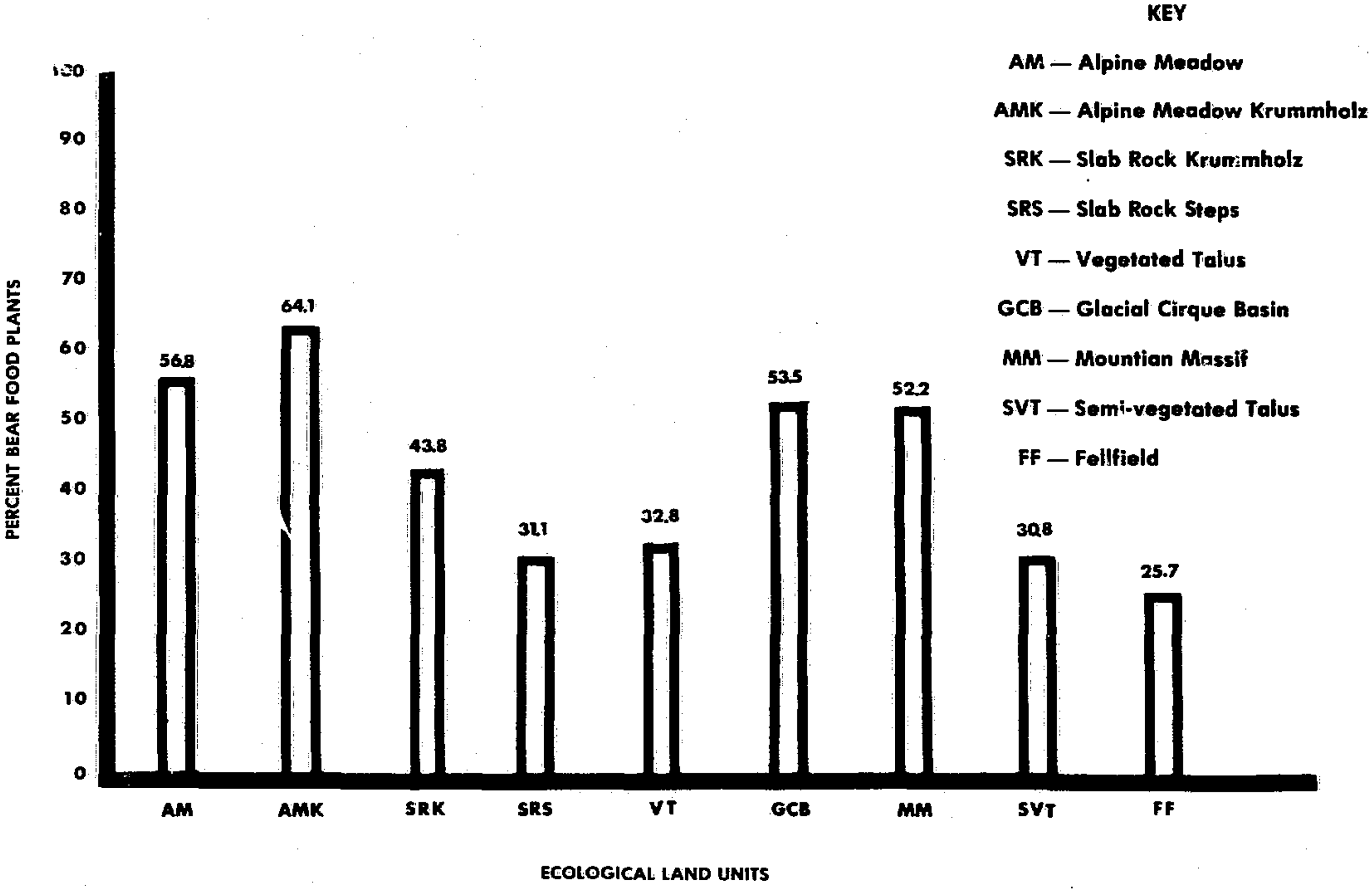
Ecological Land Units (Number Sample Plots)	Meadow (39)	Meadow Krummholz (22)	Slab Rock Krummholz (8)	Slab Rock Steps (21)	Vegetated Talus (4)
Carex spp.	23.8/76.9	18.0/36.4	17.9/25.0	20.0/57.1	5.7/50.0
Festuca idahoensis	14.3/43.6	33.3/63.6	8.0/12.5	4.4/14.3	14.3/25.0
Arctostaphylos uva-ursi	9.1/17.9		2.7/12.5	.9/4.8	1.4/25.0
Hedysarum	2.5/30.8	1.6/13.6		.4/4.8	1.4/25.0
sulphurescens					
occidentale					
Polygonum	2.2/25.6				
bistortoides		1.0/13.6			
viviparum			.9/12.5		
Vaccinium scoparium		4.6/18.2	2.7/12.5	1.8/9.5	
Erythronium grandiflorum		2.6/4.5	8.0/12.5		
Juncus parryi	.4/2.6	1.3/9.1	3.6/12.5		
Fragaria virginiana					2.9/25.0
Lomatium	.9/7.7	.7/9.1		T/T	
cous					
sandbergii					
Claytonia lanceolata		.3/4.5			
Cirsium scariosum	T/T	.3/4.5			1.4/25.0
Ribes lacustre			T/T	.9/4.8	T/T
Oxyria digyna				T/T	
Gramineae	3.6/25.6	.3/4.5	T/T	2.7/9.5	5.7/100.0
Total Bear Food Plants	56.8	64.0	43.8	31.1	32.8
Other Species	43.2	36.0	57.1	68.9	67.2
Total Vegetation	100.0	100.0	100.0	100.0	100.0

*T = occurred at less than the 5% sampling level for abundance. _Poa_ and _Calamagrostis_ not included. All others at 5% or greater; no limit on occurrence.

Table 11. Percent abundance and occurrence of grizzly bear food plants by ecological land units in the Alpine Zone (65 plots, 75,140 square feet).

Ecological Land Units (Number Sample Plots)	Glacial Cirque Basin (32)	Mountain Massif (12)	Semi-Vegetated Talus (10)	Fellfield (11)
Festuca idahoensis	20.7/37.5		3.6/10.0	
Carex spp.	14.4/46.9	29.5/50.0	5.5/30.0	24.3/54.5
Juncus parryi	6.7/15.6			
Arctostaphylos uva-ursi	3.3/9.4	21.6/33.3	3.6/20.0	1.4/9.1
Claytonia megarhiza			10.9/30.0	
Gramineae	5.4/100.0		1.8/100.0	
Lomatium	1.7/15.6		T/T	
cous				
sandbergii				
Ribes lacustre	T/T			
Agoseris spp.	T/T			
Heracleum lanatum	T/T			
Hedysarum spp.	.7/3.1	1.1/8.3	3.6/10.0	
Fragaria virginiana			1.8/10.0	
Erythronium grandiflorum	.3/3.1			
Claytonia lanceolata	.3/3.1			
Total Bear Food Plants	53.5	52.2	30.8	25.7
Other Species	46.5	47.8	69.2	74.3
Total Vegetation	100.0	100.0	100.0	100.0

Fig. 11 GRIZZLY BEAR FOOD PLANT ABUNDANCE BY ECOLOGICAL LAND UNITS ALPINE ZONE



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bear food plant abundance percentage of only 30.8 percent, of which 10.9 percent represents Claytonia megarhiza, a nutritious and highly preferred bear food. This plant occurred only in the Semi-Vegetated Talus and not in the Alpine Meadow unit. Thus, the food plant abundance values of 56.8 percent and 30.8 percent for the two ecological units measure the potential food plant base, not its importance in the grizzly's diet. This is true also of the values for the other seven units. Specific food plant values will be treated in Section II. Plants recorded to have been used by grizzlies as food represent more than half the total ground cover in the Alpine Meadow, Meadow Krummholz, Glacial Cirque Basin, and Mountain Massif land units. These land units would appear to be potentially more important to the grizzly as sources of food than the other six units.

Evaluation of the Alpine Zone as a Source of Food Plants

The specific abundance values presented in Tables 10 and 11 are summarized in Table 12. These values have then been used to develop a composite habitat rating for the alpine zone.

The most abundant bear food plants in the grass-shrublands were the graminales (grasses and sedges), which comprised 38 percent of the vegetation. Among these, Carex spp. (19.9 percent) and Festuca idahoensis (15.1 percent) dominated the vegetation. Only one shrub, Arctostaphylos uva-ursi,

Table 12: Percent abundance and percent occurrence of grizzly bear food plants in the Forb-Grasslands of the Alpine Zone in the Scapegoat Study Area (159 plots).

Species	Percent Abundance	Percent Oecurrence
Graminales		
Carex spp.	19.9	52.2
Festuca idahoensis	15.1	30.8
Gramineae*	3.0	14.5
Subtotal	38.0	
Forbs and Shrubs		
Arctostaphylos uva-ursi	5.3	12.6
Juncus parryi	1.6	5.7
Hedysarum spp.	1.5	12.6
Vaccinium scoparium	1.1	4.4
Polygonum bistortoides viviparum	1.0	8.8
Erythronium grandiflorum	.9	1.9
Lomatium cous andbergii	.7	6.3
Claytonia megarhiza	.3	1.9
Cirsium scariosum	.1	.6
Ribes lucustre	.1	.6
Claytonia lanceolata	.1	1.3
Fragaria virginiana	T	T
Agoseris spp.	T	T
Heracleum lanatum	T	T
Oxyria digyna	T	T
Subtotal	12.7	
Summary		
Total Bear Food Plants	50.7	
Other Species	49.3	
Total	100.0	

*Gramineae includes grasses that could not be identified when plots were taken because they were in immature stages. These unknowns were later identified from mature specimens by Klaus Lockschewitz at the University of Montana herbarium.

T = Trace

Note: Pinus albicaulis occurred as Krummholz and was not included in this table.

was common (5.3 percent). Forbs such as *Juncus parryi*, *Hedysarum* spp., *Polygonum* spp., *Erythronium grandiflorum*, *Lomatium* spp., and *Claytonia megarhiza* seldom contributed more than 2 percent of the vegetation individually. However, forbs and shrubs collectively composed nearly 13 percent of all food plants (Table 12).

The graminales were not only the most abundant, but also had the widest distribution of the alpine foods. *Carex* spp. occurred in 52.2 percent of the plots, while *F. idahoensis* occurred in 30.8 percent. *Arctostaphylos uva-ursi* and *Vaccinium scoparium* were the most widely distributed shrubs, while *Hedysarum* spp., *Polygonum* spp., *Lomatium* spp., and *Juncus parryi* were widely distributed forbs. Other forbs observed to be utilized as food by grizzlies occurred in less than 2 percent of the plots (Table 12).

In summary, then, the most available food plants in the alpine zone (in terms of both percent cover and distribution) were *Carex* spp., *F. idahoensis*, *A. uva-ursi*, *J. parryi*, *Hedysarum* spp., *V. scoparium*, *Polygonum* spp., and *Lomatium* spp. Species used by grizzlies to one degree or another constituted 50.7 percent of the total ground vegetation; species comprising the remaining 49.3 percent were not observed in use as food.

Krummholz of three conifer species characterized four ecological land units occupying approximately 19 percent of the total alpine land area. Sparsely scattered clumps of krummholz were distributed throughout a varied assortment of ground cover and soil conditions (Figs. 5 and 8). Species composition was Abies lasiocarpa, 70 percent; Pinus albicaulis, 26 percent; and Picea engelmannii, 4 percent. Vaccinium scoparium was present, but dwarfed and not abundant. Vaccinium scoparium and P. albicaulis rarely fruit abundantly in the alpine zone and therefore the berries and nuts are not considered important foods there.

Ecological Landtypes in the Subalpine Zone

The abundance and distribution of specific bear food plants were recorded for components of the grass-shrublands of the subalpine zone (Table 13). As in the alpine zone, the values both for specific food plants and for the landtypes supporting these foods portrayed a potential, rather than an importance value, for grizzlies. Over 50 percent of the ground vegetation in four of five ecological landtypes was used by bears (Fig. 12). This indicates a high food source potential, although high abundance values for Xerophyllum tenax in three of the landtypes tends to inflate the potential somewhat. This food plant is used sparingly by grizzlies. We will address the bias introduced by extremely abundant, but low preference, food plants later in the text.

