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Too Bad Bandy & Eastman took this literally

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AN ECOLOGICAL STUDY OF ROCKY MOUNTAIN BIGHORN SHEEP WINTER RANGES IN THE EAST KOOTENAY REGION OF BRITISH COLUMBIA

by

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Approved by .....

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INTRODUCTION

General

Rocky Mountain bighorn sheep[1] of the East Kootenay region of British Columbia have recently suffered a drastic reduction in numbers as a result of an epidemic-like disease and depleted winter ranges. Bandy (1966) outlined the factors involved in the decline of the Bull River population in the winter of 1964-65. He explained that a complex of environmental factors, including poor winter range conditions, lungworms (Protostrongylus spp.) and other parasites, adverse climatic factors, and a bacterial eruption of a Pasteurella multocida-like organism, caused this population to die out. The epidemic then spread northward and affected bighorn herds on the Premier Ridge and Columbia Lake ranges in the fall and winter of 1965-66. Eventually, in the fall and winter of 1966-67, the epidemic reached the northernmost herd occupying winter ranges in the Rocky Mountain Trench, the Stoddart Creek-Kootenay National Park herd.

As a result of the die-off on the Bull River range, Dr. P. J. Bandy of the Wildlife Research Division initiated a series of studies designed to determine the pathological agents involved, to assess the distribution of

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[1] See appendix I for a complete list of scientific names authorities for animals and plants.

overwintering bighorn sheep, the parasite burdens of the affected sheep and the degree of mortality suffered by bighorn sheep herds. In addition, he established a study of range conditions in 1966. These studies are currently limited to those which serve as bighorn sheep winter ranges and upon which significant mortalities have occurred. It is the purpose of these studies to delimit and describe the floristic composition of the ranges, to assess their condition and productivity in relation to the needs of sheep, to ascertain the effect of various factors such as climate, soil and grazing upon productivity, and to measure the degree and distribution of range use by wild and domestic stock.

Additional studies were established in 1966 and 1967 to assess the effect of protection from grazing to measure the response of range plants to fertilization and to determine the suitability of certain grass species for a range improvement program. As the results of these studies will not be available for some time, they are not included in this progress report.

The Study Area

The ranges studied are located in the East Kootenay region of British Columbia in the south-east corner of the province. This region includes all lands bounded by the British Columbia-Alberta border to the east, the Canada-United States border to the south, the height of land on the Purcell Mountains to the west and the Trans-Canada highway, Highway No. 1 to the north. Included in this region are the

headwaters of the Flathead, Elk, Kootenay, and Columbia rivers.

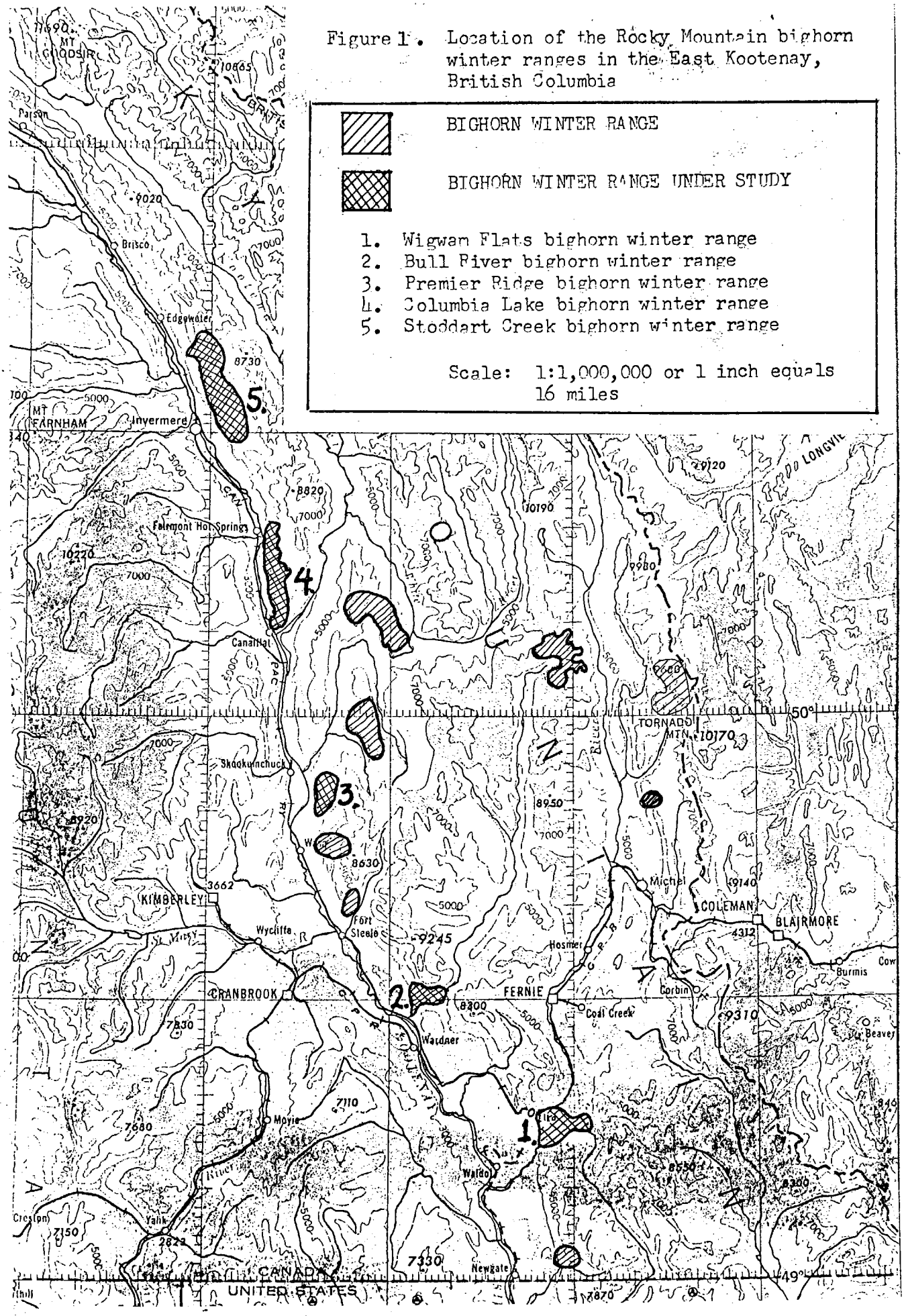
Bighorn populations in the East Kootenays are found in the Rocky Mountains on the east side of the Rocky Mountain Trench but not in the Purcell Mountains to the west. Bighorn winter in six localities in the Rocky Mountain Trench, from Elko north to Edgewater, and in five known areas at higher elevations in the Rocky Mountains (see Figure 1). Intensive use of winter ranges by bighorn bands is confined to small specific areas, although movement between some of these ranges is known to occur and small bands may be found between the localities shown in Figure 1.

The winter ranges under study are located at: Elko, north of the confluence of the Elk and Wigwam Rivers (Wigwam Flats); Bull River, north of the Bull River from the Bull River townsite to the Aberfeldie Dam; Premier Lake, north of Wolf Creek and east of the Kootenay River to the south end of Premier Lake; Columbia Lake, from Canal Flats north along the east side of Columbia Lake to Fairmont Hot Springs; and Radium Hot Springs, along the west facing slopes of the Rocky Mountains from Windermere Creek north to Edgewater (Stoddart Creek range).

Description of the East Kootenay Region

The following description is paraphrased from a report by Wright and Jungen (1966). The East Kootenay region is an area of upland continental-type climate, with well defined

Figure 1. Location of the Rocky Mountain bighorn winter ranges in the East Kootenay, British Columbia



seasons of cold winters and dry summers. The landscapes are youthful with the latest glaciation affecting all land surfaces. The landscape is dominated by steep, dissected and folded mountain ranges with wide ice-carved valleys infilled with many kinds of glacial debris.

The land forms are occupied by relatively youthful soils or are unstable and soil processes have made only a weak impression in the various parent soil materials. Thus, the soil pattern expresses a high measure of uniformity in regard to the grade of weathering and the general youthfulness of all soils. Any diversity in the soil pattern can be related to: (a) differences in the mineral composition of the parent soil materials, or (b) differences in the local moisture conditions and the accompanying changes in the nature of the plant cover, or (c) local differences in the stability of the land forms.

The geological patterns in the region are complex and are as yet incompletely known. In general, it is known that the ranges lying to the west of the Rocky Mountain Trench have fewer calcareous strata, while those to the east (with the exception of the Fernie Basin) are dominantly calcareous. The most common rocks in the East Kootenay region are ancient sediments that have undergone deformation under pressure, and various kinds of metargillite, varying from phyllite and shale to grayweke and quartzite. Intrusive volcanic rocks are not common and rocks derived from basic magmas are almost absent. The calcareous rocks occurring to the east of the Rocky

Mountain Trench are mainly metargillites with calcite veins or dark coloured dolomitic limestones. Glacial debris, in the lateral valleys to the east of the Trench, is usually slightly to moderately calcareous. The two geological factors most clearly expressed in the soil pattern are (a) presence or absence of carbonates and (b) presence or absence of silt and clay in the original parent soil materials.

Changes in the soil moisture regime within the East Kootenay region result from an interplay between the strong north-south alignment of major landforms and the oblique impact of the northeast-southwest ebb and flow of the major air masses. Thus, sites with a north-easterly aspect are markedly cooler and moister than those with a south-westerly aspect and soil formation is influenced accordingly. The main valleys open to the south and north and have a rather drier moisture regime than the shorter east-west aligned lateral valleys.

Various climatic and topographic factors affecting the soil moisture regime also play a large part in determining the nature of plant cover. Open boreal coniferous forest with a well-developed ground cover of perennial grasses is dominant throughout the subhygrous moisture zone, while the forests become more dense and lose their graminaceous ground cover in the hygrous zone. The East Kootenay region contains a complete range of ecological types from grassland prairies, through park-like coniferous forest with small patches of open grassland, to dense coniferous forest without any ground

cover or with a ground cover dominated by mor-forming ericaceous plants. In part, this vegetation pattern represents accidents of history (fires, occupancy by men, grazing pressure of indigenous and introduced herbivores, etc.), but the main features are undoubtedly related to the major moisture regimes.

METHODS

Range Composition

Aerial photographs were studied for each winter range prior to the commencement of field work. Using tone and texture, different vegetation types were mapped directly from the air photos onto an acetate overlay. Once mapped on the acetate overlay, this detail was then transferred to provincial forest cover maps (Scale 1" = 20 chains).

Potential study sites were located on aerial photographs and were later selected and established in the field following a general reconnaissance of each range. Sites used in this study were selected on the basis of the following:

(a) only ecological communities which could be directly related to the winter distribution of bighorn were studied.

(b) sites were selected to represent a maximum degree of uniformity within each plant community.

(c) only major plant communities were sampled with no attempt being made to sample small, isolated communities or areas of intergradation.

The macroplot method described by Poulton and Tisdale (1961) was used to describe and classify the vegetation and soils. The macroplots measured 15 by 30 meters in which four randomly selected, parallel, 15-meter transects were located. At every one and one-half meters along each transect, a tenth-square meter sampling frame was employed to describe

the canopy-coverage. The canopy-coverage method of Daubenmire (1959) was used to determine species cover and frequency percent. Cover percent is the percent occurrence of a plant species in the samples from a given study site. Single 20-meter transects were used on study sites which were too small to accommodate a macroplot. Canopy-coverage for single transects was measured every half-meter. Macroplots and single transects were positioned parallel to the contours of terrain surrounding the study sites.

Animal Distribution

Ungulate fecal droppings were counted in each study site to assess the amount of use given each plant community by various ungulate species. Ungulate fecal counts were conducted within 15 x 1.5 meter belts extending along the transects in each macroplot. All fecal groups that were at least fifty percent in these belts were recorded by species. However, mule and white-tailed deer and bighorn pellet groups could not be separated by species and were grouped. For single transects, in communities too small to establish a macroplot, two 18 x 1.5 meter belts were established, one on either side of each vegetation transect.

Soils

Soil profiles were studied at twenty-four of the forty-seven study sites. The following features were recorded for each soil profile; number, thickness, colour, texture, structure, consistency and reactions of the horizons, drainage,

stone content and slope. This information, together with such external features as relief, aspect, elevation, nature of parent material and vegetation were used to classify the soil. These latter criteria were also used to classify the remaining twenty-three vegetation plots.

Samples of every horizon from each profile were taken to the Soils Division of the B. C. Department of Agriculture at Kelowna, B. C. for chemical analysis. The results are not available at this time.

Range Exclosures

Exclosures were established in major plant communities on each range to determine the effect of protection from grazing. The exclosures were also constructed for use in fertilizer and reseeding trials to test means of increasing the productivity of the range. Two sizes of exclosures were built in the summer of 1966, depending upon the area and the uniformity of the communities enclosed. Large exclosures of 110 feet x 110 feet and smaller ones of 60 feet x 110 feet were constructed of angle iron posts, four foot high page wire and barbed wire stands ten inches apart extending to seven feet above ground level.

Range Productivity Rating

Twelve sites were chosen for productivity sampling. Each of these sites sustains competition between bighorn and other ungulate users of the range. At each chosen site, five one-

square meter productivity cages and an equivalent unprotected area will be clipped twice a year. The clipping will take place in the spring of the year after the big game have left the winter range and in the fall of the year after the livestock have been removed from the range.

Comparisons will be made between oven-dried weights of protected and unprotected clippings, thereby establishing the level of use of grasses and forbs by the summer and winter users of the range.

Climatological Stations

Weather stations were established within one exclosure on each winter range studied. Each weather station consists of a Stevenson Screen housing a minimum (alcohol) thermometer, a maximum (mercury) thermometer and a 31-day temperature recorder. Two rain collectors and two evaporimters are also located at each station.

Climate affects the distribution and abundance of plant species. If a fertilizer and a re-seeding program is to be of any value, the climatological conditions that exist on each range must be established. Also, the response of range plants to fertilizers and differences in productivity can be interpreted in relation to climatological conditions.

ECOLOGY OF THE PREMIER RIDGE

BIGHORN WINTER RANGE

ECOLOGY OF THE PREMIER RIDGE BIGHORN WINTER RANGE

A. Soils

Two soil types are present on the Premier Ridge bighorn winter range between altitudinal limits of 2800 feet and 4400 feet; Melanized Brown Wooded and Brown Wooded soils which intergrade with adjacent Dark Gray Chernozems. Soils on this range have been derived from parent materials of colluvial and fan outwash debris which include large boulders not found in the general area, some limestones as well as stony and sandy outwash in which calcium carbonate is still present (Wright et.al. 1966).

(a) Melanized Brown Wooded Soils

From soil profiles, Melanized Brown Wooded soils were identified on five study sites; PR 1, 2, 3, 6, L-1, L-2. Other study sites (PR L-5, L-6, L-7 and L-8) were classified by external features to be of this soil type.

A shallow profile has developed on glacial outwash gravels with abundant calcium carbonate. This profile is characterized by a thin, stony, fine-sandy-loam "A" horizon of one inch; a stony, sandy-loam "B" horizon of about 12 inches; and a five inch "C" horizon composed of similar materials. In colluvium a fourth horizon occurs which is also a stony, sandy-loam and which may extend down to a depth of 22 inches. (Appendix II, Table A shows a more detailed description of this soil profile.

(b) Brown Wooded Soils which intergrade to Dark Gray Chernozemic soils

From soil profiles, a soil which roughly equates with

Melanized Brown Wooded soils (the Brown Wooded soils) intergrading to Dark Gray Chernozemic soils was located at two study sites; PR L-3 and L-4. From external characteristics, two other study sites (PR 4 and 5) were also judged to be of this type.

The shallow profile has developed on steep hillsides of bedrock and a stony surface. It is characterized by a thin, one inch "A" horizon of stone, fine-sandy-loam; a seven inch "B" horizon of stony, fine-sandy-loam; and a four inch "C" horizon of stony, coarse-sandy-loam. These soils are calcareous at the surface. Appendix II, Table B shows a more detailed description of this soil profile.

B. Topography

The Premier Ridge bighorn winter range lies on the east bank of the Kootenay River and to the south of the Lussier River. Wasa and Wolf Creeks form the southern boundary while the eastern boundary follows the 4500 foot contour on the Hughes Range of the Rocky Mountains.

The winter range is located on a ridge which rises to 4406 feet through a glacial terrace. The land rises abruptly above the Kootenay River for 300 feet, forming a terrace of from one to three miles in width and seven miles in length. At the eastern border another increase in elevation of 1400 feet occurs within a distance of two miles. The ridge reaches a peak elevation of approximately 4400 feet and then drops rapidly for 200 feet. The

terrain then rises again to form the Hughes Range of more than 8000 feet in elevation. Two lakes, Premier Lake and Rockbluff Lake are found in the trench between Premier Ridge and the Hughes Range. Wolf Creek descends from the Hughes Range into this same trench and then flows south to form many swamps.

C. History of Vegetation

British Columbia Forest Service records of logging and forest fires date back only to 1930. Thus much of the history of this big game winter range is not available. Local residents believe that Indians regularly burned some of this range to provide forage for their horses. However, several large fires, which occurred between 1910 and 1930 were probably caused by the activities of loggers rather than by Indians. During this period, the Canadian Pacific Railway constructed many miles of track for the removal of timber, thereby indicating that the ridge was still heavily forested with merchantable timber.

Existing Forest Service records, reveal that one large fire did occur in 1931. This fire burned most of the open west-facing slopes of Premier Ridge from about 3000 feet to the top of the ridge. One other small fire occurred on a terrace supporting a stand of Pinus contorta located on the southern portion of the range. This was a small lightning-caused fire that burned less than 20 acres in the early 1960's.

Once fires and logging had opened up the forests and the seral grasses and shrubs developed, big game populations probably

underwent a tremendous increase in numbers. This range became a wintering concentration spot for elk from as far away as the Purcell Mountains and the Upper Kootenay River area. Whitetailed deer immigrated from Skookumchuck Creek across the Kootenay River while Mule deer and bighorn built up large populations.

Following deforestation by logging and fire, cattle and horses were introduced to the range concomitantly with an increase in wintering big game populations. Horses ran wild in unchecked numbers until the B.C. Forest Service began to remove them in 1958. The program was completed in 1965 with the removal of several hundreds of horses from this range. However, ranchers using this range now exercise their permits for cattle, thereby maintaining a heavy grazing pressure. In addition, inadequate methods of distributing grazing animals, a lack of summer water and the effects of overgrazing tend to further concentrate animal use thereby resulting in severely depleted local sites.

D. Plant Communities

The plant communities established on this winter range are in various stages of fire-induced and subsequent grazing suppressed succession. Heavy use of developing seral communities by livestock and big game has hampered development of normal seral stages expected after a forest fire.

No relict sites were found but judging from the dense conifer forests to the south, the climax vegetation consisted of

Pseudotsuga menziesii - Pinus Ponderosa forest. There are relict trees on the Premier Ridge range but the understory has been presumably burned.

Throughout the burned terrace area, Pinus contorta, with an understory of Calamgrostis rubescens and Arctostaphylos uva-ursi, forms the forest type which covers most of this area. Openings in the Pinus contorta forest give way to a Purshia tridentata, Amelanchier alnifolia, Poa pratensis, Poa compressa community. This community extends for a short distance up the slopes of Premier Ridge but is replaced on the dry wind-blown areas by a community of Purshia tridentata, Agropyron spicatum and Koeleria cristata.

On this range Purshia tridentata is not found above 3500 feet, being replaced as a dominant by other shrubs at higher elevations. Shepherdia canadensis, Spirea betulifolia and Amelanchier alnifolia thus dominate the communities from the 3500 foot contour to the summit.

There are several variations in the structure of the plant community occurring above 3500 feet. These variations are influenced by the many draws and ridges found on the west slopes of Premier Ridge. The ridges are drier and support bunch grasses, such as Agropyron spicatum, Koeleria cristata as well as Stipa columbiana. The moist draws produce sod grasses such as Calamogrostis rubescens, Poa pratensis and Poa compressa as dominants.

The east-facing slope of Premier Ridge is timbered with some open sites created by recent logging and past fires. This has mainly occurred from the top of the ridge above Rockbluff Lake to the southern end of the ridge. The forest on these opened areas consists of Pseudotsuga menziesii with some Pinus ponderosa. Grasses and forbs such as Agropyron spicatum, Festuca idahoensis and Balsamorhiza sagittata form the ground cover.

On the slopes of Rockbluff Lake the plant community consists of a dense forest of Pseudotsuga menziesii and Larix occidentalis. The understory is comprised mainly of Calamagrostis rubescens and Arctostaphylos uva-ursi.

The southern and northern areas of the Premier Ridge bighorn winter range is forested by immature stands of Pinus contorta, Pseudotsuga menziesii and Pinus ponderosa. In the northern region Larix occidentalis is also prevalent.

