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Circle West Vegetation Baseline Study

Final Report

Richard Proddgers, Plant Ecologist

Montana Department of Natural Resources and Conservation

Circle West Technical Report No. 1

Energy Division
Montana Department of Natural
Resources and Conservation
32 South Ewing
Helena, Montana 59601

October 1978

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INTRODUCTION

BACKGROUND

In 1974, Dreyer Brothers, Inc., a wholly-owned subsidiary of Burlington Northern, Inc., notified the state that it proposed to develop a coal processing facility in McCone County, Montana. Governor Thomas L. Judge subsequently designated the Department of Natural Resources and Conservation (DNRC) as the lead agency in any actions taken on the proposal. Since that time, DNRC has coordinated its activities on the proposal with all state agencies involved and developed an overall study plan that would acquire information sufficient for all state agencies. In the event that Dreyer Brothers, Inc. decides to proceed with the Circle West project, DNRC would continue to coordinate state agency action in developing a joint environmental impact statement.

At the time this study was made, Dreyer Brothers, Inc. had not applied to DNRC for a certificate under the Major Facility Siting Act. However, in accordance with the act, the company chose to contract with DNRC to initiate the portions of studies which would ultimately be required by law if the project proceeds. In general, the contract called for a baseline study and the coordination of DNRC action with all levels of government as well as other interested parties. Consequently, DNRC conducted baseline studies resulting in information that will be available for preparation of any environmental impact statements. Also, since the contract called for DNRC to consult all levels of government, DNRC contacted the affected federal, state, and local agencies and sought their continued involvement in developing the study plan and conducting studies.

CIRCLE WEST PROJECT

Although an application for the project had not been submitted at the time this study was made, long-range plans which Dreyer Brother, Inc. provided to DNRC (pursuant to provisions of the Montana Major Facility Siting Act) outlined the scope of the proposed action. The long-range plans for the Circle West Project, as submitted by Dreyer Brothers, Inc. include:

1. The manufacture of up to 3,000 tons per day of ammonia, requiring up to 9,000 tons per day of lignite and up to 9,000 acre feet per year of water;
2. The manufacture of up to 5,000 tons per day of methanol-methyl fuel, requiring up to 10,000 tons per day of lignite and up to 8,000 acre-feet per year of water;

3. The manufacture of up to 30,000 barrels per day of synthetic diesel fuel oil, requiring up to 16,500 tons per day of lignite and up to 15,000 acre-feet per year of water;

4. The development of mining operations to provide the lignite requirements;

5. The development of an irrigation system for both mine reclamation and general agricultural and livestock operations on the Dreyer Ranch requiring up to 35,000 acre-feet per year of water;

6. The construction of a water supply system, based on Missouri River waters, to pump and pipeline up to 67,000 acre-feet per year of water to the plant site and to the reclamation and agricultural and livestock points of use;

7. The construction of the following ancillary transportation, access and utility facilities:

- a. A railway spur from the plant site to some point on an existing railway;
- b. A road connecting the plant site to some point on a highway;
- c. An electrical service line connecting the plant site with some point on the existing power grid.
- d. If the required electrical power cannot be otherwise obtained at a feasible cost a captive power plant to meet the facility's needs.

8. To the extent that housing is not otherwise available, the construction of a townsite to meet the housing needs of the construction work force. It is BN's hope that the permanent operating work force can be absorbed into the existing communities in the area so that a permanent "company town" can be avoided (Dreyer Brothers, Inc. 1978).

OVERALL STUDY SCOPE AND OBJECTIVES

Dreyer Brothers, Inc., has submitted long-range plans, preliminary engineering studies, and a conceptual plant design for the Circle West project. Although this material provides substantial guidance, the project and process information are not yet fully defined. Consequently, DNRC has determined that a baseline study is the limit of evaluation that can be made at this time and this study is not of the scope one might expect if Dreyer Brothers, Inc. had applied for a siting certificate. Since the specific nature and scope of the project has not been established, the studies are based on the assumption that the first application will involve only one processing facility, manufacturing either ammonia or methanol. Nevertheless, as the planning process for the project evolves, the scope of the baseline study can be expected to concomitantly evolve.