Forest Habitat Types in the Subalpine Zone

Subalpine fir habitat types 831, 820, 832, and 850

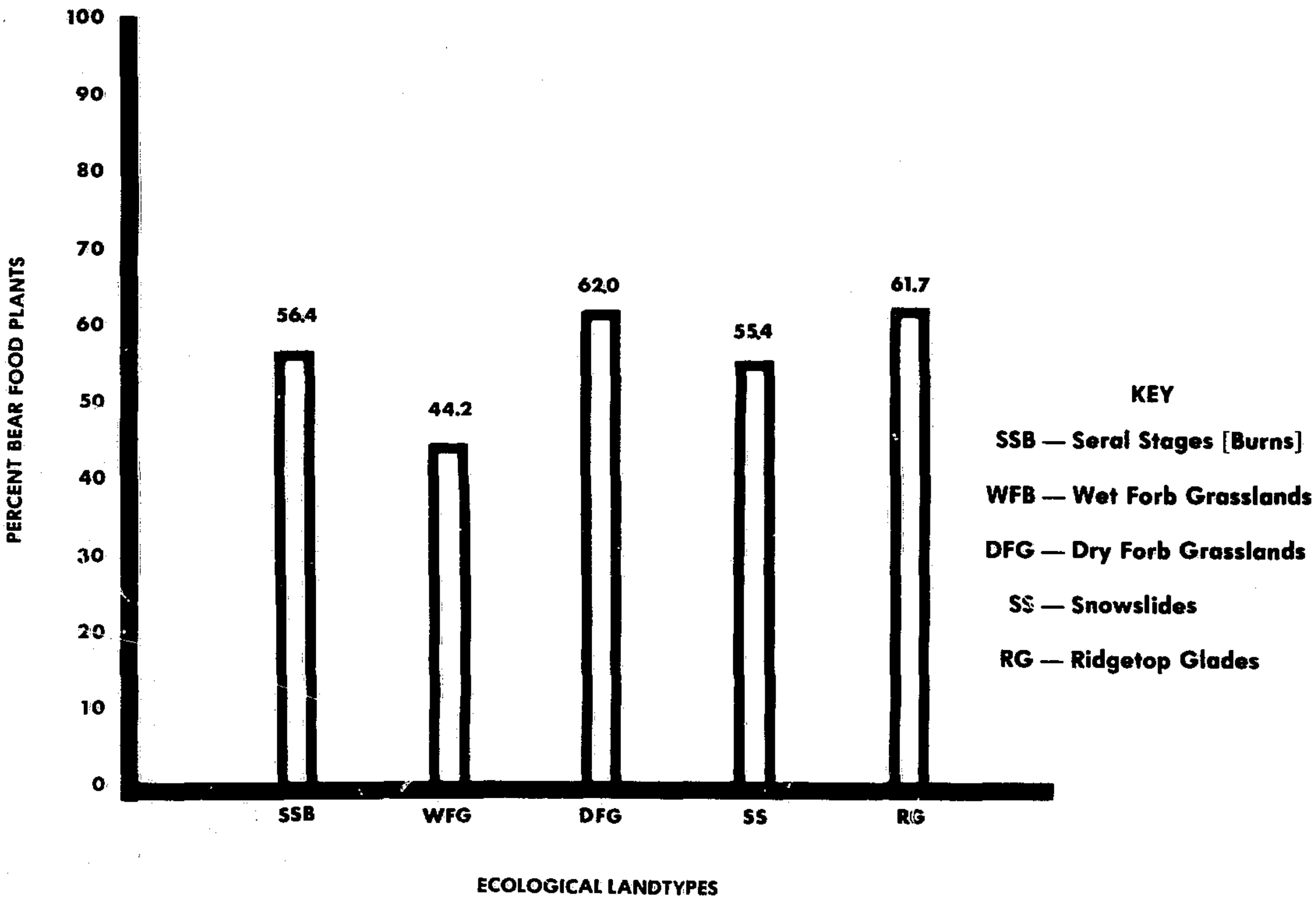
Table 13. Percent abundance and occurrence of food plants in five ecological landtypes in the Subalpine Zone (123 plots, 142,188 square feet).

Vegetation (No. Sample Plots)	Seral Stages (burns)	Wet Forb Grasslands	Dry Forb Grasslands	Snowslides	Ridgetop Glades
Xerophyllum tenax	19.0/50.0	.8/7.7	17.1/34.8	10.5/17.2	
Carex spp.	12.1/71.4	15.7/76.9	9.3/43.5	16.8/55.2	6.3/12.5
Vaccinium scoparium	7.6/23.8		4.7/13.0	.7/3.4	
Calamagrostis rubescens	4.8/31.0		1.6/8.7	1.1/10.3	
Fragaria virginiana	3.0/23.8	2.0/23.1	.3/4.3	1.2/17.2	
Shepherdia canadensis	1.9/19.0				
Gramineae	1.9/14.3	13.3/38.5	7.0/47.8	3.0/20.7	18.8/37.5
Heracleum lanatum	1.7/7.1	2.8/15.4		.7/10.3	
Festuca idahoensis	1.5/11.9	.4/7.7	11.1/26.1	10.0/41.4	25.9/43.7
Vaccinium globulare	.9/2.4			1.1/3.4	
Juncus parryi	.6/2.4				
Vaccinium myrtillus	.4/4.8				
Amelanchier alnifolia	.2/2.4				
Circium scariosum	.2/2.4				
Hedysarum sulphurescens	.2/2.4				
Erythronium grandiflorum	.2/2.4	.4/7.7	1.3/4.3	1.4/13.8	2.7/12.5
Rubus parviflorus	.2/2.4				
Ribes lacustre	T/T				
Angelica dawsonii	T/T				
Berberis repens	T/T				
Hieracium spp.			T/T		
Agoseris spp.			T/T		
Perideridia gairdneri			T/T		
Equisetum arvense		8.0/23.1		.2/3.4	
Osmorhiza occidentalis		.4/7.7	2.6/4.3	.9/6.9	
Polygonum bistortoides		.4/7.7	1.0/17.4	.2/3.4	
Calamagrostis canadensis				6.8/17.2	
Lomatium dissectum			1.0/8.7		
Arctostaphylos uva-ursi			.3/4.3		
Lomatium spp.			.3/4.3		8.0/50.0
Melica spectabilis			.5/8.7		
Claytonia lanceolata			3.6/13.0		
Hedysarum occidentale			.3/4.3	.4/6.9	
Lonicera involucrata				.4/3.4	
Total all Gramineae	20.3	29.4	29.5	37.5	51.0
Total percent bear foods	56.4	44.2	62.0	55.4	61.7
Total percent non-bear foods	43.6	55.8	38.0	44.6	48.3

Percent cover/Percent occurrence
Percent vegetation = Percent cover

Note: Festuca scabrella, Phleum pratense, Bromus sp., Allium schoenoprasum, Agropyron spp. and Poa spp. had a combined vegetative cover of 5.9%, but were not documented as utilized bear food plants in the Subalpine Zone and thus do not appear in this table.

Fig. 12 GRIZZLY BEAR FOOD PLANT ABUNDANCE BY ECOLOGICAL LANDTYPES
SUBALPINE ZONE

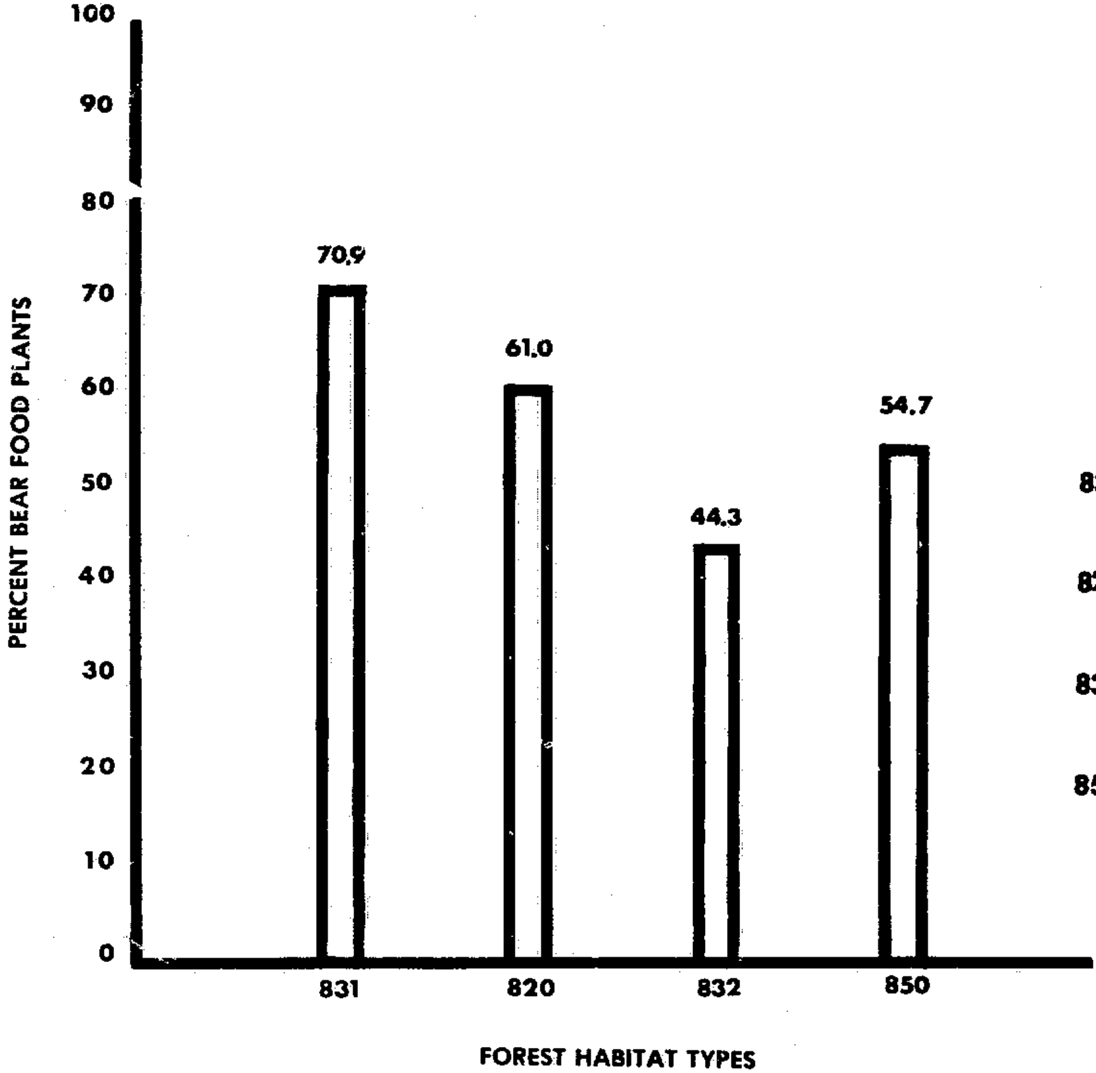


of the subalpine zone are especially important sources of energy because all of them are characterized by an abundance of Vaccinium scoparium. It was the highest ranking food plant in three of the four habitat types and actually comprised 51.1 percent of the total vegetation cover in habitat type 831 (Table 14). Sampling in 232 additional plots randomly distributed throughout the subalpine forest showed V. scoparium in over 50 percent of them (180), with an average percent cover of 13.5. Other bear food plants that occur in the subalpine forests are relatively unimportant by comparison. Carex geyeri and Xerophyllum tenax, though well represented (Table 14), are not preferred bear foods. The total food plant abundance in the four habitat types sampled ranged from 70.9 to 44.3 percent, a further evidence of the potential importance of these forest types (Fig. 13).

Evaluation of the Subalpine Zone as a Source of Food Plants

Grass-Shrublands. Graminales, comprising 31 percent of the vegetation, were the most abundant and available bear foods in the Grass-Shrublands of the subalpine zone; Carex spp. (13.1 percent) and F. idahoensis (7.7 percent) were predominant, with Calamagrostis spp. and Melica spectabilis also recorded (Table 15). Eight shrubs totaled 4.7 percent of the vegetation, with V. scoparium predominant. Twenty-one forbs used as food represented 20.4 percent of the total

Fig. 13 GRIZZLY BEAR FOOD PLANT ABUNDANCE BY FOREST HABITAT TYPE
SUBALPINE ZONE



KEY

831 — Abies lasiocarpa/Luzula hitchcockii—Vaccinium scoparium

820 — Abies lasiocarpa [Pinus albicaulis]/Vaccinium scoparium

832 — Abies lasiocarpa/Luzula hitchcockii-Menziesia ferruginea

850 — Pinus albicaulis-Abies lasiocarpa

Table 14. Percent abundance and occurrence of grizzly bear food plants in four major forest habitat types of the Subalpine Zone.