The Wolf Creek drainage, south of Rockbluff Lake, contains several small swamps, in which Salix spp., Betula spp. and Populus tricocarpa are dominant. The drier areas support admixtures of Pinus contorta, Larix occidentalis and Pseudotsuga menziesii. There are also several rocky outcroppings in this area interspersed with small units of grassland community. This community contains Agropyron spicatum, Festuca idahoensis and Symphoricarpus albus.

Fourteen study sites were established on the Premier Ridge bighorn winter range, representing six communities. The

communities were classified on the basis of the dominant species with the highest cover-frequency ratios. Each of the associations are summarized in the following, but for detailed lists of the species present and for cover-frequency ratios refer to Appendix III.

1. The Pseudotsuga-Agropyron-Balsamorhiza Community

The Pseudotsuga-Agropyron-Balsamorhiza community has been described at three sites PR3, L-1 and L-2. These sites are located at exposures from NE to SW and at elevations from 3650 feet to 3950 feet. Ground cover varies, depending on the amount of grazing, from 18 to 69 percent vascular plants, 22 to 37 percent litter, 2 to 9 percent rock, 9 to 34 percent bare ground and up to 8 percent cryptogam cover. Dominants in this community are: Pseudotsuga menziesii, Agropyron spicatum and Balsamorhiza sagittata. Associated species found in this community are: Festuca idahoensis, Koeleria cristata, Amelanchier aluifolia and Spirea betulifolia.

See Appendix III, Table A for a list of plant species and their C/F.

2. Festuca-Koeleria Community

On areas of lasting snows and light summer grazing, the Pseudotsuga-Agropyron-Balsamorhiza community develops, after fire, into the Festuca-Koeleria community. This community was located at one site, PR-L-7, at an elevation of 4200 feet. This community has a vascular plant cover of 36 percent, a litter cover of 30 percent, 2 percent rock, 5 percent cryptogams and 27 percent bare ground.

Associated species are: Agropyron spicatum, Achillea millefolium, Antennaria rosea and Spirea betulifolia.

See Appendix III, Table A for a list of the plant species and their C/F.

3. The Purshia-Agropyron-Koeleria Community

At lower elevations of 3300 feet, and with westerly exposures, the Pseudotsuga-Agropyron-Balsamorhiza community gives rise, after a fire, to the Purshia-Agropyron-Koeleria community. The community was studied at four sites, PR 5, 4, L-3 and L-4. This community develops on soils of Brown Wooded soils which intergrade to Dark Gray Chernozemic soils. The ground cover of this community is from 21 to 33 percent vascular plants, from 14 to 31 percent litter, about 10 percent rock, from 21 to 53 percent bare ground and less than 11 percent cryptogams.

The dominant species are: Purshia tridentata, Agropyron spicatum and Koeleria cristata. Associated plant species in this community are: Amelanchier alnifolia, Rosa woodsii and Pseudotsuga menziesii.

See Appendix III, Table B for a list of plant species and their C/F values.

4. The Purshia-Amelanchier-Poa Community

The Purshia-Amelanchier-Poa community develops on moister sites after the original community of Pseudotsuga-Agropyron-Balsamorhiza

has been destroyed by fire. It is represented by 3 study sites, PR 1, 2 and 6, and was found on terraces at 3000 feet with a slight southerly exposure. The main plant species are: Purshia tridentata, Amelanchier alnifolia, Poa compressa and Poa pratensis.

The ground cover of this community is about 50 percent vascular plants, about 33 percent litter, about 13 percent bare ground, up to 3 percent rock and up to 4 percent cryptogams. Associated plant species are: Agropyron trachycaulum, Bromus tectorum, Koeleria cristata, Stipa columbiana, Achillea millefolium, Antennaria rosea, Chrysopsis villosa and Arctostaphylos uva-ursi.

See Appendix III, Table C for a list of the plant species and their C/F values.

5. Pinus contorta-Calamagrostis-Arctostaphylos Community

Portions of the terraced area developed into a Pinus contorta forest after the fires. The dominant species of this community are: Pinus contorta, Calamagrostis rubescens and Arctostaphylos uva-ursi. This community was studies at two sites PR L-5 and L-6, at an elevation of 2700 feet. Ground cover of this community consists of about 44 percent vascular plants and 56 percent litter.

Associated species in this community are: Festuca idahoensis, Astragalus miser, Fragoria virginiana and Amelanchier alnifolia.

See Appendix III, Table D for a list of the plant species and their C/F values.

6. The Calamagrostis-Poa Community

A Calamagrostis-Poa community developed after a fire on higher exposed slopes. This community was studied at one site, PR L-8, at 4000 feet, with a westerly exposure. This community develops above the elevational limits of Purshia tridentata and consists of Calamagrostis rubescens and Poa pratensis. The ground cover is 53 percent vascular plants, 23 percent litter, 2 percent rock and 20 percent bare ground.

Associated species in this community are: Agropyron spicatum, Festuca idahoensis, Koeleria cristata, Antennaria rosea, Arctostaphylos uva-ursi and Spirea betulifolia.

See Appendix III, Table E for a list of the plant species and their C/F values.

E. Animal Distribution

Heavy use is made of the Premier Ridge range by bighorn sheep, elk, mule and whitetailed deer during the six winter months and by cattle in the summer. Bighorn use is heavy in all plant communities located above 3000 feet. Deer and elk use is heavy in all but the denest Pinus contorta forests. Livestock use is heaviest in the Purshia-Amelanchier-Poa community of the terraces and on the open communities of the high slopes.

However, light the use may seem, elk, deer, cattle and formerly horses, have made use of all plant communities. The

bighorn also use most of the communities but seldom on the terraces. (See Appendix IV, TableA for the location of ungulate fecal groups in various plant communities).

DISCUSSION AND CONCLUSIONS

The ecology of the Premier Ridge bighorn winter range has been greatly influenced by its past history. Logging and fires have removed the forests and allowed shrubs such as Amelanchier alnifolia and Purshia tridentata to dominate the range. Large populations of wintering big game species and summering livestock have damaged the successional stages by severely overgrazing them.

The basic climax type formerly found on this range was a Pseudotsuga-Pinus ponderosa-Agropyron community. No relict sites representing this community now exist because the understory has been burned and heavily grazed. However, two sites (L-1 and L-2) are only slightly modified from the climax. These sites (3) while approximating this climax, is indicative of this community once it has undergone heavy grazing. At this site ground fires in 1931 and subsequent heavy use by grazing ungulates has reduced the Agropyron spicatum cover and increased the weedy forbs cover, i.e. Apocynum androsaemifolium and Antennaria rosea.

When the climax forest was burned at low elevations and then severely grazed the Purshia-Agropyron-Koeleria community developed. Purshia tridentata is a severe competitor of burned over, heavily grazed lands. When Agropyron spicatum is heavily grazed then Koeleria cristata, a weedy grass, becomes a dominant

species in the community. This community, because of its aspect, is blown free of snow by winter winds, thereby encouraging big game to concentrate on it. The community is heavily used by bighorn sheep, mule and whitetailed deer, and also received moderate use by elk.

Further down the slope on the alluvial terrace, the Purshia-Amelanchier-Poa community develops after fire. This community is found on relatively moist sites where the snow is not blown off in winter and the run-off water forms several small ponds.

The Purshia-Amelanchier-Poa community is heavily grazed by whitetailed and mule deer, elk, cattle and formerly by horses. Consequently, weedy grasses, including Bromus tectorum, Koeleria cristata, Poa compressa and Stipa columbiana are well established in this community. In addition, there are many weedy forbs, Achillea millefolium, Antennaria rosea and Chrysopsis villosa. One of the dominant shrubs of this community, Purshia tridentata, can also be considered a weed.

On the terrace areas where the 1931 fire had little effect, the Pinus contorta-Calamagrostis-Arctostaphylos community has developed. This community resulted from a forest fire that occurred between 1910 and 1930. It consists of a few species of grasses, forbs or shrubs in addition to Calagagrostis rubescens and Arctostaphylos uva-ursi. Deer and cattle used this area very lightly, mainly because of the thickness of the forest stand. Bighorn seldom, if ever, use this community.

Above the altitudinal limits of Purshia tridentata the Calamagrostis-Poa community develops with fire and heavy grazing. The shrub cover in this community is composed of Amelanchier alnifolia and Arctostaphylos uva-ursi. Several weedy forbs and grasses are present, including Astragalus miser, Antennaria rosea and Koeleria cristata. Two grasses, Calamagrostis rubescens and Poa pratensis dominate the ground cover. Heavy use is made of this community by mule deer, bighorn sheep, elk and cattle.

The Festuca-Koeleria community has developed after fire on protected slopes. It consists mainly of Festuca idahoensis, Koeleria cristata, some Agropyron spicatum and Spirea betulifolia. It is found near the top of the ridge, where lievestock grazing is light but use by bighorns, deer and elk is heavy.

In most of the moist protected draws on this winter range, Pseudotsuga menziesii seedlings are becoming established. The present level of heavy grazing may be enough to retard their development and encroachment onto the open grazing lands. However, Pseudotsuga menziesii will inevitably take over the range and crowd out the forage plants thereby resulting in a reduction in the numbers of mule deer, elk, bighorn sheep and cattle. Perhaps the whitetailed deer will be able to better utilize the resulting forest and thus withstand any reduction in their population.

Several lesser communities located near run-off ponds on alluvial terraces, in heavy stands of larch and along the marshy

creek bottom of Wolf Creek, have not been studied. These communities do not play a significant role in the maintenance of the bighorn sheep population on this winter range.

SUMMARY

1. A study of the vegetation, soils and use of the Premier Ridge bighorn winter range was conducted during the period from May 1966 to September 1967.

2. The canopy coverage method of vegetational analysis of Daubenmire (1959), the macroplot method of Poulton and Tisdale (1961) and linear transects were used to describe and classify range vegetation. Ungulate fecal groups were counted within belts along each randomly selected transect.

3. Soil profiles were described at seven study sites. Where soil profiles were not described, soil classification was based on the type of vegetation present, physiography and the interpretation of aerial photographs.

4. All of the brush and grass communities are in an overgrazed state.

5. Although cattle prefer the terraces and the gentler slopes and bighorn prefer the open slopes, big game and domestic stock were found to use all plant communities. The sole exception is the lack of use of thick Pinus contorta stands by bighorn sheep.

6. Fire and overgrazing are responsible for the abundance of Purshia tridentata, Poa-compressa, Bromus tectorum and Pinus contorta on this range.

7. Although there are no climax communities on this range, the Pseudotsuga-Agropyron-Balsamorhiza is the only community that was not destroyed by fire. This forest community develops into the Festuca-Koeleria community on high slopes which receive winter grazing. On moister sites above the altitudinal limits of Purshia tridentata a Calamagrostis-Poa community develops following burning and grazing. On lower wind-blown slopes the Purshia-Agropyron-Koeleria community develops while on moist terraces the Purshia-Amelanchier-Poa community develops following repeated burning and heavy grazing pressure. The Pinus contorta-Arctostaphylos community develops after fire on other portions of the terrace.

8. The following factors are believed to be against any future build-up and maintenance of bighorn populations:

   (a) Over-grazing of fire-induced communities by elk, mule deer and cattle.

   (b) The eventual natural reforestation of the range with Pseudotsuga menziesii.

MANAGEMENT PROPOSALS

The Premier Ridge bighorn winter range supports a large wintering population of bighorn sheep, elk, mule deer and white-tailed deer. This range is also heavily grazed in the summer by cattle. Any management proposals must be considered in this light.

The terrace area is seldom used by bighorn but it is used by other big game species. Cattle rely on this area for most of their grazing and watering. Certain areas are abused and are in worse conditions than others, i.e. around water holes and in open grasslands.

The main slopes of Premier Ridge receive most of the big game use under winter conditions. This same area, because of its slope, generally receives light cattle use by some localized areas are severely over-used by cattle, particularly around water holes.

Cattle must be confined to the terraces and not permitted to graze on the main slope. A single drift fence would confine them to the terraces. Such a fence should be built from the Lussier River to Wolf Creek, following the 3000 foot contour.

One other drift fence needs to be built for proper distribution of livestock on the terraces. This drift fence should be built south of Island Pond and should run westerly through the centre of Lot 8119 to the Kootenay River.

To increase forage production of this range most of the forest regrowth should be burned. Sites which would benefit from burning are located to the east of Premier Lake on the north and south slopes of Premier Ridge. Dense Pinus contorta stands on the terraces should also be burned in the patchwork pattern. This will provide cover for deer and elk and also increase forage production for deer, elk and cattle. The burning program should also include stands of Purshia tridentata and immature Pseudotsuga menziesii.

APPENDIX I

Scientific and Common Names and Authorities for Plant and Animal Species Mentioned

References:

Cowan and Guiget (1956)
Davis (1952)
Hitchcock, A.S. revised by Agnes Chase (1950)
Hitchcock, C.L., A. Cronquist, M. Ownbey and J.W. Thompson (1955-1964).

TABLE A

GRASSES AND GRASS-LIKE SPECIES

Agropyron spicatum (Pursh) Scribn. and Smith	Bluebunch wheatgrass
Agropyron trachycaulum (Link) Malle	Slender wheatgrass
Bromus tectorum L.	Downy chess
Calamagrostis rubescens Buckl.	Pinegrass
Carex sp. L.	Sedge
Festuca idahoensis Elmer.	Idaho fescue
Festuca scabrella Torr.	Rough fescue
Koeleria cristata (L.) Pers.	June grass
Poa compressa L.	Canada bluegrass
Poa pratensis L.	Kentucky bluegrass
Stipa columbiana Macoun.	Columbia needlegrass

FORBS

Achillea millefolium L	Yarrow
Alyssum alyssoides L.	
Antennaria rosea Green	Pink pussytoes
Apocynum androsaemilfolium L.	Dogbane
Arabis holboellii Hornem.	Rock cress
Aster sp. L.	Aster
Astragalus miser Dougl. ex. Hook.	Timber milk vetch
Balsamorhiza sagittata (Pursh.) Nutt.	Balsamroot sunflower
Chrysopsis villosa (Pursh.) Nutt. ex D.C.Golden	Golden Aster
Cirsium undulatum (Nutt.) Spreng.	Thistle
Filago arvensis L.	
Fragaria virginiana Dushesne	Strawberry

SHRUBS

Amelanchier alnifolia Nutt.	Serviceberry
Arctostaphylos uva-ursi (L.) Spreng.	Kinnikinnick ~~birch~~
Betula spp. L.	Birch
Purshia tridentata (Pursh.) D.C.	Bitterbrush
Rosa woodsii Lindl.	Rose
Salix spp. L.	Willow
Shepherdia canadensis (L.) Nutt.	Soapberry
Spiraea betulifolia (Pall.)	Flat-topped spiraea

TREES

Larix occidentalis Nutt.	Western Larch
Pinus contorta Dougl.	Lodgepole Pine
Pinus ponderosa Laws	Ponderosa Pine
Populus tremuloides Michn.	Trembling Aspen
Pseudotsuga menziesii (Mirb.) Franco	Douglas fir

ANIMALS

Cervus canadensis nelsoni Bailey	Rocky Mountain Elk
Odocoileus hemionus hemionus Rabinesque	Mule Deer
Odocoileus virginianus ochrourus Bailey	Whitetailed Deer
Ovis canadensis canadensis Shaw	Rocky Mountain Bighorn Sheep

APPENDIX II

Profile Descriptions of Representative

Soils of the Premier Ridge Bighorn Winter Range

TABLE B

Melanized Brown Wooded Soils

Study Site Number: 3 Slope and Aspect: 20 percent E

Land form and relief: convex side of drumlin Drainage: well-drained

Elevation: 3190 feet Vegetation: Pseudotsuga-Agropyron-Balsamorhiza

Horizon	Depth Inches	Description
A	0-1	Very dark brown (10YR 2/2, moist). Stony, very fine sandy-loam. Very weak crumb and granular structure. Boundary indistinct.
B	1-13	Brown (10YR 4/2, moist). Stony, sandy-loam. Very weakly developed, very fine, angular, blocky structure breaking to crumbs. Boundary distinct.
C	13-18	Pale brown (10YR 5/3, moist). Gritty sandy-loam, excessively stony. Weakly developed angular, blocky structure breaking to very fine granules and crumbs.

TABLE B

Brown Wooded intergrading to Dark Gray Chernozemic
(roughly equating with Melanized Brown Wooded).

Study Site Number: L-3 Slope and Aspect: 48 percent SW

Land form and relief: convex drumlin

Elevation: 3300 feet Vegetation: Purshia-Agropyron-Koeleria

Horizon	Depth Inches	Description
A	0-1	Brown (10YR 4/2, moist). Stony, very fine sandy-loam. Weak blocky structure breaking to granules and crumbs. Boundary distinct.
B	1-8	Brownish gray (10YR 4/3, moist). Stony very fine sandy-loam. Weakly developed blocky structure breaking to fine granules and crumbs. Boundary distinct.
C	8-12	Pale brown (10YR 6/3, dry). Very stony coarse sandy-loam. Strongly developed fine angular blocky structure breaking to coarse and fine granules.

APPENDIX III

Plant Community Structure in the Study Sites of the Premier Ridge Bighorn Winter Range

TABLE A Summary of major plant species C/F and nature of ground cover in the Pseudotsuga-Agropyron-Balsamorhiza and the Festuca-Koeleria Communities.

	Pseudotsuga-Agropyron Balsamorhiza			Festuca-Koeleria
GRASSES	3	L-1	L-2	L-7
Agropyron Spicatum	7/55	46/100	43/95	8/45
Festuca idahoensis	t/3	8/63	28/88	36/100
Festuca scabrella	6/53	t/3	-	-
Koeleria cristata	22/98	12/78	16/90	16/95
FORBS				
Achillea millefolium	1/10	2/25	1/20	1/35
Antennaria rosea	1/18	-	t/5	7/75
Apocynum androsaemifolium	2/23	-	-	-
Astragalus miser	t/5	2/10	t/3	t/2.5
Balsamorhiza sagittata	16/55	15/65	6/18	-
SHURBS AND TREES				
Amelanchier alnifolia	2/18	1/5	6/15	-
Populus tremuloides	-	2/15	-	-
Rosa woodsii	1/8	-	5/35	t
Spiraea betulifolia	-	3/53	1/13	2/25
GROUND COVER (%)				
Vascular Plants	18	47	69	36
Litter	37	24	22	30
Rock	4	9	2	2
Bare ground	34	19	9	27
Crytogams	8	1	-	5
Elevation (feet)	3650	3950	3850	4200
Slope (%)	17	48	36	55
Aspect	SW	NNE	NE	W

TABLE B Summary of major plant species C/F and nature of ground cover in the Purshia-Agropyron-Koeleria community

	Purshia-Agropyron-Koeleria			
GRASSES	L-3	L-4	4	5
Agropyron spicatum	30/100	32/100	28/100	32/100
Bromus tectorum	t/3	2/35	t/3	t/3
Festuca idahoensis	-	4/30	4/30	1/10
Koeleria cristata	9/80	8/75	8/75	18/98
FORBS				
Balsamorhiza sagittata	4/25	6/45	7/45	3/33
Cirsium undulatum	t	2/3	-	-
SHRUBS				
Amelanchier alnifolia	t	t/5	11/55	1/13
Purshia tridentata	1/5	t	15/33	13/28
Rosa woodsii	-	-	2/8	5/43
Spiraea betulifolia	--	-	1/8	t/5
GROUND COVER (%)				
Vascular Plants	21	24	33	30
Litter	14	31	28	18
Rock	10	10	8	11
Bare ground	53	22	21	39
Cryptogams	4	1	11	3
Elevation (feet)	3300	3300	3300	3300
Slope (%)	48	48	25	32
Aspect	SW	SW	SW	W

TABLE C Summary of the major plant species C/F and nature of ground cover in the Purshia-Amelanchier-Poa community

	Purshia-Amelanchier-Poa		
GRASSES	1	2	6
Agropyron spicatum	-	-	1/5
Agropyron trachycaulum	3/28	3/28	1/8
Bromus tectorum	10/30	11/43	42/93
Calamagrostis rubescens	-	4/18	t/3
Festuca idahoensis	-	-	1/5
Koeleria cristata	2/20	4/28	3/28
Poa compressa	27/73	20/68	3/23
Poa pratensis	15/35	6/20	10/50
Stipa columbiana	11/63	3/28	t/3
FORBS			
Achillea millefolium	1/18	2/25	2/20
Alyssum alyssoides	1/18	-	1/10
Antennaria rosea	3/25	2/20	5/33
Apocynum androsaemifolium	2/23	-	1/8
Arabis holboelli	t/3	t/8	1/20
Aster sp.	t/10	-	1/8
Balsamorhiza sagittata	t/3	-	t/3
Chrysopsis villosa	10/60	5/28	18/70
Filago arvensis	-	-	2/28
Frageria virginiana	t/3	t/5	t/10
SHRUBS			
Amelanchier alnifolia	9/60	16/75	11/53
Arctostaphylos uva-ursi	2/8	7/23	-
Purshia tridentata	31/68	31/78	31/78
Rosa woodsii	t	1/3	1/8
Spiraea betulifolia	-	2/13	t/3
GROUND COVER (%)			
Vascular Plants	53	50	53
Litter	28	34	33
Rock	3	1	-
Bare ground	14	15	10
Cryptogams	2	-	4
Elevation (feet)	3000	3000	2950
Slope (%)	15	16	15
Aspect	SW	S	SSW

TABLE D Summary of major plant species C/F and nature of ground cover in the Pinus-Calamagrostis-Arctostaphylos community.