In the event that Dreyer Brother, Inc. decides to proceed with the proposal, the baseline studies will be integrated into the complete evaluation required by the Major Facility Siting Act, the Montana Environmental Policy Act and other applicable statutes. It should be noted that, at this time, only the vegetation, wildlife and a portion of the aquatic resources studies have been completed.

In order to meet the statutory mandates and fulfill the contract with Dreyer Brother, Inc., DNRC designed the overall baseline study to:

1. Develop and conduct a cross-disciplinary baseline study comprised of various study components, which is harmonious with the Montana Major Facility Siting Act and the Montana Environmental Policy Act, and will permit initiation of impact evaluations if a facility application is received; and

2. Obtain baseline data that are suitable for assessment of the action under applicable statutes, and acceptable to those local, state, and federal agencies involved in the proposed project.

STUDY AREA

Initially, the study area--which is properly the focus of impact studies--was defined as the area encompassing the biotic, abiotic, and cultural characteristics that a mine and coal-conversion facility, located in McCone County near either the Fort Peck Reservoir of the Missouri River, may influence. Once Dreyer Brothers, Inc. provides a better description of plant design and DNRC understands the area's meteorological characteristics better, the location of the study area can be refined. If Dreyer Brothers, Inc. changes the location of the proposed conversion facility indicated in the current long range plan, DNRC will make the necessary adjustments in the definition of the study area.

Proposed Mining Area

In March of 1977, Dreyer Brothers, Inc. defined an eleven and one half square mile (29.8 km²) area encompassing the anticipated twenty-year strip mining activity. This area, termed the proposed mining area, became the primary focus of field study after its definition and contains all experimental study plots for the wildlife study. At the time the remaining study components are initiated, much of the monitoring equipment and study plots involved will likewise be sited in this area.

Mine Study Area

The mine study area, which surrounds the proposed mining area, was studied in nearly as much detail as the proposed mining area. The size of the area somewhat varied depending upon the study component involved. The wildlife study encompassed a ninety-nine square mile (174.3 km²) area; the vegetation evaluation was focused upon a seventy-five square mile (132.0 km²) area. The mine study area contains all control study plots, and most aerial surveys covered this area; it corresponds to the 7.5' field maps used to record data.

Reconnaissance Study Area

A reconnaissance study area, which corresponds roughly with the boundaries of McCone County and Montana Department of Fish and Game hunting district 650, is the largest of the study areas. As implied by the name, this area was studied in less detail than the others. Data gathering in this area was directed toward:

- 1) Defining critical sites, primary use areas, or major biota in the area such that any later changes in study area boundaries would not make the general baseline results inappropriate;
- 2) Setting the context for study of the areas more intensively studied; and
- 3) Providing a baseline for plant siting and assessment of impacts associated with the coal conversion facility or transportation related to coal mining and coal conversion.

Throughout this report, the term study area refers to the reconnaissance study area.

OBJECTIVES OF THE VEGETATIVE BASELINE STUDY

The goal of this baseline study was to collect sufficient information describing the vegetation of the study area so that changes in vegetation can be detected, and further baseline and monitoring studies can be expeditiously carried out. This information which will eventually be used to evaluate the impacts of the proposed development, was derived from data collected by:

Characterizing the vegetation of the area in a manner that serves the maximum number of needs and most concisely conveys information about the vegetation of any portion in the study area (Classification of vegetation into community types most nearly meets this requirement and other objectives, including the requirements of the Department of State Lands);

Characterizing the average sites associated with the various community types;

Comparing the community types with respect to species diversity;

Mapping the vegetation of the study area and the range condition of the proposed mine area;

Determining the productivity of the major community types of the proposed mine area; and

Listing all plant species found in the study area and identifying any rare or endangered plants.

GENERAL DESCRIPTION OF CLIMATE, GEOLOGY, SOILS, AND VEGETATION

The study area has a typical continental climate having hot summers, cold winters and rapid seasonal transition. At Circle, January temperatures average 13.1°F (-10.5°C) with a mean minimum temperature of 2°F (-16.7°C). Temperatures in July average 70°F (21.1°C) with a mean maximum temperature of 88°F (31.1°C). The frost free season lasts about ninety-nine days (Cordell 1971).