Bear Food Plants	Abla/Luhi-Vasc, 831 (21 plots) Percent Abundance	Percent Occurrence	Abla(Pial)/Vasc, 820 (24 plots) Percent Abundance	Percent Occurrence	Abla/Luhi-Mefe, 832 (11 plots) Percent Abundance	Perecnt Occurrence	Pial-Abla, 850 (10 plots) Percent Abundance	Percent Occurrence
Vaccinium scoparium	51.1	100.0	14.5	62.5	32.2	100.0	41.8	80.0
Xerophyllum tenax	14.6	66.6	30.4	83.3	12.1	72.7	7.0	20.0
Carex geyeri	4.3	33.3	14.6	79.2			4.7	20.0
Heracleum lanatum			.7	8.3			T	T
Fragaria virginiana	.3	4.8	.2	4.2			T	T
Vaccinium globulare	.3	4.8	.2	4.2				
Shepherdia canadensis			T	T			1.2	10.0
Ribes lacustre	T	T	.2	4.2			T	T
Hedysarum occidentale	.3	4.8						
Calamagrostis rubescens			T	T				
Calamagrostis canadensis			T	T				
Festuca idahoensis	T	T	T	T			T	T
Lomatium dissectum	T	T	T	T			T	T
Cirsium scariosum			T	T			T	T
Erythronium grandiflorum	T	T	T	T			T	T
Claytonia lanceolata							T	T
Total bear food plants	70.9		61.0		44.3		54.7	
Total non-food plants	29.1		39.0		55.7		45.3	
Total vegetation	100.0		100.0		100.0		100.00	

Percent Occurrence = Number plots in which a food plant occurred at the 5% level of cover or greater.
T = occurred at less than the 5% level of cover.

vegetation. Forbs were more varied than in other zones, and individual species abundance ranged from 12.1 to 0.1 percent. Xerophyllum tenax was the most abundant plant food species (12.1 percent), with Fragaria virginiana, Equisetum arvense, Heracleum lanatum, and Erythronium grandiflorum the only other forbs individually contributing 1 percent or more to the total vegetation.

Grasses and sedges were not only the most abundant food plants, but were also the most widely distributed (Table 15). Festuca idahoensis (25.2 percent), C. rubescens (14.6 percent), and C. canadensis (4.1 percent) were the most widely distributed grasses. Among the shrubs, Vaccinium scoparium occurred in 11.4 percent of the plots, with Vaccinium globulare and Shepherdia canadensis occurring less frequently. Xerophyllum tenax was the most widely distributed forb (28.5 percent), with Fragaria virginiana next most common (15.4 percent) and Lomatium spp., E. grandiflorum, and H. lanatum all occurring in more than 5 percent of all plots. The other 16 forb species eaten by grizzlies showed a percent occurrence ranging from trace to 4.9 percent.

In summary, then, the graminales were the food plants most available in the grass-shrubland of the subalpine zone, with Vaccinium scoparium, V. globulare, and Shepherdia canadensis the predominant shrubs. The most abundant forb species used by grizzlies were X. tenax, F. virginiana, H. lanatum, E. grandiflorum, L. cous, and P. bistortoides. Bear food plants comprised 55.8 percent of the total ground cover

Table 15: Percent abundance and percent occurrence of grizzly bear food plants in Grass-Shrublands of the Subalpine Zone in the Scapegoat Study Area (123 plots).

Species	Percent Abundance	Percent Occurrence
Graminales		
Carex spp.	13.1	55.3
Festuca idahoensis	7.7	25.2
Gramineae*	6.0	27.6
Calamagrostis canadensis	2.2	4.1
Calamagrostis rubescens	1.9	14.6
Melica spectabilis	.1	.8
Subtotal	31.0	
Shrubs		
Vaccinium scoparium	3.2	11.4
Vaccinium globulare	.6	1.6
Shepherdia canadensis	.5	6.5
Vaccinium myrtillus	.1	.8
Arctostaphylos uva-ursi	.1	.8
Amelanchier alnifolia	.1	.8
Ribes lacustre	T	-
Lonicera involucrata	.1	.8
Subtotal	4.7	
Forbs		
Xerophyllum tenax	12.1	28.5
Fragaria virginiana	1.5	15.4
Equisetum arvense	1.2	3.3
Heracleum lanatum	1.1	6.5
Erythronium grandiflorum	1.0	7.3
Osmorhiza occidentalis	.9	3.3
Claytonia lanceolata	.8	2.4
Lomatium cous sandbergii	.6	7.3
Juncus parryi	.2	3.3
Polygonum bistortoides	.3	4.9
Lomatium dissectum	.2	1.6
Hedysarum occidentale	.2	2.4
Cirsium scariosum	.1	.8
Rubus parviflorus	.1	.8
Hedysarum sulphurescens	.1	.8
Angelica dawsonii	T	-
Perideridia gairdneri	T	-
Berberis repens	T	-
Agoseris spp.	T	-
Hieracium spp.	T	-
Subtotal	20.4	
Summary		
Total Bear Food Plants	55.8	
Other Species	44.2	
Total	100.0	

*Gramineae includes grasses that were not identified when the plots were taken. These unknowns were later identified by Klaus Lockschewitz at the University of Montana herbarium.

T = Trace

Pinus albicaulis occurred only as seedlings and was not included as a bear food.

in the grass-shrublands of the subalpine zone.

Coniferous Forests. The coniferous forests of the subalpine zone are a major energy source. Grizzlies utilized the nuts of *P. albicaulis* and 16 understory plants. In terms of abundance and distribution (Tables 16 and 17) three food plants, *V. scoparium*, *X. tenax*, and *C. geyeri*, dominated and were widely distributed throughout the forests. Together they constituted 58.6 percent of the understory vegetation. Seven of the food plants occurred below the 5 percent level of sampling and are recorded as trace (T) items. These food plants, however, occurred in greater abundance in the grass-shrublands (Table 5) and were utilized there more intensively than in the forests. Bear food plants composed 59.4 percent of the total understory vegetation.

Pinus albicaulis, the only tree species providing food, was confined to the subalpine zone and averaged 17.0 percent of the forest canopy (Table 18). In the Xeric Whitebark Pine Forests (Group V), *P. albicaulis* was observed to comprise from zero to 40 percent of the forest canopy for an average of 16.3 percent. In the Mesic Alpine Fir Forests (Group VI) of this zone, it varied from 0 percent to 50 percent, averaging 21.3. The presence of *P. albicaulis* makes the subalpine zone unique as an energy source. Many factors, to be discussed later, determine the abundance and availability of pine nuts and thus their importance as a

Table 16. Summary of percent abundance of grizzly bear food plants in four major forest habitat types of the Subalpine Zone (66 plots).

Bear Food Plants	Total Percent Vegetative Cover	Percent Abundance
Vaccinium scoparium	1910	32.4
Xerophyllum tenax	1130	19.2
Carex geyeri	415	7.0
Heracleum lanatum	15	.3
Fragaria virginiana	10	.2
Vaccinium globulare	10	.2
Shepherdia canadensis	5	.1
Ribes lacustre	5	.1
Hedysarum occidentale	5	.1
Calamagrostis rubescens	T	T
Calamagrostis canadensis	T	T
Festuca idahoensis	T	T
Lomatium dissectum	T	T
Cirsium scariosum	T	T
Erythronium grandiflorum	T	T
Claytonia lanceolata	T	T
Total bear food plants	3505	59.4
Total non-food plants	2395	40.6
Total vegetation	5900	100.0

Table 17. Summary of percent occurrence of grizzly bear food plants in four major forest habitat types of the Subalpine Zone (66 plots).

Bear Food Plants	Number Plots Where Plant Occurred	Percent Occurrence
Vaccinium scoparium	55	83.3
Xerophyllum tenax	44	66.7
Carex geyeri	28	42.4
Heracleum lanatum	2	3.0
Fragaria virginiana	2	3.0
Vaccinium globulare	2	3.0
Ribes lacustre	1	2.0
Shepherdia canadensis	1	2.0
Hedysarum occidentale	1	2.0
Calamagrostis rubescens	T	T
Calamagrostis canadensis	T	T
Festuca idahoensis	T	T
Lomatium dissectum	T	T
Cirsium scariosum	T	T
Erythronium grandiflorum	T	T
Claytonia lanceolata	T	T

Table 18: Average percent canopy cover and percent occurrence of *Pinus albicaulis* in the Subalpine Zone of the Scapegoat Study Area (219 plots).

Forest Grouping	Number of Plots	Total Canopy Cover	Average Percent Canopy Cover	Occurrence	Percent Occurrence
V-Xeric Pinus albicaulis	188	3055	16.3	162	86.2
VI-Mesic Abies lasiocarpa	31	660	21.3	31	100.0
Total Subalpine Zone	219	3715	17.0	193	88.1

component of grizzly bear diet.

Ecological Landtypes in the Temperate Zone

Differentiation between grass-shrubland landtypes of the temperate zone were less pronounced than in the alpine and subalpine zones. Also, the altitudinal demarcation between subalpine and temperate grass-shrubland communities was less evident than between alpine and subalpine. Data on food plant abundance and distribution indicate that a wide range of food plants was available to grizzly bears in four major landtypes (Table 19). Abundance values exceeding 70 percent (Fig. 14) occurred in the seral forest stages and in the Dry Forb-Grasslands. Additional sampling of plant communities, especially in the Wet Forb-Grasslands and SCREE landtypes, will eventually provide a better basis for comparison and evaluation.

Forest Habitat Types in the Temperate Zone

Four forest habitat types in the temperate zone were considered important energy sources. Three (691, 692, and 670) belong to the subalpine fir series, while one type (320) belongs to the Douglas-fir series. *Vaccinium scoparium* and *V. globulare* occurred, and one or both were abundant in the three habitat types of the subalpine fir series. Total bear food plants exceeded 80 percent of the ground cover in habitat types 691, 692, and 320, but were less than half that value in habitat type 670 (Table 20 and Fig. 15). *Calamagrostis*