	Pinus contorta-Calamagrostis-Arctostaphylos	
GRASSES		
Calamagrostis rubescens	35/100	34/98
Festuca idahoensis	t/5	1/13
Carex sp.	4/25	-
FORBS		
Astragalus miser	7/55	1/10
Fragaria virginiana	t/10	1/8
SHRUBS		
Amelanchier alnifolia	3/28	2/25
Arctostaphylos uva-ursi	39/95	42/98
GROUND COVER (%)		
Vascular Plants	43	44
Litter	57	56
Elevation (feet)	2700	2800
Slope (%)	5	3
Aspect	NNW	NNW

TABLE E Summary of major plant species C/F and nature of ground cover in the Calamagrostis-Poa community

	Calamagrostis-Poa
	L-8
GRASSES	
Agropyron spicatum	3/5
Calamagrostis rubescens	28/83
Festuca idahoensis	4/13
Koeleria cristata	8/65
Poa pratensis	18/58
Carex sp.	3/8
FORBS	
Achillea millefolium	t/15
Antennaria rosea	2/33
Aster sp.	t/13
Astragalus miser	15/78
Fragaria virginiana	1/10
SHRUBS	
Amelanchier alnifolia	4/25
Arctostaphylos uva-ursi	9/23
Rosa woodsii	1/15
Spiraea betulifolia	4/40
GROUND COVER (%)	
Vascular Plants	55
Litter	23
Rock	2
Bare ground	20
Crytogams	-
Elevation (feet)	4000
Slope (%)	12
Aspect	W

APPENDIX IV

Ungulate Use of Various Plant Communities on the Premier Ridge Bighorn Winter Range

TABLE A The distribution and abundance of domestic and wild ungulates on the basis of fecal deposits according to plant communities

Plant Community	Plot	Bighorn & Deer	Elk	Cattle	Horses
Pseudotsuga-Agropyron-Balsamorhiza	3	1441	1110	89	89
	L-1	1408	296	--	--
	L-2	1112	445	--	74
Festuca-Koeleria	L-7	1186	1630	--	74
Purshia-Agropyron-Koeleria	L-3	1260	445	--	--
	L-4	2964	74	74	--
	4	2664	1332	133	--
	5	1554	710	89	133
Purshia-Amelanchier-Poa	1	1243	220	266	178
	2	1649	44	444	89
	6	2309	266	311	133
Calamagrostis-Poa	L-8	963	1037	593	74
Pinus-Calamagrostis-Arctostaphylos	L-5	74	--	148	74
	L-6	74	---	--	--

RESULTS

ECOLOGY OF THE COLUMBIA LAKE BIGHORN WINTER RANGE

A. Climate

The climate of the Columbia Lake winter range region is profoundly influenced by the adjacent mountains and by the Columbia Lake. Precipitation patterns and precipitation:evaporation ratios are highly variable.

Precipitation records have been kept at the Canal Flats Ranger Station for 41 years. This station is 2680 feet in elevation and is located on the broad river flat between the Columbia Lake and the Kootenay River. Precipitation data for 41 years and monthly mean temperatures for six years are summarized in Table I.

From Table I it may be seen that mean monthly temperatures are above freezing between April and October. The precipitation pattern at Canal Flats indicates a dry period in March and April with a June peak. The remaining months show only minor variations in precipitation. Winter snowfall is four feet. The depth of snow accumulated is affected by the degree of exposure to wind and sunlight. Some melting does occur throughout the winter and when followed by freezing temperatures, icing occurs.

TABLE I Temperature and Precipitation records from the Canal Flats Ranger Station Weather Station. Data from B.C. Department of Agriculture (1965).

Month	Mean Temperature F	Total [1] Precipitation (in.)
January	10	1.55
February	24	1.22
March	29	0.99
April	44	0.83
May	52	1.45
June	57	2.14
July	64	1.20
August	62	1.30
September	53	1.23
October	44	1.12
November	32	1.45
December	21	1.64
Absolute Max. - Min.	98 -44	
Annual Average	41	16.20
Average Snowfall		47.4
Years Recorded	6	41

1 Total precipitation is the sum of the rainfall plus the water equivalent of the snowfall. (Snowfall divided by ten).

B. Soils

Three types of soils are present on the Columbia Lake range between the elevational limits of 2650 and 4500 feet; Dark Gray Chernozemic, Brown Wooded and Melanic Brown Wooded Soils.

Soils on this range have been derived from parent material from the Stanford Range. Alluvial fans originating in these mountains bring rock and debris to the lakeshore. These alluvial fans overlie sediments of glacial lacustrian deposits.

No soil profiles were described in this region.

C. Topography

The Columbia Lake bighorn winter range lies on the slopes of the east side of Columbia Lake. The southern limit of the range is the south slopes of Mount Sabine, just north of the townsite of Canal Flats. The Columbia Lake shore forms the western boundary. The northern limit of this range is Fairmont Creek near the townsite of Fairmont Hot Springs. The elevational boundary on the east side is about 4500 feet on the Stanford Range. The elevation of Columbia Lake is 2650 feet and the tops of the alluvial fans are about 3000 feet. The total area of the winter range is about 9.2 square miles.

The winter range area consists of several large alluvial terraces which have their origins from the Stanford Range. These alluvial terraces originate from rocky hills and bluffs and terminate at the steep banks on the shores of Columbia Lake.

D. History of Vegetation

British Columbia Forest Service records of forest fires, dating back to 1930, reveal that there have been no fires on this winter range during this period.

This area has been badly abused by horses since before 1925 (See Figure 1). In 1954 the Forest Service built a drift fence from the shores of the southern end of the lake to the steep slopes of Mount Sabine. The purpose of this fence was to enforce a no-grazing regulation on the Columbia Lake range. However, horses from the nearby Indian Reserve at Fairmont Hot Springs continued to graze the area. In 1956 a second drift fence was built, this time at the north end of Columbia Lake, just south of a grassy knoll frequented by bighorns. Since this time no domestic stock has grazed the Columbia Lake winter range.

E. Plant Communities

The plant communities established on this range are in various stages of ungulate-induced overgrazed succession. Heavy use of the grasslands on the alluvial terraces has retarded the normal development of climax vegetation expected in the region.

No large relict sites could be located. However, several small isolated areas were observed and classified as sub-climax. The climax community was probably a community of Pseudotsuga-menziesii-Agropyron spicatum, Chrysothamnus nauseosus, Juniperus scopulorum and Juniperus communis.

At the present Chrysothamnus nauseosus and Koeleria cristata are the dominant species forming communities on alluvial terraces and in swales. In swales, these two species are associated with Pseudotsuga menziesii. The steep areas above the alluvial fans contain Pseudotsuga menziesii forests which consist of two main communities; on exposed south-facing slopes it combines with Koeleria cristata and Agropyron spicatum; and on the north-facing slopes it combines with Calamagrostis rubescens and Arctostaphylos uva-ursi.

The forests in this area are generally about 80 to 100 years old.

The grasslands of the Columbia Lake winter range can be separated into two main plant communities based upon two or three dominant species with the highest cover-frequency ratios. Each of these is summarized in the following, but for detailed lists of the species present and for cover-frequency ratios, refer to Appendix II.

1. The Chrysothamnus-Koeleria community

The Chrysothamnus-Koeleria community has been described on two sites, CL-L1 and L2, both located on west-facing alluvial fans at 2700 feet of elevation. The area occupied by this community is acres. This community has developed on a Dark Gray Chernozemic soil.

There is site variation within this association. Plot CL-L1 shows a higher density of plant cover and less bare ground than Plot CL-L2. The principal components of this community are Chrysothamnus nauseosus and Koeleria cristata, however, Plot CL-L1 also has a significant percentage of Stipa columbiana, a grass that is not present in Plot CL-L2. Both plots have a high frequency of spring flowering plants e.g. Draba nemerosa and Erigeron filifolius.

The ground cover varies between 27 and 43 percent, living plants, 9 and 39 percent bare ground, with about 21 percent cryptogams and 19 percent litter. Averaging the data for plots L-1 and L-2 reveals a plant cover/frequency ratio of; Koeleria cristata 28/100, Chrysothamnus nauseosus 10/65, Danthonia spicata 3/20 and with plot CL-L1 having Stipa columbiana with23/100 and plot CL-L2 having none. See Appendix II, Table A for a comparison between plots L1 and L2.

2. The Chrysothamnus Agropyron-Koeleria community

The Chrysothamnus Agropyron-Koeleria community is found on steeper land than the Chrysothamnus-Koeleria community, and usually at the base of the mountain slopes and at the top and on the alluvial terraces. This community has developed on a Dark Gray Chernozemic soil.

The ground condition of the Chrysothamnus-Agropyron-Koeleria community is quite similar to the Chrysothamnus-Koeleria

community. There is slightly less cryptogam cover, more rock and less litter.

The principal difference between this community and the former is that Agropyron spicatum and Festuca idahoensis are found in appreciable amounts of this community. Agropyron spicatum has a cover frequency of 42/100 and Festuca idahoensis 9/58. See Appendix II, Table A, for a comparison between the two plots of the Chrysothamnus-Koeleria community and the one plot of the Chrysothamnus-Agropyron-Koeleria community.

Figure 1. Horses over-grazing on alluvial fan on the Columbia Lake bighorn winter range in 1925. (Photo credit R. Lake).

F. Animal Abundance

The Columbia Lake winter range is used by elk, mule and whitetailed deer, bighorn sheep and formerly, by horses and cattle. Both species of deer had to be recorded with bighorn, as pellet groups from these three species cannot be readily separated. Fecal groups last a long time on this range as shown by the cowchips found in plot CL-L1 (See Table II). As no cattle have used this range since 1956, the recorded cowchips do not represent current range use.

TABLE II Fecal group counts on the grassland communities per acre

Community	Chrysothamnus-Koeleria with Stipa present	Chrysothamnus-Koeleria	Chrysothamnus-Agropyron-Koeleria
Deer and Bighorn	3334.5	741.0	1185.6
Elk	2297.1	2445.3	444.6
Cattle	--	148.2	--

Big game species have been sighted in all plant communities on this range, and bones of dead horses and cows indicate that the same was probably true for domestic stock as well. However, bighorn sheep tend to congregate on the steep grassy slopes. Elk and deer confine their diurnal movements to the timbered areas and "move out" into the open alluvial fans between dusk and dawn.

F. Discussion and Conclusions

This entire range has been evenly abused by ungulate over-use. The grassland ranges have been placed in overgrazed-induced seral communities by the added burden of horses and cattle to this range. These communities consist of Chrysothamnus nauseosus, Koeleria cristata and spring flowering weeds and have been maintained as such by big game, even though the domestic stock has been removed for about ten years.

Some of the area has developed faster than others, viz. CL-L3, but perhaps areas such as these received more moisture and are able to retain moisture longer. The entire range is greatly affected by the amount of moisture present during the growing season. Areas in the shadows of gullies, hills and forests appear to have a slightly different plant community structure than areas that are not afforded shade. There is a definite trend from south to north on each alluvial terrace for sod grasses to be replaced by bunch grasses. Agropyron smithii, Poa compressa and Poa pratensis are common in shaded areas, very rare in the open.

The bulk of the alluvial fan areas are away from the effect of any shadows and thus the low productivity of most of the range is enhanced by this large area. Most of the range consists of spring flowering and growing plants such as Poa secunda, Koeleria cristata, Draba nemorosa and Linum perenne; which are unavailable to winter grazing ungulates.

The species present now that are most important as food for wildlife are Chrysothamnus nauseosus, Artemisia frigida, Agropyron spicatum and Festuca idahoensis.

The general plant community structure on this range consists of the Chrysothamnus nauseosus-Koeleria cristata community. The only variations that occur in this basic community are under Pseudotsuga menziesii forests on northern slopes and in areas of high June-July moisture. The structure of the Chrysothamnus-Koeleria community is the main building block for most communities from dry alluvial fan grasslands through grassy slopes to Pseudotsuga-Juniperus forests on alluvial fans and south-facing slopes.

With the existance of such a uniform plant community throughout the range, big game distribution is equally uniform. However, areas that afford psychological protection are used more frequently, viz. bighorn on grassy slopes, elk and deer in forests in the daylight.

The Chrysothamnus-Koeleria community on the alluvial fans is not a dense stand of vegetation. There is only 27 to 43 percent vascular plant cover, thus the rest of the ground cover consists of litter and cryptogams for soil protection from weathering factors, e.g. sunlight, rain and wind. The bare ground comprises from 9 to 39 percent and although variable, it is significant in the area of site CL-L2.

The main plant cover on the alluvial terrace is; Koeleria cristata 20 to 32 percent, Stipa columbiana 22.5 percent (site L1), and Chrysothamnus nauseosus 10 percent. The remaining grasses, forbs, and shrubs cover less than 10 percent of the ground. Cryptogam cover in the community is very important as it covers 16 to 27 percent of the ground. This factor may also be important in inhibiting seedling establishment now that domestic stock has been removed from the range.

The extent of ground cover is similar on both the alluvial terraces and the adjacent, higher elevation grasslands. However, there are less cryptogams, 9 percent, less litter, 11 percent, and more rocks, 5 percent. Bare ground and vascular plants* are about the same with 39 and 36 percent. The vascular plant composition in this community consists of Agropyron spicatum, 42 percent, Festuca idahoensis, 9 percent, Koeleria cristata, 8 percent, and Chrysothamnus nauseosus, 7 percent. The remaining grasses, forbs and shrubs cover less than 12 percent of the ground.

The Chrysothamnus-Agropyron-Koeleria community is near the climax potential but animal movement through it may be sufficient to maintain it in a subclimax stage. Presently, Agropyron spicatum is near its maximum density with the increaser species of Koeleria cristata, Poa secunda, Achillea millefolium and

* It is to be expected that vascular plant ground cover will be less than that for the sum of the species due to plant stratification.

Erigeron filifolius being maintained due to soil disturbance.

G. Management Proposals

The Columbia Lake winter range is in a state of suppression. Use by big game is maintaining the overgrazed condition induced by domestic stock. After ten years of livestock removal there is very little recovery on much of this range.

Consideration must be given to the amount of water present in the soil during the plant growing season. There are six streams which flow from the mountains to Columbia Lake in the spring. A program of ditch irrigation should be undertaken so that at least part of this water flows over the alluvial fan grasslands during the growing season.

Once this water is made available to the alluvial fans then perhaps, a seeding and fertilizer program could be established to change the species composition.

SUMMARY

1. A study of vegetation, soils and use of the Columbia Lake bighorn winter range was conducted during the summer months of 1966 and 1967.

2. The canopy coverage method of vegetational analysis of Daubenmire (1959), the macroplot method of Poulton and Tisdale (1961) and linear transects were used to describe and classify range vegetation. Ungulate fecal groups were counted within belts along each randomly selected transect.

3. Soils were classified during a field survey of the East Kootenay by the A.R.D.A. soils staff.

4. The entire bighorn winter range is in an overgrazed state.

5. Present ungulate use is general throughout the entire range.

6. Past and present overgrazing by ungulate users of the range are responsible for the abundance of Chrysothamnus nauseosus, Koeleria cristata and spring flowering weeds.

7. There are no climax communities on this range. Rather the entire area is represented by a community of Chrysothamnus nauseosus and Koeleria cristata with some areas having Agropyron spicatum and others with

Pseudotsuga mensiesii, Juniperus communis and Juniperus scopulorum, depending on the water content of the soil.

8. Water appears to be the limiting factor to range improvement and subsequent increases in big game numbers.

APPENDIX I

Scientific and Common Names and Authorities for Plant and Animal Species Mentioned

References include: Cowan and Guiguet (1956)
Davis (1952)
Hitchcock, A.S., revised by Agnes Chase (1950)
Hitchcock, C.L., A.Cronquist, M. Ownbey and J.W. Thompson (1955-1964)

TABLE A

GRASSES	
Agropyron smithii Rydb.	Western wheatgrass
Agropyron spicatum (Pursh) Scribn. and Smith	Bluebunch wheatgrass
Calamagrostis rubescens Buckl.	Pinegrass
Danthonia spicata (L.) Beauv. ex. Roem & Schult	Poverty Oatgrass
Festuca idahoensis Elmer. 8	Idaho fescue
Koeleria cristata (L.) Pers.	June grass
Poa compressa L.	Canada bluegrass
Poa pratensis L.	Kentucky bluegrass
Poa secunda Presl.	Sandberg bluegrass
Stipa columbiana Maconn.	Columbia needlegrass
FORBS	
Achillea millefolium L.	Yarrow
Draba nemorosa L.	
Erigeron Filifolius Nutt.	Fleabane
Linum perenne L.	Flax
Phlox hoodii Rich.	Wild Sweet William
SHRUBS	
Arctostaphylos uva-ursi (L.)	Spreng. Kinnikinnick
Artemisia frigida Willd.	Pasture sage
Chrysothamnus nauseosus (Pull.) Britt.	Rabbit brush
Juniperus communis L.	Dwarf juniper
Juniperus scopulorum Sarg.	Rocky Mountain juniper
TREES	
Pseudotsuga menziesii (Mirb.)	Douglas fir
ANIMALS	
Cervus canadensis nelsoni Bailey	Rocky Mountain Elk
Odocoileus hemionus hemionus Rubinesque	Mule Deer
Odocoileus virginianus ochrourus Bailey	Whitetailed Deer
Ovis canadensis canadensis Shaw	Rocky Mountain Bighorn Sheep

APPENDIX II

Plant Community Structure in the Study Sites

of the

Columbia Lake Bighorn Winter Range

TABLE A Summary of major plant species cover/frequency and nature of ground cover for three sites

Plant Community	Plant Cover/Frequency (%) Chrysothamnus-Koeleria	Chrysothamnus-Agropyron-Koeleria	
	L1	L2	L3
GRASSES	3/18		
Agropyron spicatum	-	-	42/100
Danthonia spicatum	3/18	2/25	-
Festuca idahoensis	t/3	2/20	9/58
Koeleria cristata	32/100	20/100	8/58
Poa secunda	1/25	t/3	2/53
Stipa columbiana	23/100	-	-
FORBS			
Achillea millefolium	-	-	1/23
Draba nemorosa	1/35	1/53	-
Erigeron filifolius	t/10	1/20	5/80
Linum perenne	-	1/28	t/2
Phlox hoodii	-	1/20	1/15
SHRUBS			
Artemisia frigida	t	t/3	1/5
Chrysothamnus nauseosus	10/58	10/70	7/50
GROUND COVER (%)			
Vascular plants	43	27	36
Litter	21	18	11
Rock	1	-	5
Bare ground	9	39	39
Crytogams	27	16	9
Elevation (feet)	2700	2700	2750
Slope (%)	15	11	55
Aspect	W	W	W

ECOLOGY OF THE WIGWAM FLATS BIGHORN WINTER RANGE

BY

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ECOLOGY OF THE WIGWAM FLATS BIGHORN WINTER RANGE

A. Climate

The climate of the Wigwam Flats area is profoundly influenced by the mountains. This area borders on the main Kootenay River Valley and the lesser lateral valley of the Wigwam River. Mount Broadwood influences the climate of the winter range by acting as a barrier to weather patterns prevailing in the main valley. Precipitation patterns and precipitation:evaporation ratios are highly variable due to wide variations in local climate.

A weather station of long duration (37 years) is located at the Elko power plant on the south side of the Elk River. The station is 3080 feet in elevation and is located on a high terrace above the deep narrow trench cut by the Elk River. Thirty year averages (1931-60) for mean monthly temperature and total precipitation are shown in Table 1.

TABLE 1. Temperature and precipitation records from the Elko Weather Station. Data from B.C. Department of Agriculture (1965)

Month	Mean Temperature	Total Precipitation (ins.)
January	21	2.08
February	27	1.35
March	32	1.07
April	43	1.13
May	53	1.69
June	59	2.56
July	66	1.17
August	64	1.42
September	55	1.40
October	44	1.91
November	31	1.94
December	25	1.91

continued.....2

	Mean Temperature	Total Precipitation (ins.)
Absolute Min. - Max.	-29; 102	
Annual Average	43	19.63
Average Snowfall		55.2
Years	13	30 year standard (1931-1960) *

From Table 1, it may be seen that mean monthly temperatures are above freezing between April and October. However, below freezing temperatures have been recorded in nearly all months. As is found in many lateral valleys in British Columbia, a June precipitation peak is recorded. Relatively high temperatures and low rainfall in July and August cause drought periods in most years.