Precipitation for the area is variable and unevenly distributed and drought strongly influences vegetation. Figure 1 portrays the precipitation at Circle and Fort Peck for approximately twenty-five years. The fifty-year average at Circle is 12.46 inches (31.65 cm). Between 1952 and 1977 the average was 12.9 inches (32.77 cm) with a standard deviation of 3.6 inches (9.14 cm). At Fort Peck, the average precipitation between 1955 and 1975 was 11.3 inches (28.7 cm) with a standard deviation of 3.4 inches (8.64 cm).

The annual precipitation of the study area averages between 12 and 16 inches (30.5 cm 40.6 cm). The proposed mine area has an average annual precipitation of about 14 inches (35.6 cm) (USDA-DNRC 1977). On the average eighty-two percent of the annual precipitation falls between April and September, and fifty-five percent falls between May and July (Cordell 1971).

The Circle West study area is underlain by nearly horizontal beds of sedimentary rock which are poorly exposed except in local badlands in the western half of the area. The oldest exposed formation, the Bearpaw Shale, of Late Cretaceous age, is exposed in bluffs along the Missouri River and near Fort Peck. Overlying the Bearpaw are the Fox Hills Sandstone (Cretaceous), the Hell Creek Formation (sandstone and claystone, some lignite; Late Cretaceous age), and the Fort Union Formation (shale, sandstone, and lignite; Paleocene age). The Fox Hills and Hell Creek Formations have outcrops along the Big Dry Arm of Fort Peck Reservoir and along the breaks of the Missouri River. The Fort Union Formation occupies the central and southern parts of the Circle West study area, and is divided into three members, the Tullock, Lebo and Tongue River. The Tongue River Member contains the coal beds of the proposed Circle West strip mine.

During Pleistocene continental glaciation, glaciers deposited till throughout the northern half of the study area. Erosion has mostly removed the till along the main streams and rivers and little remains south of the Missouri River.

Alluvium consisting of silt, sand and gravel underlies the bottom lands of most of the major streams and rivers in the study area. Saline soils, which result from a combination of poor subsurface drainage and a nearby source of salts, are widespread on poorly drained alluvial terraces,

Figure 1
Annual precipitation at Circle and Fort Peck

especially in the southern half of the study area. Salts are derived from the leaching of shale beds in the Tongue River Member of the Fort Union Formation and from the Bearpaw Shale. Other formations also have saline shales which may locally contribute to salinity buildup. Leaching of salts may be accelerated where permeable zones have been formed by the burning of coal beds within saline shale sequences.

Badlands topography is common in areas underlain by the Fox Hills, Hell Creek and Tullock units, primarily in the western third of the area. Silt deposits, probably wind blown loess (Colliver and Knechtel 1939) mantle many parts of the area and may have influenced the present topography as well as soils.

Several major kinds of soils are found in the study area. There are Ertisols and Aridisols (Lithosols and Brown soils), e.g. Bainville silt loam, Mollisols (Chestnut and Chernozem soils), e.g. Bearpaw clay loam, Sprole loam, Vida loam; Ertisols and bedrock outcrops (badlands); Aridisols and some agrids and natragrids (glaciated Brown and Solidized-Solentz soils), e.g. Phillips loam, Scobey clay loam, Thoeny loam, and Fluvents (alluvial soils) e.g. Bowdoin clay, Lohmiller clay loam (after Southard 1973).

The study area is primarily a temperate grassland, or more precisely a mixed grass prairie (Weaver and Albertson, 1956). A second major biome type in the area is the Artemisia dominated cool semi-desert of Whittaker (1975). Other less abundant vegetation types occur in atypical sites.

Several authors have mapped the vegetation of the area at rather small scale, largely using existing data and some new samples or listing of species.

Kuchler (1964) has indicated that the area is potentially the Bouteloua gracilis-Stipa comata - Agropyron smithii vegetation type. Morris et al. (1964) has mapped the natural vegetation of the western portion of study area as the Agropyron smithii - Stipa comata - Bouteloua gracilis type and the eastern portion as a Stipa comata - Agropyron smithii - Bouteloua gracilis type. Certainly these are the three major species of the area.