Fig. 14 GRIZZLY BEAR FOOD PLANT ABUNDANCE BY ECOLOGICAL LANDTYPES TEMPERATE ZONE

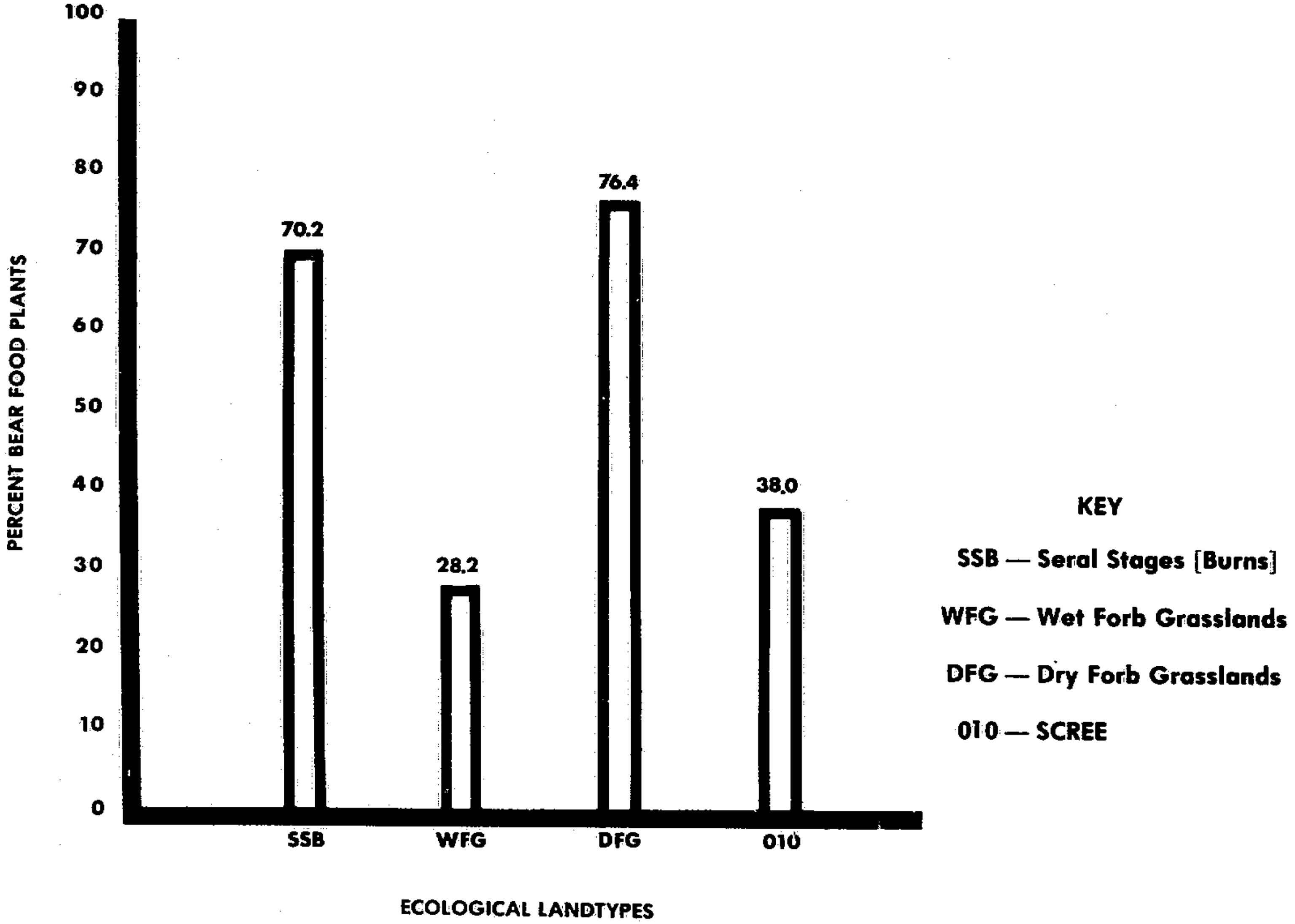


Table 19. Percent abundance and occurrence of food plants in four ecological landtypes in the Temperate Zone.

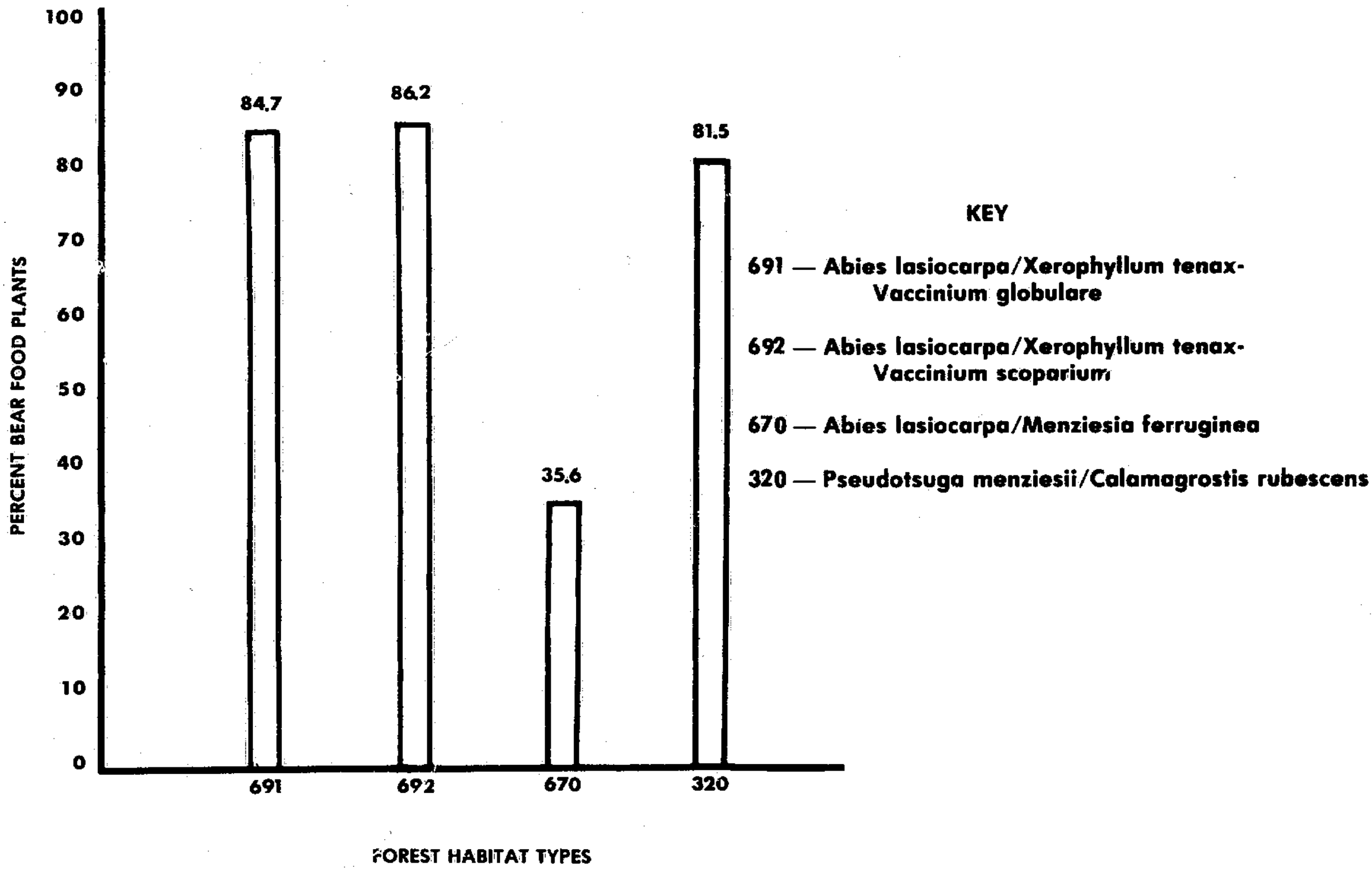
Ecological Landtypes (No. Sample Plots)	Seral Stages (burns) (11 plots)	Wet Forb Grasslands (7 plots)	Dry Forb Grasslands (19 plots)	SCREE (4 plots)
Festuca idahoensis			15.6/84.2	8.0/25.0
Festuca scabrella	.5/9.1		36.4/94.7	
Carex spp.	3.6/18.2	21.2/100.0	2.7/21.1	
Carex geyeri	15.4/54.5		2.5/15.8	6.0/50.0
Agropyron spicatum	4.6/18.2		6.8/21.1	
Phleum pratense	7.7/9.1		3.3/21.1	
Gramineae	2.1/27.3	1.6/28.6	1.4/21.1	
Bromus sp.	4.1/9.1			2.0/25.0
Deschampsia cespitosa			2.2/10.5	
Poa pratensis			1.4/10.5	
Danthonia unispicata			.8/10.5	
Poa spp.	1.0/9.1			
Calamagrostis rubescens			.5/5.3	
Phleum alpinum			.3/5.3	
Amelanchier alnifolia	3.1/18.2		1.1/5.3	2.0/25.0
Shepherdia canadensis	1.5/9.1			6.0/50.0
Symphoricarpos albus	2.1/9.1			2.0/25.0
Arctostaphylos uva-ursi			.8/10.5	4.0/25.0
Vaccinium scoparium	1.5/9.1			
Lonicera utahensis	1.0/9.1			
Prunus virginiana				4.0/25.0
Xerophyllum tenax	16.9/45.5			
Fragaria virginiana	4.1/27.3	5.4/28.6		4.0/25.0
Hieracium gracile	1.0/9.1			
Trifolium sp.			.3/5.3	
Perideridia gairdneri			.3/5.3	
Total Cover (bear foods)	70.2	28.2	76.4	38.0
Total Cover (other species)	29.8	71.8	23.6	62.0

Percent abundance/percent occurrence; Percent abundance = percent cover; Tree foods excluded from this table.

Table 20. Percent abundance and occurrence of grizzly bear food plants in four major forest habitat types of the Temperate Zone.

Bear Food Plants	Abla/Xete-Vagl, 691 (18 plots) Percent Abundance	Percent Occurrence	Abla/Xete-Vasc, 692 (24 plots) Percent Abundance	Percent Occurrence	Abla/Mefe, 670 (14 plots) Percent Abundance	Percent Occurrence	Psme/Caru, 320 (15 plots) Percent Abundance	Percent Occurrence
Xerophyllum tenax	31.0	100.0	22.2	87.5	9.9	78.6		
Vaccinium globulare	27.6	100.0	.3	4.2	4.5	50.0		
Vaccinium scoparium	21.3	88.9	50.1	100.0	20.9	92.9		
Shepherdia canadensis	3.5	16.7	6.8	37.5	.3	4.2		
Calamagrostis rubescens	1.0	16.7	2.7	25.0	T	T	57.7	66.6
Carex geyeri	.3	5.6	2.4	20.8	T	T	16.4	46.7
Arctostaphylos uva-ursi	T	T	.5	4.2				
Symphoricarpos albus			.5	4.2			1.0	6.7
Berberis repens			.3	4.2	T	T	T	T
Agropyron spicatum							2.4	26.7
Fragaria virginiana	T	T	T	T	T	T	1.7	26.7
Rubus parviflorus	T	T	T	T	T	T	.7	13.3
Rosa sp.							.4	6.7
Festuca idahoensis							.4	6.7
Festuca scabrella							.4	6.7
Hedysarum occidentale								
Ribes lacustre	T	T	T	T	T	T		
Amelanchier alnifolia			T	T			.4	6.7
Lonicera utahensis	T	T	T	T				
Lonicera involucrata	T	T						
Cirsium scariosum	T	T	T	T				
Erythronium grandiflorum	T	T	T	T				
Ozmorhiza occidentalis					T	T		
Total bear food plants	84.7		86.2		35.6		81.5	
Total non-food plants	15.3		13.8		64.4		18.5	
Total vegetation	100.0		100.0		100.0		100.0	

Fig. 15 GRIZZLY BEAR FOOD PLANT ABUNDANCE BY FOREST HABITAT TYPE
TEMPERATE ZONE



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rubescens and *Carex geyeri* composed 57.7 and 16.4 percent, respectively, of the total bear food plants recorded in habitat type 320. This habitat type would appear to be of greatest importance to grizzlies in the spring months when the grasses and sedges are emerging.

The *Pseudotsuga menziesii/Vaccinium globulare* habitat type (280) occurred at elevations below the study area and so does not appear in Table 20. However, this habitat type is widely distributed in the temperate zone and is especially important because of the abundance of *V. scoparium* and *V. globulare*. It had a food plant abundance value of 75.9 percent with *V. globulare* representing 24.5 percent of this.

Evaluation of the Temperate Zone as a Source of Food Plants

Grass-Shrublands. Graminales comprised 50 percent of the temperate grass-shrubland vegetation, with *Festuca* spp. representing 24.6 percent of the vegetation (Table 21). *Carex* spp., *Agropyron spicatum*, and *Phleum pratense* were other abundant graminales. Shrubs were poorly represented (4.4 percent), with *Amelanchier alnifolia* predominant but comprising only 1.4 percent of the vegetation. Six other shrubs totaled only 3 percent. Likewise, forbs used by grizzlies constituted only a small portion of the temperate grass-shrubland with an abundance value of 7.2 percent; *Xerophyllum tenax* and *Fragaria virginiana* were the most abundant species.

Table 21: Percent abundance and occurrence of grizzly bear food plants in Grass-Shrublands of the Temperate Zone in the Scapegoat Study Area (41 plots).