The average total snowfall approaches five feet. As the degree of exposure to wind and sunlight greatly affects snow pack, accumulated snow depths vary markedly at different locations in the area. Some melting occurs at various times throughout the winter, causing crusting when followed by freezing temperatures. Total melting of the snow is usually associated with winds and warm temperatures beginning anytime after early March.

* Total precipitation is the sum of the rainfall plus the water equivalent of snow. (Snowfall divided by ten).

B. Soils

Two types of soils have been recorded in the Wigwam Flats range between the altitudinal limits of 2500 feet and 5000 feet; Brown Wooded and Regosolic Dark Gray Chernozemic.

The soils on this range have been derived from parent materials of country rock, metargillite (indurated and metamorphosed claystone and other fine grained sediments) with rare and very thin calcite veins; alluvial and fan outwash materials which include large boulders from the nearby Silver Springs Lake chain trench, some limestones and stoney and sandy outwash in which calcium carbonate is still present.

The area of the Flats is a large alluvial terrace and was formed when a glacial lake in the Elk Valley broke a dam formed by the southern shoulder of Mount Broadwood. The debris from this broken dam formed the Wigwam Flats terrace and the trench in which the Silver Springs Lake chain is located. A large alluvial terrace blocked the Wigwam River until it weakened the eastern edge (farthest point from the origin) of the fan. The result is a deep gorge through which the Wigwam River flows. (Wright and Raunkia, 1966).

(a) Brown Wooded Soils

From the soil profiles studied, the Brown Wooded soils were described on five study sites; WF1, 4, 5, 6 and L-1. Study sites WF 2, 3 and L-3 were

judged by external features to be of this solid type. The shallow profile has developed on bedrock and on alluvial terrace of gravels and fine sands. This profile is characterized by a thin A-horizon of one-half inch, a thin sandy loam B-horizon of from two to eight inches and a gravelly sandy loam C-horizon that extends from 10 to 15 inches. The boundaries are all distinct and all are non-calcoxeous. Appendix B, Table A, shows a more detailed description of the soil profile.

(b) Regosolic Dark Gray Chernozemic

From the soil profiles studied, the Regosolic Dark Gray Chernozemic soils were described on five study sites; WF-L4, L5, L6, L7 and L8. Study site WF-L2 was judged by features to be of this soil type.

The shallow profile has developed on well drained slopes with much talus. This profile is characterized by a thin A-horizon of from one to four inches and a coarse sandy loam B-horizon of from six to eight inches deep. The C-horizon extends from 12 to 15 inches deep and consists of sandy clay loams. The horizon boundaries are

generally diffuse and vary in depth of calcareous deposits. Appendix B, Table B, shows a more detailed description of the soil profile.

C. Topography

The Wigwam Flats bighorn winter range lies to the north and east of the Elk River and west of the Wigwam River and Lodgepole Creek. The western boundary is below the China Wall on Mount Broadwood and the northern boundary is the Silver Springs Lake chain depression. The range is L-shaped and occupies shoulders and alluvial fans from Mount Broadwood, a large glacier deposited alluvial terrace and a low, rolling, rocky knoll with its associated knolls and alluvial terraces. The Elk and Wigwam Rivers form a deeply dissected canyon on the south and east sides of the range.

The elevation at the mouth of the Wigwam River is 2900 feet, the large glacial terrace is 3200 feet, the rolling knoll above Silver Springs Lake is 4000 feet and the highest point of the winter range on Mount Broadwood is 5000 feet. The total area of the winter range is approximately 10.2 square miles.

D. History of Vegetation

British Columbia Forest Service records of forest fires dating back to 1930, reveal that a large fire of unknown cause burned the area in 1931. The entire winter range was burned as

part of the fire that consumed many square miles around the winter range. A second fire in 1951, burned an area of less than 50 acres on the steep grassland slopes above the Wigwam River. This fire was caused by lightning.

In the early 1930's a hunting ban was placed on all members of the deer family in an area designated as the Morrisey Game Reserve. The Wigwam Flats bighorn winter range was included in the Game Reserve area. Elk and mule deer numbers built up to disasterous proportions. This and the fact that they lost their inhibitions and moved out onto the winter range early in the fall caused a gradual decline in the range productivity.

A few ranchers tried to utilize this area as a domestic stock range but were discouraged by the amount of wildlife grazing and browsing. The last stock rancher left the area in 1954. Since that time there has only been a few horses allowed to graze the area. They are permitted to range from April to February.

In 1965 the no hunting ban was removed from the Morrisey Game Reserve. A concentration of hunters in the area removed about 200 elk and numerous mule deer and also forced the remaining herds to remain at higher altitudes until after the hunting season. This gave the range a needed rest and as an end result there is a definite trend towards better range conditions.

E. Plant Communities

The plant communities established on this range are in various stages of fire-induced succession. Heavy use of developing seral communities by big game has hampered development of seral stages expected on this range.

No relict sites could be located. However, as evidenced by relict trees in the area and the numerous stumps, the climax vegetation was Pseudotsuga menziesii forest with an understory ranging between Calamagrostis rubescens and Agropyron spicatum depending on the density of the tree cover. A few of the slopes were open and probably contained Agropyron spicatum communities. Larix occidentalis was prevalent on the moister and higher areas. The area below China Wall was probably on Populus tremuloides seral community induced by the instability of much of the soil.

At present, the forest is regenerating on the knoll above Silver Springs Lake and on some of the area below China Wall. The Silver Springs knoll area is being reforested with Larix occidentalis, Pinus contorta and Pseudotsuga menziesii. The area below China Wall is once again developing to a Populus tremuloides.

The Wigwam Flats winter range, grassland and shrub areas, can be separated into five natural plant communities,

based upon two or three dominant species, with the biggest cover/frequency ratios. There is also one forest community of importance to the glacial terrace area.

Each of the six associations is summarized in the following, but for detailed lists of the species present and for cover/frequency ratios, refer to Appendix III.

1. The Agropyron-Koeleria-Rosa Community

The Agropyron-Koeleria-Rosa community forms the dominant community over the area of the glacial terrace. It occupies one area of acres. It has been described for Site WF1, 2 and 3. The area consists of shallow swales with no slope or aspect. There are two terraces, the lower being 3200 feet and the upper one at 3300 feet in elevation.

Ground coverage is 35 to 45 percent vascular plants, 12 percent litter, 2 percent rock, about 4 percent bare ground and between 33 and 48.8 percent cryptogams. Dominants in this community are Agropyron spicatum, Koeleria cristata and Rosa spp. Associated species found in the community are Festuca idahoensis, Lomatium Macrocarpum, Monarda fistulosa, Collomia grandiflora and Pseudotsuga menziesii.

This community has developed on Brown Wooded soil of fine sandy loam texture.

2. The Pseudotsuga-Calamagrostis-Spiraea Community

The Pseudotsuga-Calamagrostis-Spiraea Community has developed on the glacial terrace in areas where the fire of 1931 did the least damage to the forests. The areas under the existing forest are slightly kettled or with low ridges. The soil type is Brown Wooded with a texture of fine to gravelly sandy loam. The acreage of this community is acres. This community has been studied at three sites WF 4, 5 and 6.

The ground coverage consists of 32.5 to 42 percent vascular plants, 52 to 66 percent litter, 2 percent rock and 3 percent cryptogams. The dominant species in the community are: Pseudotsuga menziesii, Calamgrostis rubescens and Spiraea betulifolia. Associated species are: Festuca idahoensis, Koeleria cristata, Achillea millefolium, Aster spp. and Fragaria virginiana.

3. The Festuca-Koeleria-Danthonia Community

The Festuca-Koeleria-Danthonia community has developed in swales and on ridges forming the large knoll above Silver Springs Lakes. This area is now a grassland that developed after the fire in 1931. The soil type is Brown Wooded. The acreage of this community is acres. This community has been studied at two Sites, WF-L1 and L3.

The ground cover consists of 57.5 to 62.5 percent vascular plants, litter about 18 percent, 6 percent rock, 4 percent bare ground and 8.8 percent to 14.4 percent cryptogams. The

dominant species in the community are: Festuca ovina, Koeleria cristata and Danthonia spicata. Associated species are: Achillea millefolium, Antennaria rosea, Sedum lonceolatum, Tragopogom dubius, Rhinanthus, Cristagalli, Rosa spp., Spiraea betulifolia, and Symphori carpus ulbus.

4. The Rosa-Koeleria-Monarda Community

The Rosa-Koeleria-Monarda community has developed on the exposed knolls and terraces below China Wall. Since the fire of 1931 the soil in the area has become very unstable due to weathering at higher elevations. The soil type is Regosolic Dark Gray Chernozemic and is very stoney.

There is site variation between the two sites of this community L2 is on an alluvial fan below a rock cliff and L7 is on an exposed knoll above Plot L2. However, they both represent the same plant community. The ground coverage is 40 percent vascular plants, 10 percent litter, 14.4 to 26.3 percent rock, and 27.5 to 32.5 percent bare ground. The dominant plant species are: Rosa spp., Koeleria cristata, and Monarda fistucasa. Associated species are: Bromus tectorum, Achillea millefolium, Antennaria umbellata, Apocynum androsaemifolium, Aster spp., Penstemon eriantherus and Senecio canus. Plot L7 also has Poa compressa and Poa pratensis as associated species.

5. The Agropyron-Apocynum Community

The Agropyron-Apocynum Community has developed on steep slopes as openings to Pseudotsuga menziessii forests. The soil is unstable and rocky. The soil type developing is Regosolic Dark Chernozemic. This community has been described at three sites; one on the exposed slopes below the China Wall (L5) and two on the exposed slopes above the Elk River on the Silver Springs Knoll (L4 and L6).

There is some species difference between the three sites. The ground coverage is 34.4 to 55.6 percent vascular plants, 9.4 to 17.5 percent litter, 5 to 28.6 percent rock and 21.4 to 28.6 percent bare ground. The dominant species are: Agropyron spicatum and Apocynum androsaemifolium. Associated species are: Koeleria cristata (at site L4), Aster spp., Epilobium perenne, Monarda fistulosa (except site L6), Rosa app. (except site L4) and Symphoricarpos albus.

6. The Agropyron-Smyphoricarpus-Koeleria Community

The Agropyron-Symphoricarpus-Koeleria community has developed on rocky knolls below China Wall. It has been described to only one site, WF-L8. The soils are Regosolic Dark Gray Chernozemic. These soils are very rocky.

The ground coverage is 54 percent vascular plants, 8 percent litter, 23 percent rock, 12.5 percent bareground and 1.3

percent cryptogams. The dominant species are: Agropyron spicatum, Symphoricarpus albus and Koeleria cristata. Associated species are: Festuca ovina, Epilobium perenne and Spiraea betulifolia.

F. Animal Distribution

The Wigwam Flats winter range is used by bighorn sheep, mule deer, elk, whitetailed deer and horses. With the exception of horses, the use given the range by each species is relatively uniform. Bighorn tend to remain near the steep slopes and river banks but they do use the top of the Silver Springs knoll and the Flats. Elk and both species of deer, lately have been using the timber areas more than the open flat areas, but they do move on to these areas in the latter part of the winter. The few horses now on the range use the flat terraces and the Silver Springs knoll and avoid the steep areas.

The pellet group data for each plot is summarized in Appendix IV. In this Table, bighorn, mule deer and whitetailed deer have been grouped as the pellet groups from these three species cannot be readily separated.

DISCUSSION AND CONCLUSIONS

The Wigwam Flats bighorn winter range is divided into three main physiological units. These are: the knolls and ridges below China Wall, the large alluvial terrace and the plateau above Silver Springs Lake. The soils on this range are all youthful and have been influenced by the last ice age and by fire (the last one being in 1931). Thus the soils on this range are shallow and poorly developed.

Animal use has had an effect on the developing vegetation. The elk and deer herds were allowed to build up under protection of a hunting closure. These animals used the winter range early in the fall and until late spring. In 1954 the last homesteader left the range because he could not feed his livestock in lieu of the severe competition from big game. About 25 horses have grazed on this range from May to February every year. After the hunting closure was lifted in the fall of 1965, hunting reduced the elk and deer herds to about one-third of their previous numbers. These animals remained off the range until late in December and moved off early the next spring.

Bighorn followed the trend of the range conditions created by the elk and deer. The bighorn reached a population low in the early 1960's with low productivity. With the removal of the deer and elk herds and a corresponding general

range improvement the productivity of the bighorn increased. Continued range improvement will improve the bighorns survival changes on this range.

The alrge alluvial terrace has two main plant communities near the margin. The plant communities on this terrace are affected by the gradual deposits of fine and small rocks, Large boulders are located near the mouth of the gorge of the Silver Springs Lake chain.

This area has patches of mature Pseudotsuga Menziesii that went undamaged by the last fire. This forest consists of a plant community of Pseudotsuga-Calamagrostis-Spiraea. There is very little conifer regrowth in this plant community. The soil is shallow and rocky, the previous ungulate grazing has not affected this community too much in lieu of the soil conditions.

There is a high degree of big game use with a little use by horses. Elk and deer prefer to remain in the forest in the daylight. The bighorn use this community as an escape route towards the steeper areas from the open flats.

The other major community on the terrace is the Agropyron-Koeleria-Rosa community. Since the ungulate grazing pressure has been reduced on this range, this one plant community has shown the most immediate and impressive response. The area was formerly dominated by a Pseudotsuga menziesii forest and

will very likely return to a forest in time. At present there are few seedlings in this community. The plant community is now dominated by Agropyron spicatum and Koeleria cristata. However, the total vascular plant cover is only 35 to 46 percent of the area, much of the community is occupied by cryptogams.

This community receives heavy bighorn use and light mule deer, elk and horse use.

The slopes and knolls below China Wall on Mount Broadwood have been affected by the last fire. Much of the area is covered with Populus tremuloides. Shepherdia canadensis and Alnus sp. with very little understory developing because of unstable soil. On two ridges in this area small grasslands are developing. These grasslands are on shallow, rocky soil and are generally in poor condition because of this and because of over-use by big game.

The Rosa-Koeleria-Mondarda community does not have any good forage producing species dominating it. The 30 to 44 percent vascular plant cover consists mainly of weedy annuals, Mondarda fistulosa, Bromus tectorum and Achillea millefolium. Also there are several low growing perennials, Koeleria cristata, Antennaria umbrellata, Fragaria virginiana, Penstemon eriantherus, and Senecio canus. There is a high bighorn, mule deer and elk use on this community. The horses are fenced off from this area.

The other communities in this area are the Agropyron-Apocynum and the Agropyron-Symphoricarpus-Koeleria communities. The former is on exposed rocky slopes above Pseudotsuga menziesii relict trees and Populus tremuloides regrowth. Weak Agropyron spicatum plants combine with Apocynum androsaemifolium, Monarda fistulosa and Rosa sp. to form the majority of the 42 percent plant coverage. Big game use of this community is moderate. The main reasons for the condition of this site is the instability of the soil and the destruction of the previous plant community by fire.

On some exposed, steep, rocky slopes the community succession is such that the grassland succession is more developed than in the previous plant communities. The Agropyron-Symphoricarpus-Koeleria community is dominated by good forage producing species with a minimal amount of annuals and low-growing perennials. Bighorn use of this community is high and elk and mule deer use is moderate.

In the plateau region of Silver Springs Lake the southern slopes have a plant community similar to that on the slopes of China Wall, that of the Agropyron-Apocynum community. Bighorn and mule deer use of this community above the Elk River is high. Elk use is moderate.

On top of the plateau, a grassland community is developing on some of the area. This community is the Festuca-Koeleria-

Danthonia community. The soil is shallow in this community but several areas have springs that produce surface water in early summer. Much of the remaining area must have soil water near the surface, well in the hot summer. This moisture has produced this community after the 1931 fire. Although the area does not produce much forage it has adequate ground cover made up of a very many perennial grasses, forbs and shrubs.

Horses use localized areas in this community and overgraze it where they congregate. The area also has a high degree of big game use.

The community will eventually be included in the Larix occidentalis forest which borders it and which is just now getting re-established.

MANAGEMENT PROPOSALS

This winter range is just now improving after the severe abuse it received from the large elk and mule deer herds. Continued rest must be allowed if this range is to improve its bunchgrass cover so that bighorn will be allowed to follow this improvement trend.

Considerable forest revegetation is occurring, notably in the area below China Wall and on the plateau above Silver Springs Lake. Fire is the dominating force which has developed the grasslands on this range. Controlled burning must be carried out in the future in order to prevent the re-establishment of trees over much of this range.

At present, forest revegetation is not severe, however, it is dynamic and will slowly encompass much of the range. Preventive measures must be taken in the future to maintain this winter range as such -- a winter range for big game.

SUMMARY

1. A study of the vegetation, soils and use of the Wigwam Flats bighorn winter range was conducted during the summer months of 1966.

2. The canopy coverage method of vegetational analysis of Daubenmire (1959), the macroplot method of Poulton and Tisdale (1961) and linear transects were used to describe and classify range vegetation. Ungulate fecal groups were counted within belts along each randomly selected transect.

3. Soil profiles were described at nine study sites and chemical analysis is to be conducted on horizon samples. Where solid profiles were not described, soil classification was based on the type of vegetation present, physiography and the interpretation of aerial photographs.

4. The vegetation of this range is improving with decreased big game use.

5. Big game use is general throughout the range. Bighorn, mule, deer and elk can be found throughout the winter range. Horse use is confined to the plateau and large terrace.

6. There are no climax communities on this range. The entire area being burned in 1931. A few stands of Pseudotsuga menziesii are relict but their understory may have been burned. The terrace area grasslands are the most productive with a high coverage of Agropyron spicatum. Few other areas on this range are so fortunate. Communities developing on the ridges and slopes below China Wall are hampered by the instability of the soil as are communities on the slopes of the plateau. The Festuca-Koeleria-Danthonia community on the flat areas of the plateau has a high degree of stability, but, is a low forage producer.

7. The following factors must be controlled for maintenance of this area as a bighorn and a big game winter range.

(a) controlled burning to prevent encroachment of the grasslands by forests.

(b) Continued low animal use until the grasslands show marked improvement and the soil begins to stablize.

APPENDIX I

Scientific and Common Names and Authorities

For Plant and Animal Species Mentioned

References: Cowan and Guiguet (1956)
Davis, (1952)
Hitchcock, A.S. revised by Agnes Chase (1950)
Hitchcock, C.L., A. Cronquist, M. Ownbey and J.W.Thompson (1955-1964)

GRASSES AND GRASSLIKE PLANTS

Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch wheatgrass
Agrostis scabra Willd.	Bentgrass
Bromus tectorum	Downy chess
Calamagrostis rubescens Buckl.	Pinegrass
Danthonia spicata (L.) Beauv. ex. Roem.&Schult	Poverty Oat grass
Festuca idahoensis Elmer.	Idaho fescue
Festuca ovina L.	Sheep fescue
Koeleria cristata (L.) Pers	Junegrass
Poa compressa L.	Canada bluegrass
Poa pratensis L.	Kentucky bluegrass
Carex sp. (Rupp.) L.	Sedge

FORBS

Achillea millefolium L.	Yarrow
Allium cernum Roth.	Nodding onion
Alyssum allysoides L.	
Antennaria rosea Greene	Pink pussytoes
Antennaria umbrinella Rydb.	Everlasting
Apocynum androsaemifolium L.	Dogbane
Aster sp. L.	Aster
Balsamorhiza sagittata (Pursh) Nutl.	Balsamroot
Collinsia parviflora (Lindl.)	Blue-eyed Mary
Collomia grandiflora (Doug. ex. Lindl.)	
Epilobium minutum Lindl. ex. Hook	Willow herb
Erigeron compositus Pursh.	Fleabane
Fragaria virginiana Duchesne	Strawberry
Gaillardia aristata Pursh.	Blanketflower
Geum macrophyllum Willd.	
Heuchera cylindrica Dougl. ex. Hook	Alumroot
Lomatium macrocarpum (Nutt.) Coult. & Rose	Biscuitroot
Monarda fistulosa L.	Horsemint
Orthocarpus tenuifolius (Pursh) Benth.	Owl clover
Penstemon confertus Dougl.	Beard tongue
Penstemon eriantherus Pursh.	Beard tongue
Phlox hoodii Rich.	Wildl Sweet William
Polygonum douglasii Greene	Knot weed
Rhianthus crista-galli L.	
Sedum lanceolatum Torr.	Stonecrop
Senecio canus Hook	Butterweed
Tragopogon dubius scop.	Goatsbeard
Vicia americana Muhl. ex. Willd.	Vetch

SHRUBS

Berbevis nervosa Pursh.	Oregon grape
Rosa woodsii Lindl.	Rose
Spirea betulifolia Pull.	Flat-topped spirea
Symphoricarpus albus (L.) Blake	Snowberry

TREES

Larix occidentalis Nutt.	Western Larch
Pinus contorta Dougl.	Lodgepole Pine
Pseudotsuga menziesii (Mirb.) France	Douglas Fir

ANIMALS

Cervus canadensis nelsoni Bailey	Rocky Mountain Elk
Odocoileus hemionus hemionus Rabinesque	Mule deer
Odocoileus virginianus ochrourus Bailey	Whitetailed deer
Ovis canadensis canadensis Shaw	Rocky Mountain bighorn sheep

APPENDIX II

Profile Description of Representative Soils

of the Wigwam Flats Bighorn Winter Range

TABLE A

Brown Wooded Soil

Study Site Number: WF1 Slope and Aspect: nil

Land form and relief: slightly kettled terrace Drainage: rapidly drained

Elevation: 3300 feet Parent Materials: glacial outwash

Vegetation: Agropyron-Koeleria-Rosa Fire Sere

Horizon	Depth Inches	Description
A	0 - ½	Dark brown (10YR 3/2, dry; very dark brown, 10YR 2/2, moist) very fine sandy loam. Non-sticky and non-plastic when wet. Very loose crumb structure attached to fibrous roots. Boundary diffuse.
B	½ - 2	Pale brown (10YR 6/3, dry; dark brown, 10 YR 3/3, moist) sandy loam. Angular blocky, breaking to crumb and granules. Non-sticky and non-plastic when wet. Boundary distinct.
C	2-10	Yellowish gray (10YR 7/3, dry; yellowish, brown, 10YR 5/4, moist). Gravelly sandy loam. Weak, angular, blocky breaking to crumb and granules. Porous and riable. Non-sticky and non-plastic when wet.

TABLE B

Regosolic Dark Gray Chernozemic

Study Site Number: WF L-5 Slope and Aspect: 80 percent SW

Land form and relief: talus covered slope Drainage: well drained

Elevation: 3650 feet Parent Materials: Coarse talus materials of metargillite

Vegetation: Agropyron-Apocynum Fire Sere

Horizon	Depth Inches	Description
A	0 - 1	Yellowish gray (10YR 7/3, dry; dark brown, 10 YR 3/2, moist). Gritty very fine sandy loam. Granular structure. Non-sticky and non-plastic when wet. Boundary diffuse.
B	1 - 8	Light yellowish brown (loYR 6/4, dry; dark grayish brown 10YR 4/3 moist). Sandy loam. Weak, angular blocky breaking to medium crumb. Non-sticky and very plastic when wet. Boundary diffuse.
C	8 - 12	Pale brown (10YR, 6/3, dry; dark grayish brown, 10YR 5/2, moist). Loamy sand. Loose granules and crumb. Non-sticky and non-plastic when wet.

APPENDIX III

Plant Community Structure in the Study Sites of the Wigwam Flats Bighorn Winter Range

TABLE A Summary of major plant species cover/frequency and nature of ground cover for three sites on the grassland flats.

	Plant Cover/Frequency		
	Agropyron	Koeleria	Rosa
Plot	WF1	WF2	WF3
GRASSES			
Agropyron spicatum	21/85	38/100	38/100
Festuca idahoensis	7/57	3/17	4/33
Koeleria cristata	18/100	19/93	23/97
FORBS			
Achillea millefolium	5/50	1/5	t/5
Allium cernum	1/13	2/27	2/30
Collinsia parviflora	t/3	t/17	1/40
Collomia grandiflora	--	2/57	1/50
Fragaria virginiana	--	1/7	5/25
Gaillardia aristata	3/53	--	t/3
Lomatium macrocarpum	10/83	7/70	9/83
Monarda fistulosa	t	7/70	5/57
Orthocarpus tenuifolius	2/40	t/5	1/10
Phlox hoodii	1/20	2/45	1/33
Polygonum douglasii	--	1/30	1/13
Sedum lanceolatum	--	t/13	1/30
Senecio canus	1/10	5/70	1/30
TREES AND SHRUBS			
Pseudotsuga menziesii (seedling	t/3	t/3	t/3
Rosa woodsii	9/75	13/73	7/60
GROUND COVER (%)			
Vascular plants	45	35	46
Litter	13	12	12
Rock	1	3	2
Bareground	9	2	1
Cryptogams	33	49	40
Elevation (feet)	3300	3200	3200
Slope (%)	nil	nil	nil
Aspect	nil	nil	nil

TABLE B Summary of major plant species cover/frequency and nature of ground cover for three sites on the relict forests on the flats.

	Plant Cover/Frequency (%) Pseudotsuga-Calamagrostis-Spiraea		
PLOT	WF4	WF5	WF6
GRASSES			
Calamagrostis rubescens	57/100	31/98	37/97
Festuca idahoensis	5/35	10/57	1/5
Koeleria cristata	6/45	13/90	3/23
FORBS			
Achillea millefolium	5/50	2/30	5/43
Aster sp.	2/27	3/30	2/23
Collomia grandiflora	1/23	t/10	t/7
Fragaria virginiana	1/17	2/35	1/23
Vicia americana	--	--	5/35
SHRUBS AND TREES			
Pseudotsuga menziesii (Seedling)	1/20	3/23	1/13
Rosa woodsii	t/3	t/3	1/15
Spiraea betulifolia	19/85	21/80	10/53
Symphoricarpus albus	2/7	1/5	7/40
GROUND COVER (%)			
Vascular plants	42	41	33
Litter	54	52	66
Rock	2	3	--
Bareground	--	1	--
Cryptogams	3	4	2
Elevation (feet)	3300	3300	3300
Slope (%)	nil	nil	nil
Aspect	nil	nil	nil

TABLE C Summary of major plant species cover/frequency and nature of the ground cover for the grassland community of the Silver Springs Plateau.

	Plant Cover/Frequency (%)	
	Festuca Danthonia Koeleria	
PLOT	WF L-1	WF L-3
GRASSES		
Agrostis scabra	1/13	1/7
Danthonia spicata+	10/63	1/7
Festuca ovina	26/100	37/100
Koeleria cristata	9/63	17/93
Poa compressa	10/23	t/5
Carex sp.	t/3	1/17
FORBS		
Achillea millefolium	7/60	16/100
Antennaria rosea	5/40	5/57
Antennaria umbrinella	5/45	t/5
Aster sp.	3/35	2/45
Collomia grandiflora	1/50	2/80
Epilobium minutum	1/27	1/35
Erigeron compositus	1/23	--
Geum macrophyllum	1/25	3/27
Heuchera cylindrica	--	3/23
Penstemon confertus	--	5/43
Rhianthus crista-galli	5/43	2/45
Sedum lanceolatum	2/55	3/70
Tragopogon dubius	7/63	2/27
SHRUBS		
Berberis nervosa	4/23	1/5
Rosa woodsii	6/25	1/13
Spiraea betulifolia	4/43	2/23
Symphoricarpus albus	2/15	5/33
GROUND COVER (%)		
Vascular plants	63	57
Litter	15	21
Rock	6	7
Bareground	3	6
Cryptogams	14	9
Elevation (feet)	3750	4100
Slope (%)	15	12
Aspect	S	SE

TABLE D Summary of major plant species cover/frequency and nature of broud cover for two bunchgrass communities on sloping terrain.

	Plant Cover/Frequency (%)			
	Agropyron-Apocynum			Agropyron-Symphoricarpus-Koeleria
PLOT	WF L-4	WF L-5	WF L-6	WF L-8
GRASSES:				
Agropyron spicatum	26/100	14/95	54/100	47/100
Festuca ovina	--	--	--	3/33
Koeleria cristata	6/47	--	t	12/63
FORBS				
Achillea millefolium	t/5	1/7	t/3	1/20
Alyssum allysoides	3/53	t	t/7	--
Apocynum androsaemifolium	20/93	26/70	23/95	--
Aster sp.	1/13	8/60	t/3	--
Balsamorhiza sagittata	2/13	--	--	t
Collinsia parviflora	t/7	t/5	t/3	1/33
Collomia grandiflora	1/40	t/5	t/7	1/43
Epilobium minutum	3/77	t/15	t/5	2/63
Vicia americana	--	3/40	t	--
Monarda fistulosa	6/37	22/97	--	--
SHRUBS				
Rosa woodsii	--	6/53	2/10	1/7
Spiraea betulifolia	t/5	--	2/17	1/17
Symphoricarpus albus	3/17	1/10	6/37	17/65
GROUND COVER (%)				
Vascular plants	34	42	56	54
Litter	17	9	11	8
Rock	21	29	5	23
Bareground	29	21	28	13
Cryptogams	--	--	--	1
Elevation (feet)	3750	3650	3350	3800
Aspect	SW	SW	SW	Sw
Slope (%)	51	66	65	49

TABLE E Summary of major plant species cover/frequency and nature of ground cover for the Rosa-Koeleria community on the China Wall knolls.

	Rosa	Koeleria	Monarda
PLOT	WF L-2		WF L-7
GRASSES			
Agropyron spicatum	--		4/25
Bromus tectorum	2/40		1/27
Festuca idahoensis	1/10		--
Koeleria cristata	3/43		11/85
Poa compressa	--		12/55
Poa pratensis	--		11/30
Carex sp.	1/7		2/33
FORBS			
Achillea millefolium	2/17		3/50
Allium cernum	2/15		2/25
Alyssum allysoides	--		5/83
Antennaria umbrinella	9/67		1/10
Apocynum androsaemilfolium	3/15		8/65
Aster sp.	2/33		8/77
Collomia grandiflora	t/3		1/40
Fragaria virginiana	2/25		5/20
Monarda fistulosa	17/83		7/45
Penstemon eriantherus	4/40		3/20
Senecio canus	5/53		15/90
SHRUBS			
Rosa woodsii	22/93		10/67
Symphoricarpus albus	--		2/15
GROUND COVER (%)			
Vascular plants	34		44
Litter	13		9
Rock	26		14
Bareground	27		33
Cryptogams	--		--
Elevation (feet)	3550		3800
Slope (%)	47		35
Aspect	SE		SW

APPENDIX IV

Fecal Group Counts on the Wigwam Flats

Bighorn Winter Range

TABLE A Fecal group counts on the Wigwam Flats bighorn winter range.

Plant Community	Plot	Bighorn & Deer	Elk	Horse
Agropyron-Koeleria-Rosa	WF1	1643	89	355
	WF2	2575	133	266
	WF3	2309	177	488
Pseudotsuga-Calamagrostis-Spiraea	WF4	1909	755	444
	WF5	2398	1465	355
	WF6	977	577	444
Festuca-Danthonia-Koeleria	WF L-1	5187	815	1260
	WF L-3	1556	741	148
Agropyron-Aprocynum	WF L-4	1176	667	---
	WF L-5	815	222	---
	WF L-6	667	296	---
Agropyron-Symphoricarpus-Koeleria	WF L-8	1037	371	---
Rosa-Koeleria-Monarda	WF L-2	741	593	---
	Wf L-7	2223	74	---

RESULTS

Ecology of the Bull River Bighorn Winter Range

A. Climate

The climate of the Bull River winter range region is profoundly influenced by the adjacent mountains. Relief, altitude, aspect and position, which change markedly over short distances, cause wide variations in local climate. Precipitation patterns and precipitation:evaporation ratios are highly variable.

A weather station of long duration (15 years) is situated at the Aberfeldie power plant on the Bull River. This station is 2,640 feet in elevation and is located in the deep narrow trench cut by the Bull River. Eleven years of data are summarized in Table I.

From Table I it may be seen that mean monthly temperatures are above freezing between March and October. However, below freezing temperatures have been recorded in nearly all months. An examination of several years' records indicated that in average years only the months of June to September are frost free (B. C. Department of Agriculture, 1962, 1963 and 1964). As in many valleys in British Columbia, a June precipitation peak is recorded. Relatively high temperatures and low rainfall in July and August cause drought periods in most years. Snow melt-water usually compensates for the relatively low precipitation in March and April.

The average total snowfall approaches five feet. As the degree of exposure to wind and sunlight greatly affects snow

depth, accumulated snow depths vary markedly at different locations. Some melting occurs at various times throughout the winter causing crusting when followed by freezing temperatures. Total melting of the snow is usually associated with winds and warm temperatures beginning in March.

Table I. Eleven year average temperature and precipitation records from the Aberfeldie Weather Station. Data from B. C. Department of Agriculture (1962).

Month	Mean Temperature (°F.)	Total[1] Precipitation (in.)
January	21	3.3
February	26	1.8
March	33	1.0
April	43	1.0
May	53	1.8
June	58	2.7
July	65	1.0
August	63	1.7
September	55	1.5
October	44	1.9
November	31	2.1
December	25	2.3
Absolute Max.-Min	98 -38	
Annual Average	43	22.2
Av. Snowfall		58.8

[1]Total precipitation is the sum of the rainfall plus the water equivalent of the snowfall. (Snowfall divided by ten.)

B. Soils

Three types of soils are present in the Bull River range between the altitudinal limits of 2500 feet and 5000 feet; Regosolic Brown Wooded, Regosolic Dark Gray Chernozemic, and Minimal Brown Wooded and associated Regosols.

Soils on this range have been derived from parent materials of country rock metargillite (indurated and metamorphosed claystone and other fine grained sediments) with rare and very thin calcite veins; colluvial and fan outwash materials which include large boulders not found in the general area, some limestones and stoney and sandy outwash in which calcium carbonate is still present (Wright et. al. 1966).

(a) Regosolic Dark Gray Chernozemic Soils

From soil profiles studied, the Regosolic Dark Chernozemic soils were identified on three study sites; BR 4, L2 and L3. Study site BR 3 was judged by external features to be of this soil type.

The shallow profile has developed on glacial outwash gravels and fine sands with abundant calcium carbonate. This profile is is characterized by a thin, powdery A horizon of four inches, a weakly structured B horizon of about eight inches and in only one profile, a C horizon of seven inches, which is also weak in structure. The B and C horizons grade into stoney material and all pits show calcium carbonates at about 12 inches. Appendix II, Table A shows a more detailed description of the soil profile. These profiles have good internal drainage resulting in semi-arid conditions.

(b) Regosolic Brown Wooded Soils

The Regosolic Brown Wooded soil was found in five study sites: BR 1, 2, 5, L1 and L4. Study sites BR 7 and 8 were also classified as belonging to this soil group. This soil has developed over two different types of parent materials, (1) metargillite and (2) stoney, glacial outwash.

Regosolic Brown Wooded soil formed from metargillite parent material, is located on south-facing slopes at study sites BR L1 and L4. This soil has a shallow A horizon of less than three and one-half inches with a diffuse boundary. The B horizon is about eight inches in depth consisting of stoney, clay loam also with a diffuse lower boundary. The C horizon is about five inches deep, grading into shattered rock.

Regosolic Brown Wooded soil formed from glacial outwash parent material, is located on high terraces. The profile has a shallow A horizon of two and one-half inches which is distinctly separated from the B horizon. The latter is about ten inches deep and also has a distinct boundary. The C horizon is approximately fifteen inches deep, grading into shattered rock.

A more detailed description of the Regosolic Brown Wooded soils appear in Appendix II, Table B and C. This soil shows variation in the amount of standing water accumulated ranging from standing water and inwashing to good internal drainage.

(c) Minimal Brown Wooded Soils

The Minimal Brown Wooded soil was identified at two study sites BR 6 and 11. Study sites BR 9 and 10 were also classified as this soil type. This soil is developed from colluvial and

fan outwashes of nearby metargillite slopes.

Regosols associated with Minimal Brown Wooded soils is found on a broad outwash fan with pronounced hummocky relief. The soil profile has been described for BR 6. It is characterized by a thin, one-inch A horizon distinct from the eleven-inch B horizon which grades into larger stones and boulders.

Minimal Brown Wooded soils from metargillite colluvium, developed on a high terrace landform with hummocky micro-relief. This profile was described at BR 11 and related to BR 9 and 10. It has a shallow A horizon with a diffuse boundary to a shallow B horizon. The B horizon merges with a shallow C horizon that extends down to twelve inches. The C horizon at twelve inches rests on a boulder, clay or sand layer.

This soil type appears to have a variance of internal drainage depending on the amount of clay layering present in the parent materials of the soils. Appendix II, Tables D and E show more details for this soil type.

C. Topography

The Bull River bighorn winter range lies on the north bank of the Bull River and to the south of Little Bull Creek. The eastern boundary is blocked by the rugged Steeples and the western boundary is the Kootenay River flat between the Bull River and the Little Bull Creek. The winter range is a large glacial terrace deeply dissected by the meandering Bull River. The large terrace is covered in two places (Burnt-bridge Creek and Petar Brook) by alluvial fans which originate from the Steeples.

The elevation of the Bull River is 2,500 feet, while the terraces are located at 2,900 feet. The highest point of the winter range on the Steeples is about 4500 feet. The total area of the winter range is approximately 5.3 square miles.

D. History of Vegetation

British Columbia Forest Service records of forest fires, dating back to 1930, reveal that two large fires of unknown causes burned the area in 1931. The larger fire moved northward from Elko, burned the Pickering Hills and crossed the Bull River. This fire burned the river breaks and main terraces of the south half of the bighorn sheep winter range. The smaller fire was confined to the northside of the Bull River where it overlapped the larger fire and burned the northern three quarters of the range.

Three other fires of little consequence to the sheep range occurred in this area after 1931. In 1940 two small fires occurred on either side of the Bull River near its mouth. Another small fire caused by lightening, occurred in 1958 on steep slopes above a farm (Hansen's) located to the north of the Bull River bridge.

The two fires of 1931 burned a climax forest of Pseudotsuga menziesii and Pinus ponderosa. These fires were so intense that very few trees survived and the ground cover was completely destroyed. The damage was so great that even thirty-five years after the fire, regeneration of the forest is still very limited.

E. Plant Communities

The plant communities established on this range are in various stages of fire-induced succession. Heavy use of

developing seral communities by livestock and big game has hampered development of seral stages expected in this region.

No relict sites could be located. However, as evidenced by the dense conifer forests to the north-west of this range the climax vegetation was a Pseudotsuga menziesii-Pinus ponderosa forest.

Throughout the burned terrace area, Purshia tridentata is the dominant species forming an association with Poa compressa and P. pratensis. The alluvial fans are covered with dense shrubs, mainly Amelanchier alnifolia and Ceanothus sanguineus, but Salix spp. and Betula spp. also occur.(Fig.2). The lower reaches of the Steeples are more varied in their floristic composition. Generally, the southern exposures contain small grasslands surrounded by Pseudotsuga menziesii forests while northern exposures are covered with dense shrubby regrowth.

Only three extensive areas of forest regeneration occur on this range. The south-western end of the terrace is reforested with Pseudotsuga menziesii, Pinus contorta and Larix occidentalis. These trees are about thirty-five years old, less than thirty-five feet high and their density is low. Along the two small streams arising in the Steeples, Burnbridge Creek and Petar Brook, thirty year old Populus tremuloides and Betula spp. are established. Finally, the top of the knoll west of the Aberfeldie reservoir is poorly reforested with thirty year old Pinus contorta and Pseudotsuga menziesii less than thirty-five in height.

The Bull River winter range can be separated into eight plant

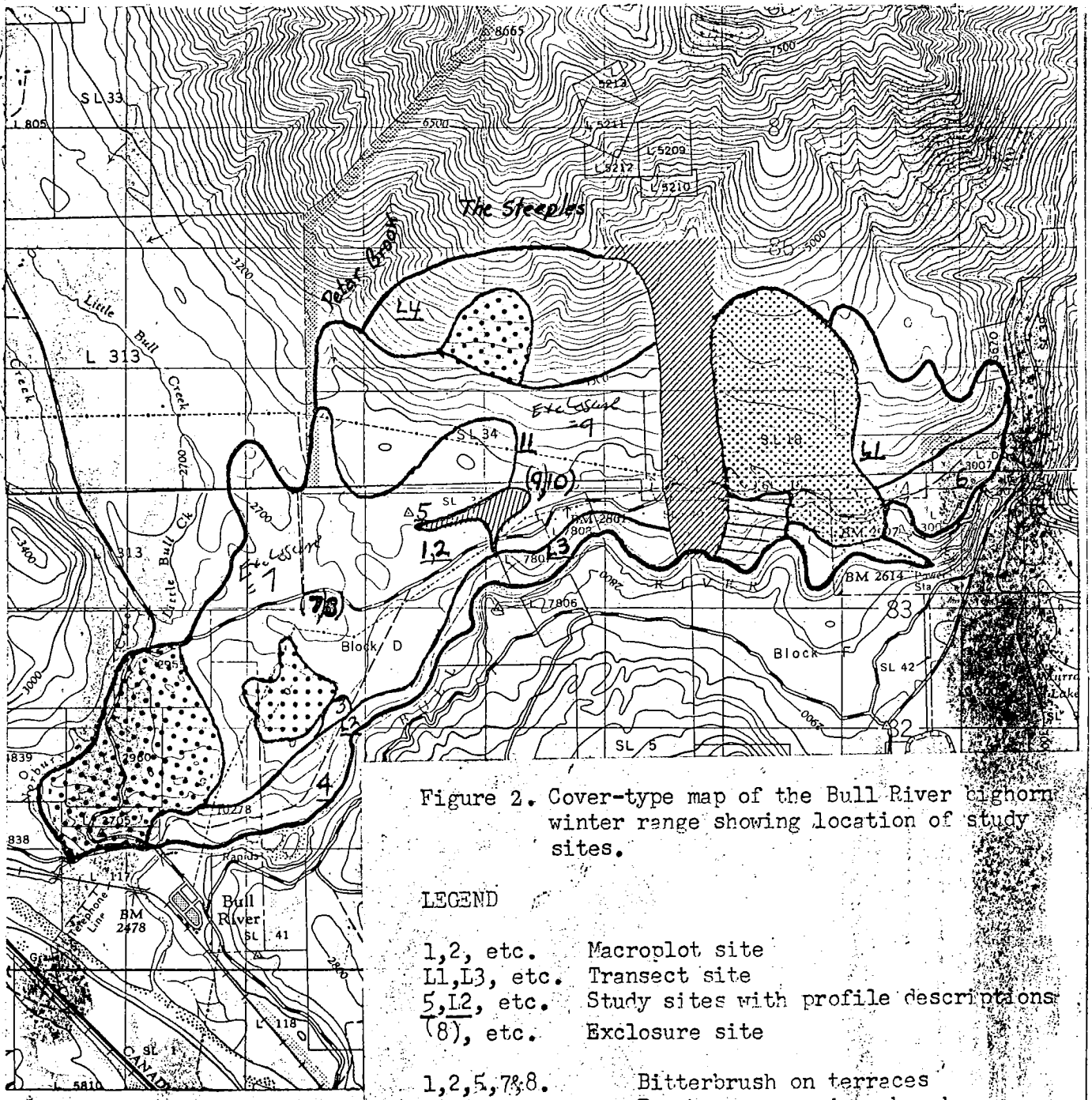

Figure 2. Cover-type map of the Bull River bighorn winter range showing location of study sites.