Species	Percent Abundance	Percent Occurrence
Graminales		
Festuca scabrella	16.9	46.3
Festuca idahoensis	7.7	41.5
Carex spp.	7.1	31.7
Carex geyeri	4.9	24.4
Agropyron spicatum	4.7	19.5
Phleum pratense	3.4	12.2
Gramineae*	1.5	22.0
Bromus sp.	1.1	4.9
Deschampsia cespitosa	1.0	4.9
Poa pratensis	.6	4.9
Danthonia unispicata	.4	4.9
Poa spp.	.3	2.4
Calamagrostis rubescens	.3	2.4
Phleum alpinum	.1	2.4
Shrubs		
Amelanchier alnifolia	1.4	9.8
Shepherdia canadensis	.8	7.3
Symphoricarpos albus	.6	4.9
Arctostaphylos uva-ursi	.6	7.3
Vaccinium scoparium	.4	2.4
Lonicera utahensis	.3	2.4
Prunus virginiana	.3	2.4
Forbs		
Xerophyllum tenax	4.2	12.2
Fragaria virginiana	2.5	14.6
Hieracium gracile	.3	2.4
Trifolium sp.	.1	2.4
Perideridia gairdneri	.1	2.4
Summary		
Total Bear Food Plants	61.3	
Other Species	38.7	
Total	100.0	

*Gramineae includes grasses that were not identified when the plot was taken. These unknowns were later identified by Klaus Lockschewitz at the University of Montana herbarium.

The most widely distributed food plants (percent occurrence) were Festuca scabrella and F. idahoensis with sedges and other grasses also well dispersed (Table 21). Four shrubs, Amelanchier alnifolia, Arctostaphylos uva-ursi, Shepherdia canadensis, and Symphoricarpos albus, were well represented throughout the zone. Forbs having a wide distribution were Xerophyllum tenax and Fragaria virginiana.

In summary, grizzly bear food plants present in greatest abundance were: Festuca spp., Carex spp., Agropyron spicatum, Poa pratensis, Amelanchier alnifolia, Shepherdia canadensis, Symphoricarpos albus, Arctostaphylos uva-ursi, Xerophyllum tenax, and Fragaria virginiana. These and other food plants comprised 61.3 percent of the ground cover.

Coniferous Forests. The coniferous forests of the temperate zone, like those of the subalpine, serve as major energy sources for the grizzly. Vaccinium scoparium dominated the ground cover and was the most abundant food plant as well as the most widely distributed (Tables 22 and 23). This, along with 20 other food plants, comprised 72.2 percent of the ground cover in the temperate coniferous forests.

Climatic Zone Habitat Evaluation

We have attempted to present a holistic description of grizzly bear habitat in the Scapegoat area, portraying comparative food plant abundance values for various segments and units of the habitat. We have also shown how some of

Table 22. Summary of percent abundance of grizzly bear food plants in four major forest habitat types of the Temperate Zone (71 plots).

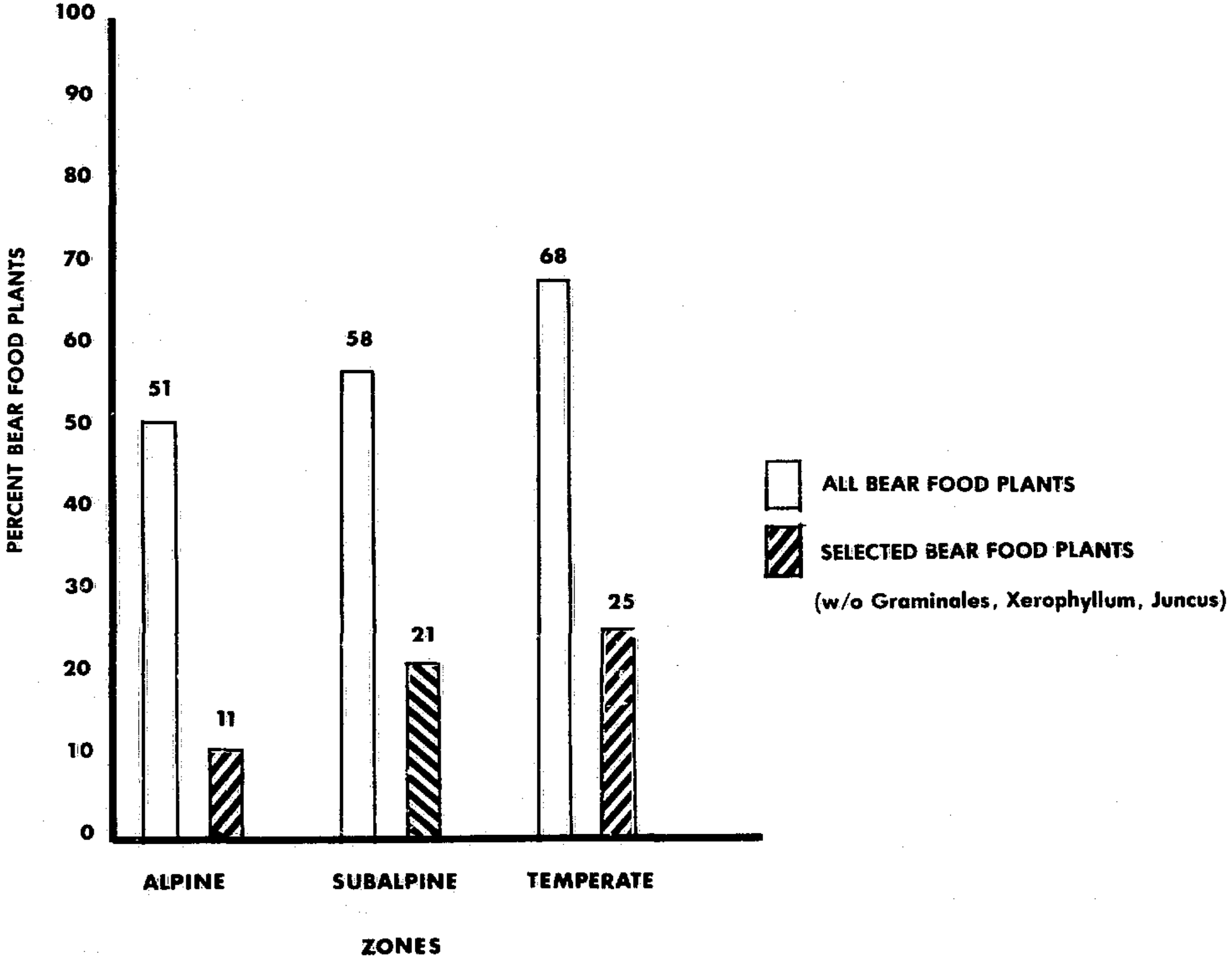
Bear Food Plants	Total Percent Vegetative Cover	Percent Abundance
Vaccinium scoparium	1555	24.8
Xerophyllum tenax	1010	16.1
Calamagrostis rubescens	890	14.2
Vaccinium globulare	470	7.5
Carex geyeri	285	4.5
Shepherdia canadensis	180	2.9
Agropyron spicatum	35	.6
Fragaria virginiana	30	.5
Symphoricarpos albus	25	.4
Rubus parviflorus	0	.2
Arctostaphylos uva-ursi	[illegible]	.2
Amelanchier alnifolia	[illegible]	.1
Berberis repens	[illegible]	.1
Rosa sp.	5	.1
Festuca idahoensis	5	.1
Festuca scabrella	5	.1
Ribes lacustre	T	T
Lonicera involucrata	T	T
Cirsium scariosum	T	T
Ozmorhiza occidentalis	T	T
Erythronium grandiflorum	T	T
Total bear food plants	4525	72.2
Total non-food plants	1745	27.8
Total vegetation	6270	100.0

Table 23. Summary of percent occurrence of grizzly bear food plants in four major forest habitat types of the Temperate Zone (71 plots).

Bear Food Plants	Number Plots Where Plant Occurred	Percent Occurrence
Vaccinium scoparium	53	74.2
Xerophyllum tenax	46	64.8
Vaccinium globulare	26	36.6
Calamagrostis rubescens	19	26.8
Carex geyeri	13	18.3
Shepherdia canadensis	12	16.9
Fragaria virginiana	5	7.0
Lonicera utahensis	1	1.4
Rubus parviflorus	2	2.8
Agropyron spicatum	4	5.6
Arctostaphylos uva-ursi	1	1.4
Symphoricarpos albus	2	2.8
Amelanchier alnifolia	1	1.4
Berberis repens	1	1.4
Rosa sp.	1	1.4
Festuca idahoensis	1	1.4
Festuca scabrella	1	1.4
Ribes lacustre	T	T
Lonicera involucrata	T	T
Cirsium scariosum	T	T
Ozmorhiza occidentalis	T	T
Erythronium grandiflorum	T	T

the more important bear food plants relate to vegetation categories and to the total vegetation complex. From information presented, we can now evaluate each zone using numerical values that express the habitat potential. This will be accomplished in two ways: (1) rating the zones on the food abundance potential of all the bear food plants; (2) rating them on the food abundance potential of a limited number of food plants. We shall refer to these as the total food plant rating (TFP) and the selected food plant rating (SFP). The TFP values include abundance values for all food plants, viz., grasses, sedges, and other abundant plants observed to have been utilized by grizzlies in the study area. The SFP value excludes the grasses, sedges, *Xerophyllum tenax*, and *Juncus*. The rationale is that these food plants are so abundant and widespread that they tend to mask the values of less abundant, but more heavily utilized, plants. The TFP rating provides an upper-limit value and the SFP rating provides a lower-limit one. The TFP and SFP percentage values for each climatic zone represent an average of the grass-shrublands and coniferous forest abundance values presented earlier (Fig. 16). For example, the TFP food plant value of 58 percent for the subalpine zone represents an average of the grass-shrubland value of 55.8 percent and the coniferous forest value of 59.4 percent. The TFP value for the alpine zone is 51 percent; the subalpine and temperate zones are 58 percent and 68 percent, respectively.

Fig. 16 COMPARISON OF TOTAL AND SELECTED BEAR FOOD PLANT VALUES



As might be expected, the rating value for each zone is considerably lower when the selective rating method is employed (Fig. 16). However, the values parallel the TFP values for all food plants. Both methods indicate that the temperate zone has the highest food plant potential for ground vegetation, followed by the subalpine and alpine. To obtain a habitat rating for each zone, we must consider land area and plant foods of the overstory, as well as the food plant abundance potentials presented in Fig. 16. Other factors being equal, the larger the area, the greater the biomass of potentially available energy. There are obvious qualifying stipulations, but for the present these will be ignored. The alpine zone represented only 15 percent of the study area, whereas the subalpine and temperate zones composed 42 and 44 percent of the area, respectively. Since the biomass of potential food tends to be proportional to the size of the area, we will incorporate these percentages into a rating system.

The whitebark pine (P. albicaulis), the only important food-producing tree, occurred almost entirely within the subalpine zone, and for rating purposes we have treated it as a multi-layer of the subalpine zone. Its abundance value (percent canopy) can be added directly to the food plant abundance value of the ground vegetation. By combining the food plant abundance values shown in Table 24 with the area percent values, we arrived at rating indices for each

Table 24. Habitat Rating System

Rating Categories	Alpine Zone		Subalpine Zone		Temperate Zone	
Evaluation Method	All Food Plants	Selected Food Plants	All Food Plants	Selected Food Plants	All Food Plants	Selected Food Plants
Acreage Value (%)	15.0	15.0	42.0	42.0	44.0	44.0
Food Plant Abundance (%) (Ground Veg.)	51.0	11.0	58.0	21.0	68.0	25.0
Food Plant Abundance (%) (Overstory Veg.) *P. albicaulis*)	-	-	17.0	17.0	-	-
Total Food Plant Abundance Value	51.0	11.0	75.0	38.0	68.0	25.0
Climatic Zone Rating						
(Acreage % x Food Plant Abundance % / 100	7.65	1.65	31.1	16.0	29.9	11.0
Numerical Rating	3		1		2	

zone. The subalpine zone rated highest, with the temperate second and the alpine third. Ratings for the subalpine and temperate zones are four times higher than for the alpine zone. The higher ratings for the subalpine and temperate zones are due to their greater land masses and higher total food plant abundance.

The subalpine zone has the highest rating because *P. albicaulis*, a major energy source, is largely confined to this zone. The other zones did not support overstory plant foods (Table 24). All zones support major energy sources, and all are seasonally essential and therefore critical to the grizzly. The temperate zone is normally subjected to greater man-caused modifications; the subalpine, because of shallower soils and slower plant growth, is slower to recover from drastic man-caused or natural modifications, while the alpine is both the most restricted and most fragile of the three zones. A more specific evaluation of the relative importance of each zone spatially and temporally will be obtained by correlating specific food plant abundance, distribution, phenology, and potential energy content with frequency of utilization by grizzlies. This will be the substance of Section II.