LEGEND

1,2, etc.	Macroplot site
L1,L3, etc.	Transect site
5,L2, etc.	Study sites with profile descriptions
(8), etc.	Exclosure site

1,2,5,7&8.	Bitterbrush on terraces
L2 & L3.	Bunchgrass on river breaks
3 & 4.	Bitterbrush on river breaks
L1 & L4.	Bunchgrass on rocky knolls
9,10,11 &	Deciduous shrubs on alluvial fans
6 &	Sodgrasses on terraces
	Willows on creek bottoms
	Forest regeneration

Scale, 1:50,000

communities based upon two or three dominant species with the highest cover-frequency ratios. Each of these associations is summarized in the following, but for detailed lists of the species present and for cover-frequency ratios, refer to Appendix III.

1. The Agropyron-Festuca Community

The Agropyron-Festuca community has been described at only one site, BR-L1, located on a south-facing exposure at 3,550 feet of elevation. The area occupied by this community is 170 acres. Ground coverage is forty-eight percent vascular plants, twenty-four percent litter and eighteen percent rock and bare ground. Dominants in this community are Agropyron spicatum, Festuca idahoensis and F. scabrella as noted in Figure 3. Associated species found in this community are Collinsia parviflora, Collomia grandiflora, Apocynum androsaemifolium, Sedum lanceolatum and Symphoricarpus albus.

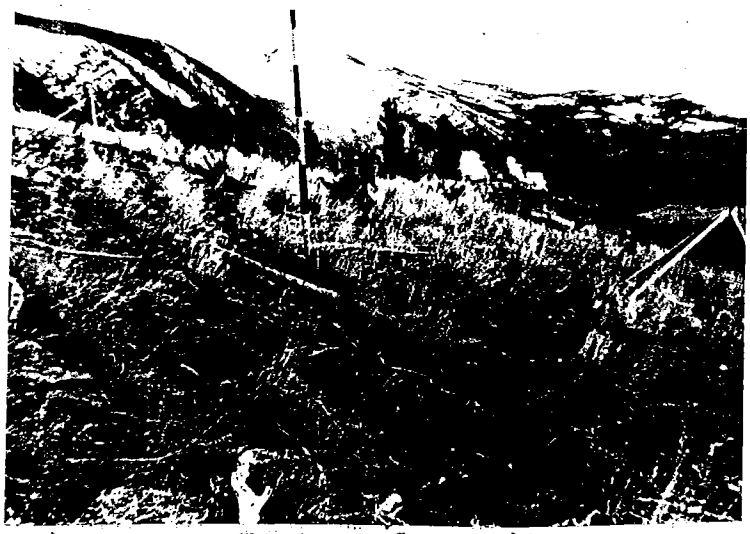

Figure 3. The Agropyron-Festuca Community. This sere is established on rocky knolls above high terraces. The tall grass plants are Agropyron spicatum, the short grass plants are Festuca idahoensis.

2, The Agropyron-Symphoricarpus Community

At elevations above the Agropyron-Festuca community the Festuca dominant gives way to Symphoricarpus albus, previously listed as only an associated species. On one site, BR L4, at 4300 feet, a plant community of Agropyron spicatum-Symphoricarpus albus was found on Regosolic Brown Wooded Soils. This community, occupying 50 acres, has a high plant coverage of 66 percent, very little litter, 8 percent and a high percentage of rock, twenty-three percent.

Associated plant species are Calamagrostis rubescens, Achillea millefolium, Collinsia parviflora and Ceanothus velutinus.

3. The Purshia-Poa Community has developed on terraces composed of Regosolic Brown Wooded Soils and occupies an area of 610 acres. This area is characterized by stoney glacial outwash of well stratified clay and stone layers with calcium carbonate present from one to one and one-half feet below the soil surface.

This community consists of three dominant species, one shrub Purshia tridentata, and two grasses, Poa pratensis and P. compressa. Associated species are: Koeleria cristata, Achillea millefolium, Antennaria rosea and Amelanchier alnifolia. In this community, plant cover varies from fifty-two to seventy percent and litter accumulates from eleven to forty-one percent.

There is site variation within this association with differences in the internal drainage affecting the cover and frequency percent[1] of various species. Plots BR 1, 2, 7 and 8

---

[1] Henceforth referred to as C/F.

have poorly drained soils with evidence of inwashing. These plots also show a higher density of vascular plant cover, fifty-six to seventy-nine percent and a lower level of litter coverage, eleven to twenty-seven percent. In contrast, BR 5 has well drained soils, a vascular plant cover of fifty-two percent and a litter cover of forty-one percent. The C/F of some species on site BR 5 show that Poa compressa is 62.7/97.5 but P. pratensis is a low 5.9/20. Purshia tridentata is also low with 24.4/40. Plot BR 5 differs from the others in this community in the C/F of other plants but such differences are not considered significant. However, Bromus tectorum occurs in only trace amounts in this plot and Chrysopsis villosa is most frequently encountered at this site.

The four other plots in this community, BR 1, 2, 7 and 8 do not have as high C/F for Poa compressa. Rather, P. pratensis has a high C/F, and Purshia tridentata is the most frequently encountered shrub.

Figure 4. The Purshia-Poa community is most common on terraces. Summer grazing by cattle left very little forage for carry over. Note the density of Purshia tridenta and the limited size of grassy intershrub areas.

4. The Agropyron-Purshia Community

The Agropyron-Purshia community has developed on Regosolic Dark Gray Chernozemic soils and Regosols associated with Dark Gray Chernozemic soils. The area occupied by this community is 120 acres and is characterized by glacial outwash materials of gravels and sands. The soils have abundant calcium carbonate, and are developed on steep, south and southwest facing slopes from 2,700 to 2,800 feet.

The Agropyron-Purshia community has developed on an area which was burned twice in 1931 and has since then received only winter ungulate grazing and browsing. This area was frequented by bighorn and is still used by deer but not by domestic stock. The ground coverage is vascular plants fifty-four to sixty-one percent, litter nineteen to twenty-two percent, and bare ground fifteen to twenty-one percent. Two plots were established in this association, BR-L2 and L3.

The dominants are Agropyron spicatum, and Purshia tridentata (see Fig. 5), with associates of Koeleria cristata, Chrysopsis villosa, Epilobium minutum, Linum perenne, Artemisia frigida and Symphoricarpus albus.

In areas of gentler slope the community changes to Purshia-Bromus-Agropyron and to Purshia-Bromus seres. The area occupied by both these variants is 180 acres.

Figure 5. The Agropyron-Purshia Community. This sere is established on steep river breaks where there is no livestock grazing. Note the abundance and condition of Agropyron spicatum in the foreground.

5. The Purshia-Bromus-Agropyron Community

The Purshia-Bromus-Agropyron community is represented by only one plot BR 3. The area occupied by this community is 110 acres and is characterized by a slope of only twenty-six percent, compared to fifty percent for the Agropyron-Purshia community.

Vascular plants form seventy-three percent of the ground cover while litter comprises twenty-three percent. The dominants are Purshia tridentata, Bromus tectorum and Agropyron spicatum, with associates of Koeleria cristata, Achillea millefolium, Chrysopsis villosa, Colloma grandiflora, Tragopogon dubius and Symphoricarpus albus. See Appendix III, Table C for a comparison between the Agropyron-Purshia community and the Purshia-Bromus-Agropyron sere.

6. The Purshia-Bromus Community

The Agropyron-Purshia community regresses further to a state where Agropyron spicatum is no longer a dominant species but only an associate. On flat areas along the river breaks, (represented by Plot BR 4) animal use has changed the plant communities on Regosolic Dark Gray Chernozemic soils to a sere where Purshia tridentata and Bromus tectorum are dominants, with associates of Agropyron spicatum, Koeleria cristata, Chrysopsis villosa, Achillea millefolium, and Amelanchier alnifolia. The ground coverage in this sere of seventy acres is sixty-six percent vascular plants and twenty-eight percent litter.

See Appendix III, Table C for a comparison of plant C/F in the Purshia-Bromus sere with other seres and associations on the Regosolic Dark Gray Chernozemic soil type.

7. The Amelanchier-Ceanothus-Poa Community

On Regosolic soils associated with Minimal Brown Wooded Soils that have developed on alluvial fans or metargillite fragments, a complex sere of Amelanchier-Ceanothus-Poa has developed. This community occupies an area of 1100 acres. It is represented by three plots BR 9, 10 and 11.

The ground coverage of vascular plants is about seventy to eighty percent and of litter about twenty percent. Dominant plant species are Amelanchier alnifolia, Ceanothus sanguineus and Poa compressa (see Fig. 6). Associated species are Agropyron trachycaulum, Calamagrostis rubescens, Apocynum androsaemifolium, Symphoricarpus albus and Berberis nervosa.

Figure 6. The Amelanchier-Ceanothus-Poa community on alluvial fans at the base of the Steeples. Overuse by wildlife and cattle has deformed the Amelanchier alnifolia on the right.

8. The Poa-Symphoricarpus Community

The Poa-Symphoricarpus community is located on a terrace of Minimal Brown Wooded Soil occupying forty acres. This community (Plot BR 6) is established on metargillite colluvium over glacial fill at an elevation of 2,950 feet.

Vascular plants and litter form sixty-six percent and twenty-nine percent of the ground cover respectively. In this sere Poa compressa and Symphoricarpus albus are dominant with Koeleria cristata, Achillea millefolium, Spiraea betulifolia and artificially planted Pinus ponderosa occurring as associates (see Fig. 7).

See Appendix III, Table D for a list of plant species and their C/F for this sere and for a comparison with the Amelanchier-Ceanothus-Poa sere.

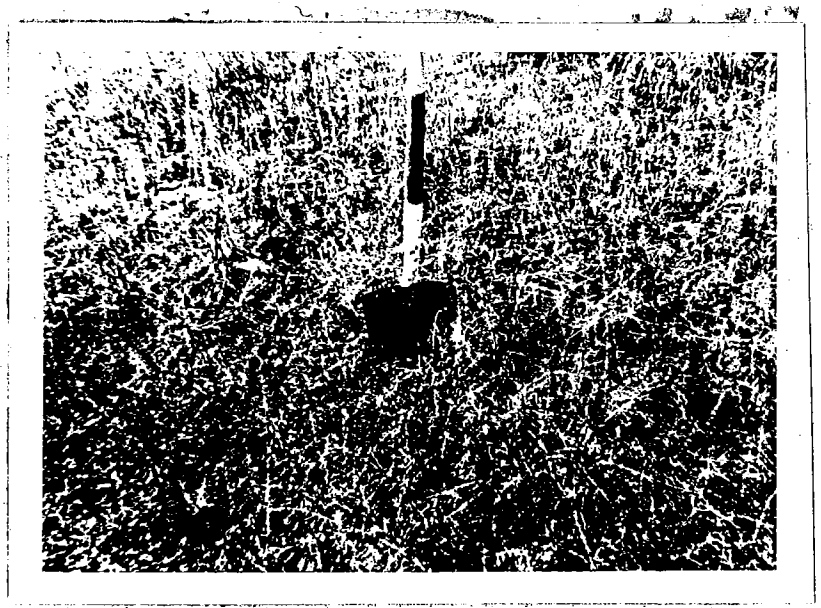

Figure 7. The Poa-Symphoricarpus community forms on terraces of metargillite colluvium. Overuse by cattle and big game has reduced the winter grazing potential of this community.

F. Animal Distribution in Relation to Topography and Plant Associations.

The Bull River winter range is used by cattle, white-tailed and mule deer, elk and was formerly used by bighorn sheep. The use given to the range is not distributed evenly but is affected by topography and the plant associations present.

Fecal group counts were conducted on each study site in order to determine the relative abundance and distribution of each ungulate species. Unfortunately, both species of deer had to be grouped with bighorn as pellet groups from these three species cannot be readily separated.

The numbers of fecal groups per acre for four topographical units and eight plant associations are summarized by species or species groups in Appendix IV. It is noteworthy from these results that in terms of relative abundance, elk and horses do not contribute heavily to the utilization of the range. It is also obvious that from a topographical point of view, cattle and horses do not use steep shoulders or the river breaks, but tend to concentrate primarily on high terraces and alluvial fans (e.g. study sites 5 and 7).

Bighorn sheep and deer, as represented by fecal droppings, are widely distributed throughout all topographical types but tend to concentrate on steep shoulders and river breaks. It is also apparent that the use of associations containing Agropyron spicatum is twice as heavy as for all other associations. (Average of 1,650 pellet groups per acre as opposed to 792) It is impossible from these data

to determine if topography influences distribution to a greater extent than does plant associations. However, if the terraces are revegetated, similar counts should be re-run to determine if plant association is important in limiting or extending the distribution of the wild ungulates.

DISCUSSION AND CONCLUSIONS

Areas used only by bighorn sheep and deer have better Agropyron spicatum cover than those used by livestock and wild ungulates. Steep river breaks and rocky knolls are heavily used by bighorn sheep and deer yet they support the healthiest stands of Agropyron spicatum. On these cattle-free sites, plant associations are stable and near climax but their small size and poor distribution prevent them from contributing significantly to the total productivity of the range. From a total of 2,450 acres classified into eight associations, those in which Agropyron is one of the dominants comprise no more than 360 acres.

Various over-used seres, comprising the bulk of range, are relatively unproductive as the plant species represented are not, as a whole, good forage producers. The shrub species of Purshia tridentata, the grasses of Poa compressa, Bromus tectorum and Koeleria cristata and the forbs of Achillea millefolium, Apocynum androsaemifolium, Chrysopsis villosa, Antennaria rosea, ~~Collinsia villosa~~, Collinsia parviflora, Collomia grandiflora and Linum perenne, are all present in high C/F throughout most of the plant communities. Collectively, they occupy most of the total plant volume on this range. These plants are weedy species; the forbs and grasses being mainly short-lived or very low growing. Others, such as Poa compressa, are long-lived perennials which form a uniform but thin mat over the ground where heavy grazing has occurred.

Purshia tridentata is an unpreferred shrub that has become established throughout this range as a result of fire and over-grazing. It is dominant in two associations and two seral communities of one association. It is an undesireable shrub that occupies large proportions of the range surface, thereby preventing a higher growth production from grasses and forbs. The low growing, densely branched form of this shrub prevents ungulates from using grasses and forbs that grow close to its base, thus causing the inter-shrub areas to support the ungulate populations (refer to Fig. 4).

This range in its climax stage would support less complex communities than are now present. This is evidenced by the seral associations of Agropyron-Purshia, Agropyron-Festuca and Agropyron-Symphoricarpus. These three communities are the furthest developed and are the only ones that enable a projection towards climaxes.

Although bighorn and deer are widely distributed in their use of the range, they tend to concentrate on steep areas of near climax vegetation and those that are highly productive such as the Agropyron-Purshia community. Cattle, on the other hand, use the flat portions of terraces and alluvial fans. These areas are over-used and support grazing seres of low productivity. Although the range was initially placed in a seral stage of fire in 1931, ungulate use has hindered the rate of succession. The Purshia-Poa fire sere is heavily used by cattle and moderately by bighorn sheep and deer. Such use has undoubtedly lowered the productivity of this

association and has caused Poa compressa to become a dominant species. In the Agropyron-Purshia fire sere, cattle, bighorn and deer have changed this association in terrace areas to Purshia-Bromus Agropyron and Purshia-Bromus grazing seres. The productivity of grasses has decreased and Purshia tridentata has increased in density.

Similarly, within the Amelanchier-Ceanothus-Poa and Poa-Symphoricarpus fire seres, heavy ungulate use has caused an increase of the weedy grass species such as Poa compressa. In these two fire seres, over-use has deformed all the preferred browse species.

MANAGEMENT PROPOSALS

The Bull River winter range plant communities are in a state of regression. Continued use by livestock and wildlife at the present rate of stocking can only result in a continuation of this process. If bighorn are ever to re-establish themselves on this range, better grazing conditions must be created and maintained.

Consideration should be given to the stocking permits issued for the use of this range. A revision of cattle turnout dates as well as a reduction in stocking rates is in the best interest of wildlife and the range resource.

In the interests of better range management for both livestock and big game, a range restoration program should be undertaken immediately. It should include the eradication of Purshia tridentata , fertilization and the building of drift fences on terrace areas to effect a better distribution of grazing pressure. This program would ensure more surface area for the growth of preferred shrub and grass species, a reduction of soil deficiencies, proper livestock and big game distribution and an ample forage supply for wildlife during the critical winter period.

SUMMARY

1. A study of the vegetation, soils and use of the Bull River bighorn winter range was conducted during the summer months of 1966.
2. The canopy coverage method of vegetational analysis of Daubenmire (1959), the macroplot method of Poulton and Tisdale (1961) and linear transects were used to describe and classify range vegetation. Ungulate fecal groups were counted within belts along each randomly selected transect.
3. Soil profiles were described at nine study sites and chemical analysis is to be conducted on horizon samples. Where soil profiles were not described, soil classification was based on the type of vegetation present, physiography and the interpretation of aerial photographs.
4. The entire terrace area of the winter range is in an overgrazed state.
5. Cattle are confined to terraces and alluvial fans while bighorn and deer mainly use steep river breaks and the shoulders of the Steeples. There is also some general use by bighorn and deer throughout the entire range.
6. Past and present overgrazing by ungulate users of the range are responsible for the abundance of Poa compressa and Purshia tridentata on terrace areas.

7. There are no climax communities on this range. On Regosolic Brown Wooded Soils, near climax communities of Agropyron-Festuca and Agropyron-Symphoricarpus have developed. Overgrazed terraces of this soil type have regressed into a Purshia-Poa association. On Regosolic Dark Gray Chernozemic soils, the near climax community of Agropyron-Purshia occurs where it is protected from overuse by steep slopes. On areas of gentler slopes heavy ungulate use changes this to associations of Purshia-Bromus-Agropyron and Purshia-Bromus.

8. The following factors are believed to be against any future bighorn population build-up:

   (a) dominance of the range by Purshia-tridentata and Poa compressa through overgrazing of fire-induced communities.

   (b) the maintenance of the overgrazed seres by livestock and big game use.

LITERATURE CITED

Bandy, P. J., 1966. Bighorn sheep die-off in British Columbia: a complex of environmental factors. Presented to the 1966 Annual Meeting of the Canadian Society of Wildlife and Fishery Biologists. (unpublished)

British Columbia Department of Agriculture, 1962. Climate of British Columbia. (Tables of temperature, precipitation, and sunshine report for 1962.)

British Columbia Forest Service. 1966. Pre-emption series, reference map. (unpublished)

Cowan, I. McT. and C. J. Guiguet. 1966. The Mammals of British Columbia. B. C. Prov. Museum, Handbook No. 11.

Daubenmire, R. F. 1959. A canopy coverage method of vegetational analysis. Northwest Sci. 33:43-64.

Davis, R. J. 1952. Flora of Idaho. Wm. C. Brown Co., Dubuque, Iowa.

Hitchcock, A. S. revised by Agnes Chase. 1950. Manual of the Grasses of the United States. 2nd Edition. U. S. Dept. Ag.

Hitchcock, C. L., A. Cronquist, M. Ownbey and J. W. Thompson. 1955-1966. Vascular Plants of the Pacific Northwest. Parts 2-5, U. of Wash. Press.

Poulton, Charles E. and E. W. Tisdale. 1961. A quantitative method for the description and classification of range vegetation. J. Range Mgmt. 14(1):13-21.