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APPENDIX

Table 1. Percent cover of plant species in the Alpine Meadow (39 plots, 45,084 square feet)

Alpine Vegetation	Total % Vegetative Cover	Percent Vegetation
Carex spp.	825	23.8
Festuca idahoensis	495	14.3
Dryas octopetala	355	10.2
Arctostaphylos uva-ursi	315	9.1
Phlox pulvinata	310	8.9
Oxytropis campetris	145	4.2
Salix arctica	135	3.9
Gramineae	125	3.6
Hedysarum spp.	85	2.5
Polygonum spp.	75	2.2
Eritrichium nanum	60	1.7
Ranunculus eschscholtzii	60	1.7
Caltha leptosepala	55	1.6
Potentilla fruiticosa	50	1.4
Potentilla diversifolia	45	1.3
Antennaria spp.	45	1.3
Astragalus spp.	40	1.2
Achillea millefolium	35	1.0
Lomatium spp.	30	.9
Erigeron simplex	25	.7
Douglasia montana	20	.6
Pedicularis spp.	15	.4
Anemone multifida	15	.4
Juncus parryi	15	.4
Arenaria spp.	15	.4
Erigeron speciosus	10	.3
Arabis nuttallii	10	.3
Solidago multiradiata	10	.3
Senecio megacephalus	10	.3
Trace forbs	10	.3
Lloydia serotina	5	.1
Anemone parviflora	5	.1
Delphinium bicolor	5	.1
Valeriana edulis	5	.1
Physaria didymocarpa	5	.1
Total	3465	99.7

Note: Cover recorded only at the 5% level or greater.

Table 2. Percent cover of plant species in the Alpine Meadow Krummholz (22 plots, - 25,432 square feet)

Alpine Vegetation	Total % Vegetative Cover	Percent Vegetation
Festuca idahoensis	510	33.3
Carex spp.	275	18.0
Luzula hitchcockii	115	7.5
Vaccinium scoparium	70	4.6
Thalictrum occidentale	65	4.2
Valeriana spp.	55	3.6
Ranunculus eschscholtzii	50	3.3
Erythronium grandiflorum	40	2.6
Potentilla diversifolia	40	2.6
Caltha leptosepala	35	2.3
Hedysarum spp.	25	1.6
Juncus parryi	20	1.3
Pedicularis groenlandica	20	1.3
Trace forbs	20	1.3
Arnica latifolia	20	1.3
Achillea millefolium	15	1.0
Erigeron simplex	15	1.0
Gentiana calycosa	15	1.0
Phlox pulvinata	15	1.0
Polygonum bistortoides	15	1.0
Anemone parviflora	10	.7
Antennaria spp.	10	.7
Arenaria spp.	10	.7
Besseya wyomingensis	10	.7
Lomatium cous	10	.7
Potentilla fruiticosa	10	.7
Poa spp.	10	.7
Cirsium scariosum	5	.3
Claytonia lanceolata	5	.3
Dodecatheon spp.	5	.3
Gramineae	5	.3
Salix spp.	5	.3
Total	1530	100.2

Note: Cover recorded only at the %5 level or greater.

Table 3. Percent cover of plant species in the Slab-Rock Krummholz (8 plots, 9,248 square feet)

Alpine Vegetation	Total Vegetative Cover	Percent Vegetation
Luzula hitchcockii	145	25.9
Carex spp.	100	17.9
Thalictrum occidentale	50	8.9
Festuca idahoensis	45	8.0
Erythronium grandiflorum	45	8.0
Ranunculus eschscholtzii	35	6.3
Juncus parryi	20	3.6
Antennaria spp.	20	3.6
Valeriana edulis	15	2.7
Arctostaphylos uva-ursi	15	2.7
Vaccinium scoparium	15	2.7
Arnica latifolia	10	1.8
Veronica sp.	10	1.8
Dryas octopetala	10	1.8
Pedicularis groenlandica	5	.9
Senecio triangularis	5	.9
Polygonum viviparum	5	.9
Potentilla fruiticosa	5	.9
Salix spp.	5	.9
Total	560	100.2

Table 4. Percent cover of plant species in the Slab-Rock Steps (21 plots, 24,276 square feet)

Alpine Vegetation	Total Vegetative Cover	Percent Vegetation
Carex spp.	225	20.0
Thalictrum occidentale	215	19.1
Anemone parviflora	90	8.0
Valeriana spp.	65	5.8
Dryas octopetala	60	5.3
Potentilla fruiticosa	55	4.9
Festuca idahoensis	50	4.4
Trace forbs	50	4.4
Gentiana calycosa	35	3.1
Phlox pulvinata	35	3.1
Gramineae	30	2.7
Erigeron spp.	25	2.2
Ranunculus eschscholtzii	25	2.2
Salix arctica	25	2.2
Senecio triangularis	20	1.8
Vaccinium scoparium	20	1.8
Potentilla diversifolia	15	1.3
Arctostaphylos uva-ursi	10	.9
Arabis nuttallii	10	.9
Luzula hitchcockii	10	.9
Ribes spp.	10	.9
Arnica latifolia	10	.9
Hedysarum spp.	5	.4
Caltha leptosepala	5	.4
Senecio megacephalus	5	.4
Achillea millefolium	5	.4
Dodecatheon spp.	5	.4
Phyllodoce spp.	5	.4
Juniperus communis	5	.4
Total	1125	99.6

Table 5. Percent cover of plant species in the Vegetated Talus (4 plots, 4,624 square feet).

Alpine Vegetation	Total Percent Vegetative Cover	Percent Vegetation
Festuca idahoensis	50	14.3
Astragalus spp.	35	10.0
Dryas octopetala	35	10.0
Gentiana calycosa	35	10.0
Achillea millefolium	25	7.1
Carex spp.	20	5.7
Gramineae	20	5.7
Calamagrostis rubescens	15	4.3
Galium boreale	15	4.3
Potentilla diversifolia	10	2.9
Fragaria virginiana	10	2.9
Hieracium spp.	10	2.9
Arctostaphylos uva-ursi	5	1.4
Arnica latifolia	5	1.4
Cardamine rupicola	5	1.4
Cirsium scariosum	5	1.4
Dodecatheon spp.	5	1.4
Erigeron spp.	5	1.4
Eritrichium nanum	5	1.4
Hedysarum spp.	5	1.4
Penstemon ellipticus	5	1.4
Potentilla fruiticosa	5	1.4
Senecio megacephalus	5	1.4
Trace forbs	5	1.4
Arabis spp.	5	1.4
Saxifraga spp.	5	1.4
Total	350	99.7

Note: Cover recorded only at the 5% level or greater.

Table 6. Percent cover of plant species in the Glacial Cirque Basin (32 plots, 36,992 square feet)

Alpine Vegetation	Total Vegetative Cover	Percent Vegetation
Festuca idahoensis	310	20.7
Carex spp.	215	14.3
Salix spp.	160	10.6
Phyllodoce spp.	120	8.0
Dryas octopetala	105	7.0
Juncus parryi	100	6.7
Gramineae	80	5.3
Antennaria spp.	65	4.3
Arctostaphylos uva-ursi	50	3.3
Phlox pulvinata	50	3.3
Trace forbs	40	2.7
Potentilla fruiticosa	35	2.3
Gentiana calycosa	25	1.7
Lomatium cous	25	1.7
Ranunculus eschscholtzii	25	1.7
Luzula hitchcockii	20	1.3
Achillea millefolium	15	1.0
Arenaria spp.	15	1.0
Potentilla diversifolia	15	1.0
Hedysarum spp.	10	.7
Claytonia lanceolata	5	.3
Erigeron simplex	5	.3
Erythronium grandiflorum	5	.3
Valeriana spp.	5	.3
Pedicularis spp.	5	.3
Total	1505	100.3

Table 7. Percent cover of plant species in the Mountain Massif (12 plots, 13,872 square feet).

Alpine Vegetation	Total Percent Vegetative Cover	Percent Vegetation
Dryas octopetala	170	38.6
Carex spp.	130	29.5
Arctostaphylos uva-ursi	95	21.6
Potentilla fruiticosa	20	4.5
Phlox pulvinata	10	2.3
Silene acaulis	5	1.1
Hedysarum spp.	5	1.1
Poa alpina	5	1.1
Total	440	99.8

Table 8. Percent cover of plant species in the Semi-Vegetated Talus (10 plots, 11,560 square feet).

Alpine Vegetation	Total Percent Vegetative Cover	Percent Vegetation
Dryas octopetala	50	18.2
Trace forbs	35	12.7
Claytonia megarhiza	30	10.9
Arabis spp.	20	7.3
Anemone parviflora	15	5.5
Carex spp.	15	5.5
Cardamine rupicola	15	5.5
Potentilla diversifolia	15	5.5
Potentilla fruiticosa	15	5.5
Arctostaphylos uva-ursi	10	3.6
Festuca idahoensis	10	3.6
Gentiana calycosa	10	3.6
Hedysarum spp.	10	3.6
Penstemon ellipticus	10	3.6
Fragaria virginiana	5	1.8
Besseya wyomingensis	5	1.8
Gramineae	5	1.8
Total	275	100.0

Note: Cover recorded only at the 5% level or greater.

Table 9. Percent cover of plant species in the Fell field (11 plots, 12,716 square feet).

Alpine Vegetation	Total Vegetative Cover	Percent Vegetation
Dryas octopetala	240	68.6
Carex spp.	85	24.3
Saxifraga spp.	10	2.9
Phlox pulvinata	5	1.4
Arctostaphylos uva-ursi	5	1.4
Cushion plants	5	1.4
Total	350	100.0

Note: Cover reported only at 5% level or greater.

Table 10. Percent cover of plant species in five ecological land units of the Alpine Meadow Landtype (94 plots, 108,664 square feet).

Alpine Vegetation (No. sample plots)	Meadow (39)	Meadow Krummholz (22)	Slab Rock Krummholz (8)	Slab Rock Steps (21)	Vegetated Talus (4)
Carex spp.	23.8	18.0	17.9	20.0	5.7
Festuca idahoensis	14.2	33.3	8.0	4.4	14.3
Dryas octopetala	10.2			5.3	10.0
Arctostaphylos uva-ursi	9.1		2.7		
Phlox pulvinata	8.9			3.1	
Oxytropis campetris	4.1				
Salix arctica	3.9			2.2	
Hedysarum sulphurescens occidentale	2.5				
Polygonum bistortoides	2.2				
Luzula hitchcockii		7.5	25.9		
Vaccinium scoparium		4.6	2.7		
Thalictrum occidentale		4.2	8.9	19.1	
Valeriana sitchensis edulis		3.6	2.7	5.8	
Ranunculus eschscholtzii		3.3	6.3	2.2	
Erythronium grandiflorum		2.7	8.0		
Potentilla diversifolia		2.7			2.9
Caltha leptosepala		2.3			
Juncus parryi			3.6		
Antennaria spp.			3.6		
Anemone parviflora				8.0	
Potentilla fruiticosa				4.9	
Gentiana calycosa				3.1	10.0
Erigeron spp.				2.2	
Astragalus spp.					10.0
Achillea millefolium					7.1
Calamagrostis rubescens					4.3
Fragaria virginiana					2.9
Galium boreale					4.3
Hieracium spp.					2.9
Other species*	20.9	18.2	9.9	19.3	25.3
Total	99.8	100.4	100.2	99.6	99.7
Abies lasiocarpa	0	67.4	76.4	75.9	0
Picea engelmannii	0	4.3	10.9	0.6	25.0
Pinus albicaulis	0	28.3	12.7	23.4	75.0
Total	0	100.0	100.0	99.9	100.0

*See species list for percent representation.

Table 11. Percent occurrence of plant species in five ecological land units of the Alpine Meadow Complex (94 plots, 108,664 square feet).