Wright, A. C. S. and J. R. Jungen, 1966. Notes accompanying the preliminary soil reconnaissance map of the East Kootenay region. (unpublished)

_____ and D. Parsons. 1966. Notes accompanying the soil samples for the bighorn sheep winter range survey. (unpublished)

APPENDICES

APPENDIX I

SCIENTIFIC AND COMMON NAMES AND AUTHORITIES FOR PLANT AND ANIMAL SPECIES MENTIONED

References include: Cowan and Guiguet, (1956)
Davis (1952)
Hitchcock, A. S. revised by Agnes Chase, (1950)
Hitchcock, C. L., A. Cronquist, M. Ownbey and J. W. Thompson, (1955 - 1964)

TABLE A

GRASSES:	
Agropyron spicatum (Pursh) Scribn. and Smith.	Bluebunch wheatgrass
Agropyron trachycaulum (Link) Malle.	Slender wheatgrass
Bromus tectorum L.	Downy chess
Calamagrostis rubescens Buckl.	Pinegrass
Festuca idahoensis Elmer.	Idaho fescue
Festuca scabrella Torr.	Rough fescue
Koeleria cristata (L.) Pers.	Junegrass
Poa compressa L.	Canada bluegrass
Poa pratensis L.	Kentucky bluegrass
FORBS:	
Achillea millefolium L.	Yarrow
Antennaria rosea Greene	Pink pussytoes
Apocynum androsaemifolium L.	Dogbane
Chrysopsis villosa (Pursh) Nutt. ex. D.C.	Golden aster
Collinsia parviflora Lindl.	Blue-eyed Mary
Collomia grandiflora Dougl. ex. Lindl.	
Epilobium minutum Lindl. ex. Hook	Willow Herb
Linum perenne L.	Flax
Sedum lanceolatum Torr.	Stonecrop
Taraxicum officinale Weber.	Common dandelion
Trǒgopogon dubius Scop.	Goatsbeard
SHRUBS:	
Amelanchier alnifolia Nutt.	Serviceberry
Artemisia frigida Willd.	Silver sage
Berberis nervosa Pursh	Oregon grape
Betula spp. L.	Birch
Ceanothus sanguineus Pursh	Red-stem buckbrush
Ceanothus velutinus Doubl. exltook.	Sticky laurel
Purshia tridentata (Pursh) D. C.	Bitterbrush
Salix spp. L.	Willow
Spiraea betulifolia Pall.	Flat-topped spiraea
Symphoricarpus albus (L.) Blake	Snowberry
TREES:	
Larix accidentalis Nutt.	Western larch
Pinus ponderosa Laws	Ponderosa pine
Populus tremuloides Michx.	Trembling aspen
Pinus contorta Dougl.	Lodge pole pine

Pseudotsuga menziesii (Mirb) Franco	Douglas fir

ANIMALS:

Cervus canadensis nelsoni Bailey	Rocky Mountain elk
Odocoileus hemionus hemionus Rabinesque	Mule deer
Odocoileus virginianus ochrourus Bailey	White-tailed deer
Ovis canadensis canadensis Shaw	Rocky Mountain bighorn sheep

APPENDIX II

PROFILE DESCRIPTIONS OF REPRESENTATIVE SOILS OF THE BULL RIVER BIGHORN WINTER RANGE

Table A

Regosolic Dark Gray Chernozemic Soil

Study Site Number	:	L-3
Landform and Relief	:	very steep river breaks
Elevation	:	2,700 feet
Slope and Aspect	:	sixty-six percent S.S.W.
Parent materials	:	glacial outwash
Drainage	:	rapidly drained
Vegetation	:	Agropyron-Purshia fire sere

Horizon	Depth Inches	
A	0-4	Light gray (10YR 6/1, dry) stoney and gravelly, fine sandy loam. Very friable, porous and powdery when dry. Moderately developed, very fine subangular blocky and granular structure. Boundary fairly distinct. Calcareous at two inches.
B	4-12	Pale brown (10YR 6/3) stoney, heavy, silty loam to loam. Very friable, porous, strongly developed, fine, subangular and angular blocky structure. Highly calcareous. Grades downward to more stoney and bouldery, fine, sandy loam.

Table B

Regosolic Brown Wooded Soils on Steep Slopes

Study Site Number	:	L-1
Landform and Relief	:	steep rock bluff
Elevation	:	3,550 feet
Slope and Aspect	:	twenty-five percent S.W.
Parent Material	:	metargillite with rare calcite veins
Drainage	:	well drained
Vegetation	:	Agropyron-Festuca fire sere

Horizon	Depth Inches	
A	0-3.5	Dark grayish brown (10YR 4/3, dry) gravelly, fine sandy loam. Very friable, porous. Very fine sub-angular blocky structure. Boundary diffuse.
B	3.5-11	Brown (10YR, dry) stoney and gravelly clay loam. Friable, slightly porous. Very weakly developed medium and fine subangular blocky structure. Boundary diffuse.
C	11-16	Light yellowish brown (10YR 6/4, dry) light clay interstices of abundant rock fragments. Slightly firm, no visable pores. Strongly developed fine angular blocky structure. Grades into shattered rock at about thirteen inches.

Table C

Regosolic Brown Wooded Soils on Terraces

Study Site Number	:	1 and 2
Landform and Relief	:	very flat terrace
Elevation	:	2,800 feet
Slope and Aspect	:	0 percent
Parent Material	:	stoney glacial outwash
Drainage	:	soil inwashing and some standing water
Vegetation	:	Purshia-Poa fire sere

Horizon	Depth Inches	
A	0-1	Grayish brown to brown (10YR 5/2-4/2, dry) gravelly, fine sandy loam to loam. Firm and compact. Very finely porous. Well developed laminar structure. Boundary distinct.
B	0-11	Pale yellowish brown (10YR 6/4, dry) stoney, silty clay loam. Very strongly developed fine angular blocky structure. Boundary distinct.
C	11-15	Brown (10YR 5/3, dry) exceedingly stoney, gritty clay loam. Fine material between the stones is loosely packed and calcareous. No visible structure. Grading into layered sand and gravel.

Table D

Regosolic Minimal Brown Wooded Soils

Study Site Number	:	11
Landform and relief	:	gently sloping outwash fan
Elevation	:	3,000 feet
Slope and Aspect	:	ten percent S.S.W.
Parent Material	:	coarse fan materials of metargillite
Drainage	:	well drained
Vegetation	:	Amelanchier-Ceanothus-Poa sere

Horizon	Depth Inches	
A	0-1	Dark Gray (10YR 4/1, dry) gritty and gravelly, sandy loam. Very friable, very porous. Very fine granular and crumb structure, with some single grains of sand. Boundary irregular but distinct.
B	1-12	Pale brown (10YR 6/3, dry) stoney and gravelly sandy loam. Friable porous. Weakly developed irregular fine subangular blocky and crumb structure, with a few fine granules. Grading into similar material with a marked increase of large stones and boulders.

Table E

Minimal Brown Wooded Soils

Study Site Number	:	6
Landform and Relief	:	high terrace with hummocky microrelief
Elevation	:	2,950 feet
Slope and Aspect	:	two percent S.E.
Parent Material	:	colluvial and fan outwash materials from metargillite slopes
Drainage	:	local drainage restricted
Vegetation	:	Poa-Symphoricarpus sere

Horizon	Depth Inches	
A	0-1.25	Dark grayish brown (10YR 4/2, dry) gritty loam. Very friable, porous. Very weakly developed fine subangular blocky structure. Boundary diffuse.
B	1.25-6.76	Brown (10YR 5/3, dry) stoney, clay loam. Friable, porous. Moderately developed medium and fine subangular blocky structure. Boundary merging.
C	6.75-12	Grayish brown (10YR 5/2, dry) very stoney, clay alternating with sandy clay loam. Friable. Medium angular blocky structure. Resting on bouldery clay-sand.

APPENDIX III

PLANT COMMUNITY STRUCTURE IN THE STUDY SITES OF THE BULL RIVER BIGHORN WINTER RANGE

Table A

Summary of major plant species C/F and nature of ground cover for two sites, one in the Agropyron-Festuca and the other in the Agropyron-Symphoricarpus communities.

Plant Community -	Plant Frequency Ratios	
	Agropyron-Festuca	Agropyron-Symphoricarpus
Plot -	L-1	L-4
GRASSES:		
Agropyron spicatum	24.9/87.5	43.3/100.0
Calamagrostis pubescens	-	3.1/25.0
Festuca idahoensis	13.8/50.0	-
F. scabrella	5.5/25.0	-
FORBS:		
Achillea millefolium	1.9/25.0	6.1/47.5
Apocynum androsaemifolium	4.8/40.0	-
Collinsia parviflora	1.4/55.0	1.7/42.5
Collomia grandiflora	1.3/52.5	0.8/30.0
Epilobium minutum	1.9/40.0	5.4/35.0
Sedum lanceolatum	9.8/75.0	-
SHRUBS:		
Ceanothus velutinus	-	17.5/42.5
Spiraea betulifolia	t/5.0	20.0/17.5
Symphoricarpus albus	3.9/15.0	22.5/92.5
GROUND COVER (%):		
Vascular plants	48	66
Litter	24	8
Rocks	15	23
Bare ground	3	2
Cryptograms	11	1

Table B

Summary of major species C/F and nature of ground cover for five sites of the Purshia-Poa community.

Plant Community - Purshia-Poa Plot -	Plant Frequency Ratios 1	2	5	7	8
GRASSES:					
Bromus tectorum	1.4/32.5	1.3/12.5	t/5.0	9.3/35.0	8.5/32.5
Koeleria cristata	4.2/42.5	5.9/52.5	3.1/27.5	10.1/60.0	6.3/35.0
Poa compressa	17.6/50.0	16.8/57.5	62.7/97.5	16.8/47.5	1.2/10.0
P. pratensis	26.3/82.5	20.8/80.0	5.9/20.0	35.1/82.5	32.6/77.5
FORBS:					
Achillea millefolium	5.7/65.0	5.6/50.0	13.4/70.0	9.8/55.0	6.3/45.0
Antennaria rosea	3.3/12.5	4.7/30.0	0.8/5.0	5.3/40.0	10.4/45.0
Chrysopsis villosa	t/2.5	-	5.6/30.0	-	t/2.5
Epilobium minutum	-	-	t/10.0	1.6/25.0	4.6/50.0
Taraxicum officinale	t/12.5	t/17.5	0.6/25.0	1.9/27.5	4.0/47.5
Tragopogon dubius	0.8/7.5	t/5.0	5.5/57.5	5.1/32.5	4.3/35.0
SHRUBS:					
Amelanchier alnifolia	25.6/80.0	22.6/40.0	t	1.6/2.5	7.1/20.0
Arctostaphylos uva-ursi	2.1/10.0	t	t/2.5	2.7/7.5	15.8/45.0
Purshia tridentata	32.4/85.0	25.7/72.5	24.4/40.0	35.7/72.5	44.6/77.5
Spiraea betulifolia	-	t/2.5	2.9/17.5	t/2.5	2.7/10.0
Symphoricarpus albus	15.4/65.0	-	-	-	t
GROUND COVER (%):					
Vascular plants	64	56	52	77	79
Litter	27	22	41	18	11
Rocks	-	-	-	-	-
Bare ground	2	5	-	4	2
Cryptograms	7	18	8	2	8

Table C

Summary of major species C/F and nature of ground cover for four sites, two in the Agropyron-Purshia community, one in the Purshia-Bromus-Agropyron sere and one in the Purshia-Bromus sere.

Plant Community -	Plant Frequency Ratios			
	Agropyron-Purshia		Purshia-Bromus-Agropyron	Purshia-Bromus
Plot -	L-2	L-3	3	4
GRASSES:				
Agropyron spicatum	55.4/100.0	54.1/100.0	17.7/75.0	3.6/22.5
Bromus tectorum	4.1/32.5	t/2.5	10.3/62.5	46.8/90.0
Koeleria cristata	13.3/87.5	t/2.5	8.2/57.5	2.3/20.0
Poa pratensis	-	-	3.7/2.5	13.7/37.5
FORBS:				
Achillea millefolium	3.3/35.0	0.8/5.0	7.8/75.0	7.5/47.5
Chrysopsis villosa	5.6/42.5	-	7.4/42.5	15.1/67.5
Collomia grandiflora	1.4/30.0	t/2.5	3.9/45.0	1.7/30.0
Epilobium minutum	4.6/70.0	t/2.5	2.0/27.5	2.0/42.5
Linum perenne	2.2/25.0	2.7/32.5	-	-
Tragopogon dubius	t/2.5	3.5/27.5	6.3/52.5	4.0/35.0
SHRUBS:				
Amelanchier alnifolia	-	7.0/27.5	4.8/12.5	15.9/35.0
Artemisia frigida	2.4/15.0	14.1/67.5	-	t
Purshia tridentata	21.9/55.0	2.9/20.0	38.5/75.0	34.8/72.5
Symphoricarpus albus	-	10.0/67.5	37.6/62.5	t/2.5
GROUND COVER (%):				
Vascular plants	61	54	73	66
Litter	19	22	23	28
Rocks	4	3	2	3
Bare ground	15	21	-	1
Cryptograms	2	-	3	2

Table D.

Summary of major species C/F and nature of ground cover for four sites, three of the Amelanchier-Ceanothus-Poa sere and the other of the Poa-Symphoricarpus sere.

Plant Community -	Plant Frequency Ratios			
	Amelanchier-Ceanothus-Poa			Poa-Symphoricarpus
Plot -	9	10	11	6
GRASSES:				
Agropyron spicatum	1.5/10.0	-	-	3.4/5.0
A. trachycaulum	7.8/45.0	7.6/70.0	7.7/57.5	t/2.5
Bromus tectorum	6.4/40.0	t/7.5	t/12.5	-
Calamogrostis rubescens	5.1/22.5	2.3/75.0	4.3/25.0	1.9/15.0
Koeleria cristata	2.8/22.5	1.7/17.5	1.2/10.0	6.8/40.0
Phleum pratensis	5.4/35.0	8.3/65.0	-	-
Poa compressa	8.0/32.5	17.2/85.0	17.7/55.0	52.3/95.0
P. pratensis	9.9/42.5	-	5.3/17.5	2.7/10.0
FORBS:				
Achillea millefolium	6.6/57.5	3.1/37.5	3.1/37.5	5.1/52.5
Apocynum androsaemifolium	5.7/30.0	t	9.5/45.0	-
SHRUBS:				
Amelanchier alnifolia	29.1/60.0	21.6/55.0	15.0/30.0	6.3/15.0
Berberis nervosa	1.4/7.5	9.9/47.5	8.2/37.5	2.1/35.0
Ceanothus sanguineus	26.1/57.5	8.0/22.5	23.9/50.0	3.4/7.5
Purshia tridentata	t/2.5	t	6.1/7.5	-
Spiraea betulifolia	4.9/27.5	2.3/30.0	8.9/42.5	23.4/60.0
Symphoricarpus albus	36.2/82.5	41.5/90.0	20.4/45.0	2.1/35.0
GROUND COVER (%):				
Vascular Plants	81	68	80	66
Litter	18	23	18	29
Rocks	1	2	-	-
Bare ground	-	1	2	-
Cryptograms	1	6	1	5

APPENDIX IV

UNGULATE USE OF VARIOUS TOPOGRAPHICAL AND COMMUNITAL STRUCTURES ON THE BULL RIVER BIGHORN WINTER RANGE

Table A

The distribution and relative abundance of domestic and wild ungulates on the basis of fecal deposits, according to topographical features and plant associations.

Topographic feature and Plant community	Study Site Number	Number of fecal deposits/acre			
		Bighorn & Deer	Elk	Cattle	Horse
TERRACE					
Purshia Poa	1	667	-	400	178
"	2	311	-	356	89
"	5	133	-	1467	-
"	7	178	45	711	-
"	8	356	-	222	44
Pur.Brom.	3	1511	45	267	44
"	4	1467	-	222	-
Poa-Sym.	6	622	-	489	-
STEEP SHOULDER					
Ag.Fest.	L-1	1926	74	-	-
Ag.Sym.	L-4	1778	74	-	-
RIVER BREAKS					
Ag. Pur.	L-2	2148	-	-	-
"	L-3	889	74	-	-
ALLUVIAL FAN					
Amel.Cean.Poa	9	889	45	133	-
"	10	756	45	133	44
"	11	1022	89	222	44

THE ECOLOGY OF THE STODDART CREEK BIGHORN WINTER RANGE

Dennis A. Demarchi
September, 1968

A young ram with two ewes on the Stoddart Creek bighorn winter range. (B. E. Clapp photo.)

A. CLIMATE

A meterological station has been in operation for 11 years at the Kootenay National Park administration offices. The station, situated at 3,570 feet elevation, is located on a high terrace dominated by a Pseudotsuga menziesii forest. Precipitation and monthly mean temperatures for 11 years are summarized in Table 1.

The climate of the Stoddart Creek bighorn winter range is profoundly influenced by Windermere Lake, the meandering Columbia River and the surrounding mountains. Precipitation patterns and precipitation evaporation ratios are highly variable.

From Table 1 it may be seen that mean monthly temperatures are above freezing between March and October. The precipitation pattern at Radium indicates that at least one inch of precipitation falls in most months with February and March being the driest and June, July, August and September the wettest. Winter snowfall is six feet. The depth of accumulated snow is affected by the degree of exposure to wind and sunlight. Some melting and drifting does occur on the open grasslands.

TABLE 1. Temperature and precipitation records from the Kootenay National Park weather station at Radium Hot Springs. Data from B.C. Department of Agriculture (1965).

Month	Mean Temperature (°F)	Total[1] Precipitation (in.)
January	15	1.57
February	22	1.09
March	29	0.85
April	41	1.54
May	50	1.80
June	56	3.07
July	62	2.54
August	60	1.93
September	50	1.93
October	40	1.45
November	24	1.36
December	17	2.08
Absolute Max.-Min.	95 - 27	
Annual Average	39	21.50
Average Snowfall		73.8
Years Recorded	11	11

[1] Total precipitation is the sum of the rainfall plus the water equivalent of the snowfall (snowfall divided by ten).

B. SOILS

Three types of soils are present on the Stoddart Creek range between elevational limits of 2.700 feet and 5,000 feet; dark grey chernozemic, brown-wooded, and regosals related to acid brown-wooded soils.

On steeper slopes, soils are derived from parent material from the Stanford Ranges. On alluvial terraces the soils are derived from glacial lacustrian deposits with an overburden of alluvial debris from the Stanford Range.

Two similar soil profiles were found on the grasslands in this region:

1. Dark grey chernozemic soils on high terraces.

The soil profile found on the terraces (site SC--1) was described as a dark grey chernozemic. From external features, the profile at site SC-2 was also considered to consist of this type.

A shallow profile has developed in an alluvial fan of limestone rocks overlaying silty glacial lacustrian deposits. It is characterized by a thin, stoney, very fine, sandy loam "A" horizon of one inch; a very stoney, sandy loam "B" horizon of about 5 inches; and a 5 inch "C" horizon composed of similar materials. (Appendix II, Table A shows a more detailed description of this soil profile.)

2. Dark grey chernozemic soils on steep slopes.

This profile was characteristic of the steep slopes exemplified by site SC L-1. Site SC L-2 was judged to be of the same type by similarities

in external features.

A shallow profile has developed in an alluvial soil of limestone rock origin. This soil profile is characterized by a thin "A" horizon of 3 inches of very stoney, sandy loam; and a "B" horizon of 12 inches of stoney, sandy loam. (Appendix II Table B shows a more detailed description of this soil profile.)

C. TOPOGRAPHY

The Stoddart Creek bighorn winter range is situated on the lower slopes of the east side of the Rocky Mountain Trench, above the Columbia River marshlands. Shuswap Creek forms the southern limit of this range (just across the Columbia River from Wilmer) and Highway 93/95 forms the western boundary. The northern limit follows the north side of Sinclair Creek in Radium Hot Springs and Kootenay National Park. The eastern boundary follows the 5,000 foot contour from Dry Creek to Stoddart Creek. The elevation of the Columbia River is 2,650 feet and the alluvial fans are about 3,000 feet high. The total area of the winter range is about 6 square miles.

The winter range consists of several large alluvial terraces which originate from rocky slopes and bluffs of the Standord Range. These terraces terminate on flat, glacial, lacustrine deposits. Several streams dissect the winter range; notably Sinclair, Dry, Stoddart and Shuswap Creeks. These creeks originate from deep within the Stanford Range and flow into the Columbia River.

For the purpose of this report only the important portion of the winter range lying outside the Kootenay National Park boundary was surveyed intensively.

D. HISTORY OF VEGETATION

British Columbia Forest Service records of forest fires, dating back to 1930, revealed that no fires occurred on this winter range. However, fire scars and burned stumps indicate that the area was burned prior to 1930.

Cattle and horses have heavily grazed this range in the past. Park wardens tried unsuccessfully to keep the animals south of Stoddart Creek to prevent them from entering the National Park. In the 1960's grazing was stopped on the north side of Stoddart but light trespass grazing persisted. Between Stoddart and Shuswap Creeks, the range is grazed under permit by Indian livestock. In general, grazing by horses has been reduced and replaced by cattle but the Shuswap Indians still graze large herds of horses.

In the past, dense populations of bighorn sheep, elk and mule deer have wintered on this range. These animals have perpetuated the overgrazed situation created by livestock. Now, the use of this range by mule deer and elk seems minimal. However, until the recent die-off, winter grazing by bighorn sheep continued, and has prevented range recovery.

Die-offs of bighorn sheep occurred in the early 1940's and again in the winter of 1966-67. Following the 1940 die-off, the population

built up slowly until it reached numbers well above the carrying capacity of the range. Bighorn numbers were probably in excess as early as 1958 or 1959. As a result of the last die-off, sheep numbers have been reduced to a level which may be below the present carrying capacity of this overgrazed range, and as a result some natural range improvement may be expected.

E. PLANT COMMUNITIES

The plant communities of this range have been drastically altered by severe overgrazing with the result that no relic climax communities now exist. However, some plant species belonging to climax stages are still present, thereby permitting one to interpret the nature of the undisturbed climax.

On the high alluvial terraces, the grassland climax was probably a Agropyron spicatum-Artemisia frigida community with a trace of Koeleria cristata present. On steeper slopes, the grassland climax may have been similar but differed in the form of Agropyron spicatum present. On alluvial terraces this plant exists in the normal bunch-like form but on the slopes it is represented by a rare rhizomatic form. This variant does not form typical bunches and is also much coarser.

Other climax associations which are probably typical of the area are: a dense Pseudotsuga menziesii forest with associated species of Symphoricarpus albus and Calamagrostis rubescens; or a Pseudotsuga menziesii forest with associated species of Juniperus communis and Juniperus scopulorum,

Symphoricarpus albus, Arctostaphylos uva-ursi; and Agropyron spicatum.

At present overgrazing has reduced the communities on the alluvial terraces to an association of Koeleria cristata, Stipa comata, Antennaria rosea and Artemisia frigida, a very unproductive forage producing community.

On the grassland slopes, Agropyron spicatum and Aretemisia frigida are more abundant than upon the alluvial fans. Weedy forbs, such as Achillea millifolium, Apocynum androsaemifolium and others are also abundant. However, the soils are now very unstable, with a considerable amount of bared soil and rock movement. (Appendix III).

In the coniferous community, overbrowsing has reduced the productive potential of Amelanchier alnifolia.

A high ridge of limestone rock occurs immediately above the bighorn winter range, between Dry and Stoddart Creeks. The talus from this ridge is sterile with little or no soil developing on it. At lower elevations, several limestone out-croppings occur with associated talus. These areas produce no forage and are unstable.

Four study sites, representing two grassland communities, were established on the Stoddart Creek bighorn winter range. These communities were classified on the basis of the dominant species with the highest cover-frequency ratios. Each of the associations are summarized in the following, but for detailed lists of the species present and for cover-frequency ratios refer to Appendix III.

1. The Stipa-Koeleria-Artemisia Community

The Stipa-Koeleria-Artemisia community occurs at two sites, SC1 and 2, located on an alluvial terrace with a slight south westerly aspect and an elevation of 3,050 feet. Ground cover is varied; vascular plant cover occupies 33 and 45 per cent, litter 6 and 24 percent, rocks occupy only 1 percent, bare ground 6 and 9 percent and cryptogams cover 22 and 55 percent of the ground surfaces. Dominants in this community are; Stipa comata, Koeleria cristata and Artemisia frigida. Associated species found in this community include Antennaria rosea, Chrysothamnus nauseaus and Agropyron spicatum (bunch form).

2. The Agropyron-Artemisia-Apocynum Community

The Agropyron-Artemisia-Apocynum community is found on a steep west facing slope of between 56 and 68 percent, at an elevation of 3,400 feet. (Sites SC L-1 and L-2). Between 26 and 33 percent of the ground is covered by vascular plants; 11 percent by litter, between 10 and 17 percent by rock with 47 percent being bare ground. Dominants in this community include Agropyron spicatum which occurs in the rhizomatic form together with Artemisia frigida, and Apocynum androsaemifolium. Associated forbs found in this community are: Chrysopsis villosa, Linum perenne and Achillea millefolium. Koeleria cristata and Chrysothamnus nauseosus also occur in this community.

F. ANIMAL ABUNDANCE

The Stoddart Creek winter range is used mainly by bighorns, but elk, mule and whitetailed deer and a few mountain goat can

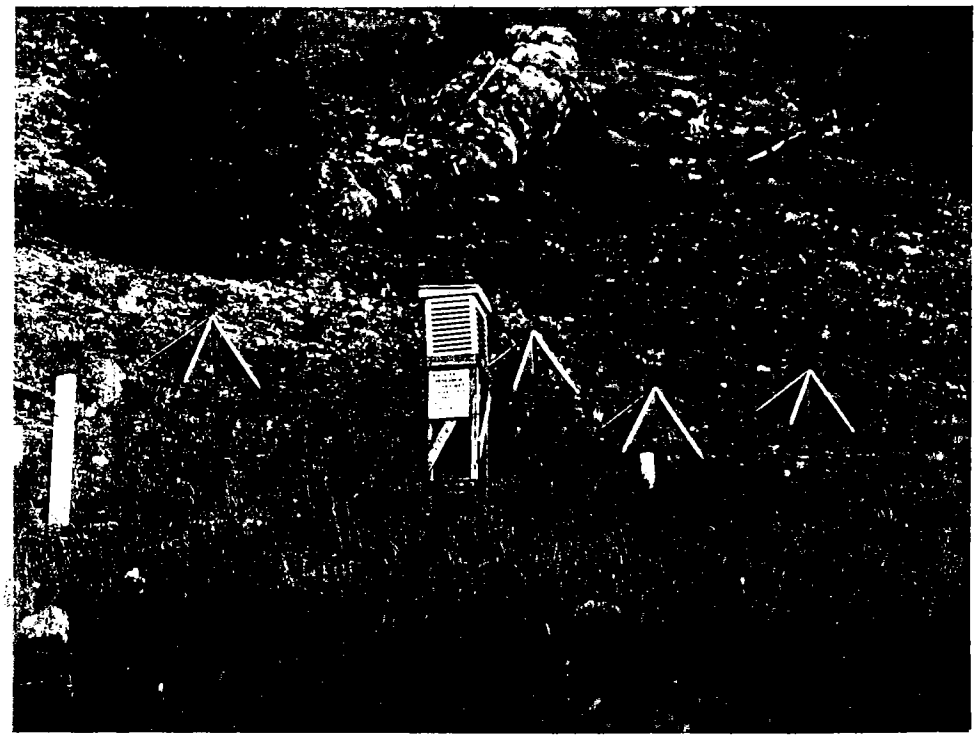

Figure S.C. 1. Stoddart Creek exclosure site [plots S.C. 1-16]
in August, 1966, the fence was constructed
in November, 1966. Agropyron - Artemisia -
Apocynum community.

be found wintering on this range during some portions of the winter. Light grazing by trespass horses and cattle also occurs at some seasons. As pellet groups from both species of deer and bighorn sheep cannot be readily identified, pellet group counts for these three species were combined. Fecal groups last for a long time on this range, as indicated by deep accumulations of pellet groups in the vicinity of sheep bedding grounds. Table II shows the number of ungulate pellet groups recorded at the four grassland plot sites.

TABLE II. Fecal group counts on the grassland communities

Community	Number of fecal groups per acre Stipa-Koeleria-Artemisia		Agropyron-Artemisia-Apocynum	
Plot	SC 1	SC 2	SC L-1	SC L-2
Bighorn & Deer	--	266	741	4,668
Elk	89	44	--	148
Cattle	139	--	--	--
Horse	222	133	--	--

There has been no established pattern of livestock use on the range north of Stoddart Creek in recent times. Trespass livestock can nevertheless appear on the range at any season. Bones of cattle and horses

indicate that they also used all plant communities. However, their distribution is usually confined to the alluvial terraces and gentler slopes as shown by the fecal counts.

Big game species (except goats) have been sighted in all plant communities on this range. The use of the winter range by big game, particularly bighorn sheep, is by no means evenly distributed. Certain sites receive extremely heavy use while other similar ones receive only light use. Elk and deer utilize this range mainly in late winter and early spring. The timbered areas are more frequently used but the open grasslands receive some use during the night.

In early March a few mountain goats have been seen using the limestone cliffs. It is possible that small numbers could use the upper portion of the bighorn range throughout the winter. One goat carcass was found in the timber at 4,000 feet.

Bighorn sheep use the winter range from November until late May. They use the Sinclair Canyon area first and then move onto the main winter range when snow begins to accumulate. In mild winters they frequently return to the Sinclair Canyon area. The rams appear on the range in November and remain there throughout the rut until December or early January. After this, they move away from the ewe herds. The range used by rams from January to May is not known but they could be using the rocky, open timbered slopes to the north of Sinclair Creek. During the winter, the rams frequently show up along the open slopes of Sinclair Creek.

The ewes, lambs and younger rams use the open grassland slopes as their main wintering areas. They frequently enter the timber to pass from one area to another and, for extended periods, even use the timber as feeding and bedding areas. From late March to early May, the ewes move off the slopes onto the alluvial grassland terraces to feed. On the terraces, the animals are extremely wary and easily spooked back to the slopes. In early spring, the animals also appear in Sinclair Canyon for extended periods. As spring progresses, they tend to remain in the Canyon and then finally migrate to the alpine summer ranges.

The ewes and lambs irregularly return to Sinclair Canyon throughout the summer to lick the soils for its natural salt content. A soil test report of the salt lick area shows a high sodium and chloride content in the soil. (April 24, 1967 report to the Canadian Wildlife Service.) Then in the fall they return to the Canyon to begin utilizing their winter ranges.

DISCUSSION AND CONCLUSIONS

The productivity of the Stoddart Creek bighorn winter range is restricted by forests and overgrazed plant communities. The few remaining areas of open grassland have been heavily overstocked in past years. Recently most of the sheep using this range died. The heavy mortality suffered by this population is attributable, partially at least, to the severely degenerate nature of the grassland.

Heavy ungulate use of the area in the past has enabled relatively few bighorn to retard range regeneration. As a consequence, most of the grassland soils are now exposed, unstable and subject to erosion. On the steep slopes only 53 percent of the ground is covered by litter or plants. Animals grazing in the rain or during the spring cause considerable trampling and thereby retard range recovery.

The grassland terraces are quite stable even though past grazing has destroyed the climax community. The grazing-induced community is very weedy, but present ungulate use is not intensive enough to cause further damage to the plants and soil.

Much of the area is covered by a dense Pseudotsuga menziesii forest which produces very little forage for bighorn use. The ground cover consists of weakly established plants that are more productive in open grasslands. Most of the undergrowth species consist of Agropyron spicatum, Chrysothomnus nauseosus, Amelanchier alnifolia, Shepherdia canadensis, Antennaria rosea, Calamagrostis rubescens, Juniperus communis, and Juniperus scopulorum.

In some areas of past burning, the forest has still not reinvaded the burn and several shrubby species form the dominants. Plants of this type are: Shepherdia canadensis, Amelanchier alnifolia, Arctostaphylos uva-ursi, Juniperus communis and Juniperus scopulorum. Plants of the burned over regions are more vigorous than those in the timber.

Along the south-facing slopes of Stoddart and Sinclair Creeks,

the exposed soil is dominated by: Arctostaphylos uva-ursi, Oryzopsis hymenoides, Juniperus communis and Artemisia frigida. Exposure to the wind and sunlight has kept this area in a weakly developed community. Conditions are harsh and much of the area is bare soil.

MANAGEMENT PROPOSALS

The Stoddart Creek bighorn winter range has been severely over-used in the past. If bighorn numbers are to be increased from their present level then forage production must be improved.

At present any grazing on this range while the soil is wet, is harmful. A large drift fence should be constructed at the edge of the northern-most grassland slope. At the onset of spring break-up, the bighorn should be herded out of the area to forage on their northern ranges.

The timbered areas should be patch-logged to enable sunlight to reach the understory. With a greater enhancement of forage production more wild ungulates could use the present timbered areas during the winter period.

The grassland terraces should be reseeded to better yielding plants than the existing non-productive, short-lived perennial weeds. The timbered areas of the terraces should also be opened and reseeded to grassland species. This would alleviate the grazing disturbance on the grassland terraces and would also make more range available.

The upper Columbia River valley has some very productive Christmas tree farms. Patch-logging on the winter range could be conducted with this in mind. If the trees were cut for Christmas trees they could be put to an economic use and it would also assure a constant thinning program. It is recommended, however, that the limbs and branches be removed from the range in order to prevent an increase in soil acidity.

Any increases in bighorn and other ungulate numbers must be retarded until the range has been enlarged and improved. Large ungulate populations at present would only hamper range improvement and bighorn survival.

Finally, cooperation between the B.C. Fish and Wildlife Branch and the National Parks Service must be attained. Only a well-implemented, fully-controlled project can save the bighorn population from further reductions. The bighorn winter range lies both in the Kootenay National Park and on provincially-owned Crown land and both areas must be improved. The National Park contains most of the forests that must be cleaned and the Provincial lands contain most of the grasslands that must be reseeded. Failure to improve one or the other would result in a failure of the project.

SUMMARY

1. A study of the vegetation, soils and use of the Stoddart Creek bighorn winter range was conducted from May 1966 to September 1967.

2. The canopy coverage method of vegetational analysis of Daubenmire (1959), the macroplot method of Poulton and Tisdale (1961) and linear transects were used to describe and classify range vegetation. Ungulate fecal groups were counted within belts along each randomly selected transect.

3. Soil profiles were described at two study sites and horizon samples have been chemically analysed. Where soil profiles were not described, soil classification was based on the type of vegetation present, physiography and interpretation of aerial photographs.

4. The entire grassland area of the winter range is in a very badly overgrazed state.

5. Livestock and big game use all portions of the range. At present, trespass cattle and horses graze north of Stoddart Creek. Whitetailed deer, mule deer and elk use the forests more than the grasslands. Mountain goats use only the upper portion of the range. Bighorn use the grassland and timbered slopes, mainly, but do use the grassland terraces in the spring.

6. Past and present grazing pressure is responsible for the lack of Agropyron spicatum on the grassland.

7. There are no climax grassland communities on this range. On dark grey chernozemic soils two successional stages are represented. On alluvial terraces the Stipa-Koeleria-Artemisia community has developed since extreme grazing pressure has been reduced. On steep west-facing slopes, the Agropyron-Artemisia community has developed under present heavy use by bighorn.

8. The following factors are believed to be against any future bighorn population build-up:

   a) lack of available grasslands because of surrounding dense Pseudotsuga menziesii forests.

   b) instability of soil ongrassland slopes caused by spring trampling.

   c) maintenance of grazing induced seral communities by current use levels.

APPENDIX I

Scientific and common names and authorities

for plant and animal species mentioned

References include:

Cowan and Guiget (1956)

Davis (1952)

Hitchcock, A.S. revised by Agnes Chase, (1950)

Hitchcock, G.L., A. Cronquist, M. Ownbey and J.W. Thompson (1955-1964)

TABLE A

GRASSES:		
Agropyron spicatum	(Pursh) Scribn.&Smith	Bluebunch wheatgrass
Calamagrostis rubescens	Buckl.	Pinegrass
Koeleria cristata	(l) Pers.	June grass
Oryzopsis humenoides	(R.&S. Richer	Indian ricegrass
Stipa comata	Trin. & Rupr.	Needle-and-thread grass
FORBS:		
Achillea millefolium	L.	Yarrow
Antennaria rosea	Greene	Pine pussy toes
Apocynum androsaemifolium	L.	Dogbane
Aster sp.	L.	Aster
Chrysopsis villosa	(Pursh) Nutt. ex D.C.	Golden aster
Erigeron compsitus	(Pursh)	Fleabane
Linum perenne	L.	Flax
Lithospermum ruderale	Dougl. ex Lehm	Puccoon
SHRUBS:		
Amelanchier alnifolia	Nutt.	Serviceberry
Arctostaphylos uva-ursi	(l) Spreng.	Kinnikinnick
Artemisia frigida	Willd.	Silver Sage
Chrysothanmus nauseosus	(Pall.) Brown	Rabbit Brush
Juniperus communis	(L)	Dwarf Juniper
Juniperus scopulorum	Sarg.	Rocky Mountain Juniper
Rosa woodsii	Lindl.	Rose
Shepherdia canadensis	(L) Nutt.	Soapberry
Symphoricarpus albus	(L) Blake	Snowberry
TREES:		
Pseudotsuga menziesii	(Mirb.) Franco	Douglas Fir
ANIMALS :		
Cervus canadensis nelsoni	Bailey	Rocky Mountain Elk
Odocoileus hemionus hemionus	Rabinesque	Mule deer
Odocoileus virginianus ochrourus	Bailey	Whitetailed deer
Creamnus oreamnus americanus	Blainville	Mountain goat
Ovis canadensis canadensis	Shaw	Rocky Mountain Bighorn Sheep

APPENDIX II

Profile descriptions of representative soils of the grasslands on the Stoddart Creek Bighorn Winter Range

TABLE A

DARK GRAY CHERNOZEMIC SOIL ON HIGH TERRACES

Study site numbers:	SC 1
Land form and relief:	Gently rolling high terraces
Elevation:	3,050 feet
Scope and aspect:	5%; S.E.
Parent material:	Limestone debris over lacustrian deposits.
Drainage:	Well drained
Vegetation:	Stipa-Koeleria-Artemisia grazing sere

HORIZON	DEPTH (inches)	
A	0-2	Very dark gray brown (10YR 3/3, moist; 10 YR 6/3 dry); very stoney (50 percent) very fine sandy loam; very porous; loose; very weak blotchy structure breaking to crumbs; boundary distinct.
B	2-7	Very dark brown (10 YR 1/4, moist; 10 YR 5/4, dry); very stoney, sandy loam, very porous; very weak blotchy structure breaking to granules and crumbs; boundary distinct.
C	7-12	10 YR 6/3 moist, 10 YR 8/3 dry; very stoney sandy loam; very fine granular and crumby structure.

DARK GRAY CHERNOZEMIC SOILS ON STEEP SLOPES

Study site number:	SC L-1
Land form and relief:	Hill slope
Elevation:	3,400 feet
Slope and aspect:	68%; West
Parent material:	Limestone debris
Drainage:	Well drained
Vegetation:	Agropyron-Koeleria-Apocynum grazing sere

HORIZON	DEPTH (inches)	
A	0-3	Very dark gray brown (10 YR 3/2, moist; 10 YR 7/1, dry); very stoney sandy loam; porous; fine granular and crumb structure; boundary diffuse
B	3-15	Brown (10 YR 4/2, moist; 10Yr 7/2 dry); stoney sandy loam; porous; weakly developed blotchy structure breaking to granules.

APPENDIX III

Plant community structure in the study sites of the Stoddart Creek Bighorn Winter Range

TABLE A

Summary of major plant species cover/frequency (C/F) and nature of ground cover for two sites in the Stipa-Koeleria-Artemisia community.

	Plant C/F Ratios	
PLOT	SC-1	SC-2
GRASSES:		
Agropyron spicatum	t/0	t/5
Koeleria cristata	24/100	33/100
Stipa comata	20/100	22/100
FORBS:		
Antennaria Rosea	4/40	5/40
Erigeron compositus	1/20	--
Lithospermum ruderale	t/3	1/20
SHRUBS:		
Artemisia frigida	5/50	5/48
Chrysothamnus nauseosus	t/0	1/10
Rosa woodsii	t/3	t/0
GROUND COVER:		
Vascular plants	33	46
Litter	7	24
Rock	1	0
Bare ground	6	9
Cryptogams	55	22
Elevation (feet)	3,050	3,050
Slope (%)	5	0
Aspect	S	-

TABLE B

Summary of major plant species cover/frequency (C/F) and nature of ground cover for two sites in the Agropyron-Artemisia-Apocynum community

	Plant C/F Ratios	
PLOT	SC L-1	SC L-2
GRASSES:		
Agropyron spicatum	28/100	39/100
Calamagrostis rubescens	--	2/40
Koeleria cristata	--	2/23
Oryzopsis humenoides	2/15	--
FORBS:		
Achillea millefolium	---	6/58
Apocynum androsaemifolium	10/93	3/38
Aster sp.	1/2	3/30
Chrysopsis villosa	1/5	2/23
Linum perenne	1/18	1/35
SHRUBS:		
Artemisia frigida	3/38	11/78
Chrysothamnus nauseosus	t/3	t/3
Symphoricarpus albus	2/25	---
GROUND COVER:		
Vascular plants	26	33
Litter	11	11
Rock	17	10
Bare ground	46	47
Elevation (feet)	3,450	3,400
Slope (1%)	68	56
Aspect	W	W