Alpine Vegetation (No. sample plots)	Meadow (39)	Meadow Krummholz (22)	Slab Rock Krummholz (8)	Slab Rock Steps (21)	Vegetated Talus (4)
Carex spp.	76.9	36.4	25.0	57.1	50.0
Festuca idahoensis	43.6	63.6			25.0
Dryas octopetala	28.2				25.0
Thalictrum occidentale		27.3	50.0	42.9	
Luzula hitchcockii		32.0	62.5		
Valeriana spp.			25.0	28.6	
Potentilla diversifolia		32.0			25.0
Potentilla fruiticosa				28.6	25.0
Hedysarum spp.	30.8				25.0
Arnica latifolia			25.0		
Astragalus spp.					50.0
Achillea millefolium					75.0
Gentiana calycosa					75.0
Eritrichium nanum					25.0
Dodecatheon spp.					25.0
Erigeron spp.					25.0
Senecio megacephalus					25.0
Penstemon ellipticus					25.0
Cirsium scariosum					25.0
Cardamine rupicola					25.0
Arctostaphylos uva-ursi					25.0
Oxytropis campetris	33.3				
Phlox pulvinata	43.6				
Polygonum spp.	25.6				
Abies lasiocarpa		46.7	50.0	61.9	
Picea engelmannii			25.0		25.0
Pinus albicaulis		40.0	50.0	57.1	25.0

Note: Species must have occurred in 25 percent or more plots in one of the land units to be included in this table.

Table 12. Percent cover of plant species in four ecological land units of the Vegetated Rock Complex (65 plots - 75,140 square feet)

Alpine Vegetation (No. sample plots)	Glacial Cirque Basin (32)	Mountain Massif (12)	Semi-Vegetated Talus (10)	Fellfield (11)
Festuca idahoensis	20.7		3.6	
Carex spp.	14.4	29.5	5.5	24.3
Salix arctica	10.0			
Phyllodoce empetriformis glanduliflora	8.0			
Dryas octopetala	7.0	38.6	18.2	68.6
Juncus parryi	6.7			
Antennaria spp.	4.3			
Arctostaphylos uva-ursi	3.3	21.6	3.6	
Phlox pulvinata	3.3	2.3		
Potentilla fruiticosa	2.3	4.5	5.5	
Claytonia megarhiza			10.9	
Arabis spp.			7.3	
Anemone parviflora			5.5	
Cardamine rupicola			5.5	
Potentilla diversifolia			5.5	
Gentiana calycosa			3.6	
Hedysarum sulphurescens			3.6	
Penstemon ellipticus			3.6	
Saxifraga spp.				2.9
*Other species	19.7	3.3	18.1	4.2
Total	99.7	99.8	100.0	100.0
Abies lasiocarpa	40.0	72.6	0	0
Picea engelmannii	20.0	0	0	0
Pinus albicaulis	40.0	27.4	0	0
Total	100.0	100.0	0	0

*See species list for percent composition.

Table 13. Percent occurrence of plant species in four ecological land units of the Vegetated Rock Landtype (65 plots - 75,140 square feet).

Alpine Vegetation (No. sample plots)	Glacial Cirque Basin (32)	Mountain Massif (12)	Fellfield (11)	Semi-Vegetated Talus (10)
Carex spp.	46.9	50.0		30.0
Festuca idahoensis	37.5			
Dryas octopetala		50.0	68.6	50.0
Arctostaphylos uva-ursi		33.3		
Claytonia megarhiza				30.0
Abies lasiocarpa		41.7		
Pinus albicaulis		33.3		

Note: Species must have occurred in 25% or more plots in one of the land units to be included in this table.

Table 14. Average percent vegetative cover related to average percent bare ground in five ecological land units of the Alpine Meadow Complex.

No. Plots	Meadow (39)	Meadow Krummholz (22)	Slab Rock Krummholz (8)	Slab Rock Steps (21)	Vegetated Talus (4)	Complex Average
Bare Ground	13	37	30	46	30	28.2
Vegetative Cover - Ground Layer	87	63	70	54	70	71.8
Vegetative Cover - Tree Layer	0	31	34	61	5	41.0
Total Vegetative Cover	87	94	104	115	75	(95.8)

Table 15. Average percent vegetative cover related to average percent bare ground in four ecological land units of the Vegetated Rock Landtype.

No. Plots	Glacial Cirque Basin (32)	Mountain Massif (12)	Semi-Vegetated Talus (10)	Fellfield (11)	Landtype Average
Bare Ground	53	63	72	68	60.5
Vegetative Cover-Ground Layer	47	37	28	32	39.5
Vegetative Cover-Tree Layer	2	26	0	0	5.5
Total Vegetative Cover	49	63	28	32	(45.1)

Table 16. Percent cover of plant species in the Subalpine Seral Stages (Burns). (42 plots, 48,552 square feet).

Vegetation	Total Percent Vegetative Cover	Percent Vegetation
Xerophyllum tenax	440	19.0
Trace forbs	300	13.0
Carex spp. (geyeri predominant)	280	12.1
Vaccinium scoparium	175	7.6
Calamagrostis rubescens	110	4.8
Lupinus argenteus	105	4.5
Aster sp.	75	3.2
Fragaria virginiana	70	3.0
Anemone parviflora	55	2.4
Shepherdia canadensis	45	1.9
Gramineae *	45	1.9
Astragalus vexilliflexus	45	1.9
Heracleum lanatum	40	1.7
Festuca idahoensis	35	1.5
Festuca scabrella	30	1.3
Thalictrum occidentale	25	1.1
Arnica cordifolia	20	.9
Agropyron spp.	20	.9
Vaccinium globulare	20	.9
Luzula hitchcockii	15	.6
Achillea millefolium	15	.6
Antennaria umbrinella	15	.6
Juncus parryi	15	.6
Senecio spp.	15	.6
Antennaria spp.	10	.4
Solidago spp.	10	.4
Phleum pratense	10	.4
Bromus sp.	10	.4
Balsamorhiza sagittata	10	.4
Vaccinium myrtillus	10	.4
Pedicularis contorta	5	.2
Amelanchier alnifolia	5	.2
Anaphalis margaritacea	5	.2
Artemisia ludoviciana	5	.2
Castilleja spp.	5	.2
Galium boreale	5	.2
Matricaria matricarioides	5	.2
Sibbaldia procumbens	5	.2
Parnassia fimbriata	5	.2
Anemone multifida	5	.2
Phyllodoce empetriformis	5	.2
Hackelia micrantha	5	.2
Cirsium scariosum	5	.2
Rubus sp.	5	.2
Senecio triangularis	5	.2
Hedysarum sulphurescens	5	.2
Erythronium grandiflorum	5	.2
Trace shrubs and trees **	150	6.5
Pinus albicaulis reproduction	5	.2
Picea engelmannii reproduction	5	.2
Total	2,315	99.3

* Gramineae includes grasses that were not identified when the plot was taken. Those unknowns were later keyed by Klaus Lockschewitz at the University of Montana herbarium.

** Includes trees and shrubs that occurred at less than the 5% level of cover.

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Table 17. Percent occurrence of plant species in the Subalpine Seral Stages (Burns). (42 plots, 48,552 square feet).

Vegetation	No. Plots Where Plants Occurred	Percent Occurrence
Trace forbs	38	90.5
Carex spp. (geyeri predominant)	30	71.4
Xerophyllum tenax	21	50.0
Calamagrostis rubescens	13	31.0
Fragaria virginiana	10	23.8
Vaccinium scoparium	10	23.8
Lupinus argenteus	8	19.0
Shepherdia canadensis	8	19.0
Aster sp.	8	19.0
Gramineae *	6	14.3
Festuca idahoensis	5	11.9
Arnica cordifolia	4	9.5
Anemone parviflora	4	9.5
Thalictrum occidentale	4	9.5
Heracleum lanatum	3	7.1
Luzula hitchcockii	3	7.1
Festuca scabrella	3	7.1
Senecio spp.	3	7.1
Antennaria spp.	2	4.8
Achillea millefolium	2	4.8
Vaccinium myrtillus	2	4.8
Pedicularis contorta	1	2.4
Amelanchier alnifolia	1	2.4
Anaphalis margaritacea	1	2.4
Solidago spp.	1	2.4
Artemisia ludoviciana	1	2.4
Castilleja spp.	1	2.4
Phleum pratense	1	2.4
Bromus sp.	1	2.4
Agropyron spp.	1	2.4
Balsamorhiza sagittata	1	2.4
Galium boreale	1	2.4
Matricaria matricarioides	1	2.4
Sibbaldia procumbens	1	2.4
Parnassia fimbriata	1	2.4
Anemone multifida	1	2.4
Antennaria umbrinella	1	2.4
Juncus parryi	1	2.4
Phyllodoce empetriformis	1	2.4
Astragalus vexilliflexus	1	2.4
Hackelia micrantha	1	2.4
Cirsium scariosum	1	2.4
Rubus sp.	1	2.4
Senecio triangularis	1	2.4
Hedysarum sulphurescens	1	2.4
Vaccinium globulare	1	2.4
Erythronium grandiflorum	1	2.4
Trace shrubs and trees**	26	61.9
Pinus albicaulis reproduction	1	2.4
Picea engelmannii reproduction	1	2.4

* Gramineae includes grasses that were not identified when the plot was taken. Those unknowns were later keyed by Klaus Lockschewitz at the University of Montana herbarium.

** Includes trees and shrubs that occurred at less than the 5% level of cover.

Table 18. Percent cover of plant species in the Subalpine Dry Forb Grasslands. (23 plots, 26,588 square feet).

Vegetation	Total Percent Vegetative Cover	Percent Vegetation
Xerophyllum tenax	330	17.1
Festuca idahoensis	215	11.1
Carex spp. (geyeri predominant)	180	9.3
Gramineae	135	7.0
Trace forbs	120	6.2
Vaccinium scoparium	90	4.7
Senecio triangularis	85	4.4
Antennaria spp.	80	4.1
Claytonia lanceolata	70	3.6
Osmorhiza occidentalis	50	2.6
Astragalus bourgovii	50	2.6
Potentilla diversifolia	35	1.8
Phyllodoce empetriformis	35	1.8
Calamagrostis rubescens	30	1.6
Lupinus argenteus	30	1.6
Juncus spp.	30	1.6
Salix spp.	25	1.3
Erythronium grandiflorum	25	1.3
Arenaria spp.	25	1.3
Lomatium dissectum	20	1.0
Polygonum bistortoides	20	1.0
Anemone multifida	20	1.0
Hackelia micrantha	20	1.0
Sibbaldia procumbens	20	1.0
Erigeron peregrinus	20	1.0
Pedicularis spp.	15	.8
Thalictrum occidentale	15	.8
Penstemon ellipticus	10	.5
Solidago multiradiata	10	.5
Melica spectabilis	10	.5
Galium spp.	10	.5
Achillea millefolium	10	.5
Ranunculus eschscholtzii	10	.5
Senecio megacephalus	5	.3
Arctostaphylos uva-ursi	5	.3
Spirea betulifolia	5	.3
Lomatium spp.	5	.3
Hedysarum occidentale	5	.3
Saxifraga spp.	5	.3
Caltha leptosepala	5	.3
Balsamorhiza sagattata	5	.3
Cerastium arvense	5	.3
Arnica cordifolia	5	.3
Sedum spp.	5	.3
Fragaria virginiana	5	.3
Eriogonum spp.	5	.3
Luzula hitchcockii	5	.3
Veratrum viride	5	.3
Taraxacum officinale	5	.3
Arnica longifolia	5	.3
Totals	1,935	100.7

Table 19. Percent occurrence of plant species in the Subalpine Dry Forb Grasslands. (23 plots, 26,588 square feet).

Vegetation	No. Plots Where Plants Occurred	Percent Occurrence
Trace forbs	14	60.9
Gramineae	11	47.8
Carex spp. (geyeri predominant)	10	43.5
Xerophyllum tenax	8	34.8
Festuca idahoensis	6	26.1
Potentilla diversifolia	6	26.1
Polygonum bistortoides	4	17.4
Lupinus argenteus	4	17.4
Antennaria spp.	3	13.0
Claytonia lanceolata	3	13.0
Juncus spp.	3	13.0
Vaccinium scoparium	3	13.0
Lomatium dissectum	2	8.7
Calamagrostis rubescens	2	8.7
Pedicularis spp.	2	8.7
Salix spp.	2	8.7
Melica spectabilis	2	8.7
Hackelia micrantha	2	8.7
Senecio triangularis	2	8.7
Galium spp.	2	8.7
Achillea millefolium	2	8.7
Phyllodoce empetriformis	2	8.7
Osmorhiza occidentalis	1	4.3
Penstemon ellipticus	1	4.3
Senecio megacephalus	1	4.3
Arctostaphylos uva-ursi	1	4.3
Spirea betulifolia	1	4.3
Lomatium spp.	1	4.3
Hedysarum occidentale	1	4.3
Saxifraga spp.	1	4.3
Caltha leptosepala	1	4.3
Balsamorhiza sagattata	1	4.3
Solidago multiradiata	1	4.3
Anemone multifida	1	4.3
Cerastium arvense	1	4.3
Erythronium grandiflorum	1	4.3
Arnica cordifolia	1	4.3
Arenaria spp.	1	4.3
Sedum spp.	1	4.3
Astragalus bourgovii	1	4.3
Fragaria virginiana	1	4.3
Thalictrum occidentale	1	4.3
Eriogonum spp.	1	4.3
Luzula hitchcockii	1	4.3
Ranunculus eschscholtzii	1	4.3
Veratrum veride	1	4.3
Sibbaldia procumbens	1	4.3
Taraxacum officinale	1	4.3
Arnica longifolia	1	4.3
Erigeron peregrinus	1	4.3

Table 20. List of plant species identified in the Scapegoat study area.

ACERACEAE

Acer glabrum Torr.

BERBERIDACEAE

Berberis repens Lindl.

BETULACEAE

Alnus sinuata (Regel) Rydb.
Betula glandulosa Michx.

BORAGINACEAE

Eritrichium nanum (Vill.) Schrad
Hackelia micrantha (Eastw.) J.L. Gentry
Lithospermum ruderale Dougl.

CAPRIFOLIACEAE

Linnaea borealis L.
Lonicera involucrata (Rich.) Banks
Lonicera utahensis Wats.
Sambucus cerulea Raf.
Symphoricarpos albus (L.) Blake

CARYOPHYLLACEAE

Arenaria capillaris Poir.
Arenaria lateriflora L.
Arenaria macrophylla Hook.
Arenaria nuttallii Pax
Arenaria obtusiloba (Rydb.) Fern.
Arenaria rossii R. Br.
Arenaria rubella (Wahlenb.) J.E. Smith
Cerastium arvense L.
Lychnis apetala L.
Silene acaulis L.
Silene parryi (Wats.) Hitchc. & Mag.
Stellaria americana (Porter) Standl.

CELASTRACEAE

Pachistima myrsinites (Pursh) Raf.

COMPOSITAE

Achillea millefolium L.
Agoseris aurantiaca (Hook.) Greene
Agoseris glauca (Pursh) Raf.
Anaphalis margaritacea (L.) B. & H.
Antennaria alpina (L.) Gaertn.
Antennaria lanata (Hook.) Greene
Antennaria luzuloides T. & G.
Antennaria microphylla Rydb.
Antennaria racemosa Hook.
Antennaria umbrinella Rydb.
Arnica alpina (L.) Olin.
Arnica cordifolia Hook.
Arnica diversifolia Greene
Arnica latifolia Bong.
Arnica longifolia D.C. Eat.
Arnica rydbergii Greene
Artemisia ludoviciana Nutt.
Artemisia tridentata Nutt.
Aster integrifolius Nutt.
Balsamorhiza sagittata (Pursh) Nutt.
Chrysothamnus nauseosus (Pall.) Britt
Cirsium scariosum Nutt.
Erigeron compositus Pursh
Erigeron Ochroleucus Nutt.
Erigeron peregrinus (Pursh) Greene
Erigeron speciosus (Lindl.) DC.
Erigeron simplex, Greene
Gaillardia aristata Pursh
Haplopappus lyallii Gray
Hieracium canadense Michx.
Hieracium gracile Hook.
Microseris nutans (Geyer) Schultz-Bip.
Prenanthes sagittata (Gray) A. Nels.
Senecio canus Hook.
Senecio cymbalaroides Buek
Senecio integerrimus Nutt.
Senecio integrifolius Nutt.
Senecio megacephalus Nutt.
Senecio resedifolius Less.
Senecio triangularis Hook.
Solidago multiradiata Ait.

Taraxacum lyratum (Ledeb.) DC.
Taraxacum officinale Weber
Townsendia montana Eat.
Townsendia parryi Eat.
Tragopogon dubius Scop.

CORNACEAE

Cornus canadensis L.
Cornus stolonifera Michx.

CRASSULACEAE

Sedum lanceolatum Torr.
Sedum roseum (L.) Scop.

CRUCIFERAE

Arabis drummondii Gray
Arabis holboellii Hornem.
Arabis lemmonii Wats.
Arabis nuttallii Robins
Cardimine rupicola (Rydb.) Hitchc.
Draba incerta Pays.
Draba lonchocarpa Rydb.
Draba oligosperma Hook.
Draba paysonii Macbr.
Erysimum cheiranthoides L.
Physaria didymocarpa (Hook.) Gray
Smellowskia calycina (Steph.) C.A. Mey.

CUPRESSACEAE

Juniperus communis L.
Juniperus scopulorum Sarg.

CYPERACEAE

Carex albonigra Mack.
Carex filifolia Nutt.
Carex geyeri Boott
Carex hoodii Boott
Carex scirpoidea Michx.
Kobresia myosuroides (Vill.) Fiori

ELAEAGNACEAE

Shepherdia canadensis (L.) Nutt

EQUISETACEAE

Equisetum arvense L.
Equisetum hyemale L.

ERICACEAE

Arctostaphylos uva-ursi (L.) Spreng.
Ledum glandulosum Nutt.
Menziesia ferruginea Smith
Phyllodoce empetriformis (Sw.) D. Don
Phyllodoce glanduliflora (Hook.) Cov.
Pyrola asarifolia Michx.
Pyrola secunda L.
Rhododendron albiflorum Hook.
Vaccinium caespitosum Michx.
Vaccinium globulare Rydb.
Vaccinium myrtillus L.
Vaccinium scoparium Leidberg

GENTIANACEAE

Frasera speciosa Dougl.
Gentiana calycosa Griseb.

GERANIACEAE

Geranium viscosissimum F. & M.

GRAMINEAE

Agropyron repens (L.) Beauv.
Agropyron spicatum (Pursh) Scribn. & Smith
Bromus inermis Leys.
Calamagrostis canadensis (Michx.) Beauv.
Calamagrostis purpurascens R. Br.
Calamagrostis rubescens Buckl.
Danthonia unispicata (Thurb.) Munro
Deschampsia cespitosa (L.) Beauv.
Festuca baffinensis Polumin.
Festuca idahoensis Elmer
Festuca scabrella Torr.
Koeleria cristata Pers.
Melica bulbosa Geyer
Melica spectabilis Scribn.
Phleum alpinum L.
Phleum pratense L.

Poa alpina L.
Poa fendleriana (Steud.) Vasey
Poa pratensis L.
Poa sandbergii Vasey
Trisetum spicatum (L.) Richter

GROSSULARICEAE

Ribes lacustre (Pers.) Poir.
Ribes cereum Dougl.

HYDROPHYLLACEAE

Hydrophyllum capitatum Dougl.
Phacelia hastata Dougl.
Phacelia sericea (Grah.) Gray

HYPERICACEAE

Hypericum formosum H.BK.

IRIDACEAE

Iris missouriensis Nutt.

JUNCACEAE

Juncus drummondii E. Meyer
Juncus parryi Engelm.
Luzula hitchcockii Hamet-Ahti.
Luzula piperi (Cov.) Jones
Luzula spicata (L.) DC.

LEGUMINOSAE

Astragalus bourgovii Gray
Astragalus miser Dougl.
Astragalus vexilliflexus Sheld.
Hedysarum occidentale Greene
Hedysarum sulphurescens Rydb.
Lupinus argenteus Pursh
Trifolium repens L.
Oxytropis campetris (L.) DC.
Oxytropis sericea Nutt.
Vicia americana Mulh.
Vicia villosa Roth

LILIACEAE

Allium cernuum Roth
Allium schoenoprasum L.
Erythronium grandiflorum Pursh
Lloydia serotina (L.)
Smilacina stellata (L.) Desf.
Streptopus amplexifolius (L.) DC.
Trillium ovatum Pursh
Xerophyllum tenax (Pursh) Nutt.
Zigadenus elegans Pursh

LINACEAE

Linum perenne L.

ORCHIDACEAE

Habernaria dilatata (Pursh) Hook.
Goodyera oblongifolia Raf.

PINACEAE

Abies grandis (Dougl.) Forbes
Abies lasiocarpa (Hook.) Nutt.
Larix lyallii Parl
Larix occidentalis Nutt.
Picea engelmannii Parry
Pinus albicaulis Engelm.
Pinus contorta Dougl.
Pinus flexilis James
Pinus monticola Dougl.
Pseudotsuga menziesii (Mirbel) Franco.

POLEMONIACEAE

Phlox pulvinata (Wherry) Cronq.
Polemonium pulcherrimum Hook.

POLYPODIACEAE

Cystopteris fragilis (L.) Bernh.

POLYGONACEAE

Eriogonum flavum Nutt.
Eriogonum ovalifolium Nutt.
Eriogonum umbellatum Nutt.
Oxyria digyna (L.) Hill
Polygonum bistortoides Pursh
Polygonum viviparum L.

PORTULACEAE

Claytonia lanceolata Pursh
Claytonia megarhiza (Gray) Parry

PRIMULACEAE

Androsace lehmanniana Spreng.
Androsace septentrionalis L.
Dodecatheon conjugens Greene
Dodecatheon pulchellum (Raf.) Merrill
Douglasia montana Gray

RANUNCULACEAE

Actaea rubra (Ait.) Wilid.
Anemone multifida Poir.
Anemone nuttalliana DC.
Anemone parviflora Michx.
Aquilegia flavescens Wats.
Aquilegia jonesii Parry
Caltha leptosepala DC.
Clematis hirsutissima Pursh
Clematis pseudoalpina (Kuntze) Neis.
Delphinium bicolor Nutt.
Ranunculus eschscholtzii Schlecht.
Thalictrum occidentale Gray

ROSACEAE

Amelanchier alnifolia Nutt.
Dryas octopetala L.
Fragaria vesca L.
Fragaria virginiana Duchesne
Geum triflorum Pursh
Prunus virginiana L.
Potentilla concinna Richards
Potentilla diversifolia Lehm.
Potentilla fruiticosa L.
Potentilla glandulosa Lindl.
Potentilla gracilis Dougl.
Potentilla ovina Macoun
Rosa spp.
Sibbaldia procumbens L.
Sorbus scopulina Greene
Spiraea betulifolia Pall.

RUBIACEAE

Galium boreale L.

Galium triflorum Michs.

SALICACEAE

Populus tremuloides Michx.
Salix arctica Pall.
Salix nivalis Hook.
Salix vestita Pursh

SAXIFRAGACEAE

Heuchera cylindrica Dougl.
Mitella pentandra Hook.
Parnassia fimbriata Konig.
Saxifraga arguta D. Don
Saxifraga bronchialis L.
Saxifraga integrifolia Hook.
Saxifraga lyallii Engl.
Saxifraga oppositifolia L.
Saxifraga rhomboidea Greene
Suksdorfia violacea Gray

SCROPHULARIACEAE

Besseya wyomingensis (A. Nels.) Rydb.
Castilleja occidentalis Torr.
Castilleja pulchella Rydb.
Collinsia parviflora Lindl.
Mimulus lewisii Pursh
Pedicularis bracteosa Benth.
Pedicularis contorta Benth.
Pedicularis groenlandica Retz.
Pedicularis racemosa Dougl.
Penstemon confertus Dougl.
Penstemon ellipticus Coult. & Fisch.
Penstemon procerus Dougl.

UMBELLIFERAE

Angelica dawsonii Wats.
Heracleum lanatum Michx.
Lomatium cous (Wats.) Coult. & Rose
Lomatium dissectum (Nutt.) Math & Const.
Lomatium macrocarpum (Nutt.) Coult. & Rose
Lomatium sandbergii Coult. & Rose
Perideridia gairdneri (H. & A.) Math.
Sium suave Walt.
Veratrum viride Ait.
Osmorhiza occidentalis (Nutt.) Torr.

VALERIANACEAE

Valeriana edulis Nutt.
Valeriana sitchensis Bong.

VIOLACEAE

Viola adunca Sm.
Viola nuttallii Pursh
Viola orbiculata Geyer