Ross and Hunter (1976) have identified three principal range sites for the area; the silty range site having 10 to 14 inches (25.4 cm - 35.6 cm) precipitation; the silty-clayey range site complex having 10 to 14 inches (25.4 cm - 35.6 cm) precipitation; and to a lesser extent the badlands. The three major climax dominants for the first two range sites are Agropyron smithii (and A. dasystachum), Andropogon scoparius, and Stipa comata. The three principal increasers for these sites are Bouteloua gracilis, Stipa comata, and Carex filifolia.

Payne (1973) had indicated three major rangeland types for the area. The southern portion of the study area is the Prairie County grassland, dominated by Stipa Comata, Carex filifolia, and Bouteloua gracilis. The northwest portion of the area is the central grassland, characterized by scattered sagebrush (Artemisia sp.), and Bouteloua gracilis, Agropyron smithii, and Stipa comata. The northeastern part of the study area is the Northeastern grassland, distinguished by Andropogon scoparius and also Bouteloua gracilis, Stipa comata, and Agropyron smithii.

The aforementioned mapping efforts attempted to characterize the vegetation of the area on a broad scale. They are not sufficiently well defined (nor were they intended) for large scale vegetation study or mapping. Although many of the community types of the area incorporate the species mentioned above, a number of less abundant and dramatically different communities occur in the area. This called for a more intensive study of the vegetation of the area.

METHODOLOGY

DATA COLLECTION

Reconnaissance Data

A reconnaissance of the vegetation was the first step toward meeting the objectives of the baseline study. Although a classification seemed to be the most desirable way to handle the vegetation to meet the objectives, the techniques to be used for classification had not been chosen. Franklin, Dyrness, and Moir (1971) have outlined a reconnaissance technique suited to community classification of which this study was roughly modelled. They note the objective is to collect maximum data in a minimum amount of time. Lambert and Dale (1964) define efficiency as the optimization of information for a given quantity of work and note that it is often more efficient to work with a large number of samples of low information content than with a smaller number of much more elaborate and time consuming records. These objectives also guided this reconnaissance.

The reconnaissance data were eventually used for community type classification and definition, estimation of species diversity, and site descriptions. These data also contributed to selecting productivity sampling locations, making species lists, and served as ground truth for aerial photography interpretation necessary for vegetation mapping.

Figure 2 displays a field data form used in this reconnaissance. An explanation of the collection of data follows:

Sampled areas. Investigators sampled a total of 552 plots, more than half of which were selected prior to field work from aerial photographs. These aerial photographs were either 1:20,000 or 1:40,000 scale panchromatic or 1:12,000 scale true color. Sample areas were selected to cover a range of photographic signatures, sites and geographic areas.

Investigators chose other sample areas in the field to assure sampling of communities not distinguishable from aerial photographs. Thus sample area location was both objective (though not random) and subjective. Mueller-Dombois and Ellenberg (1974) advocate "subjective sampling without preconceived bias." Pfister and Arno (personal communication) also advocate this technique, while rejecting random and systematic methods of sampling because of inherent inefficiency.

Upon reaching a sample area, a team of two investigators observed the general species composition of the stand and randomly picked a plot location. If both team members agreed that the resulting plot location did not differ significantly from the stand in general, they sampled the plot. Sample plots were set out along contours to minimize the chance of sampling across different soil strata, or microclimatic gradients.

Figure 2
Reconnaissance data form

Location: _____ Plot No.: _____ Air Photo No.: _____

Aspect of Vegetation: _____ Dominants: _____

Grazing Pressure: _____ Picture No.: _____

Observations: _____

Slope Aspect: _____ Slope: _____ Slope Position: _____

Elevation: _____ Horizontal Configuration: _____ Distance to Livestock Water Source: _____

Soil Texture: _____ Soil: _____ Precipitation: _____

Life-Form	Species	Cover Class	Life-Form	Species	Cover Class
			Mosses		
			Lichens		
			Litter		
			Bare Soil		
			Bare Rock		
			10		

Plot size. The rectangular sample plots measuring 27.5 feet X 13.5 feet (8.4 m X 4.1 m) and covering areas of 371 feet² (34.5 m²) represented compromises in sampling technique. Although elongate plots are superior to square plots for sampling (Clapham 1932), a problem arises when the plot cannot be viewed as a whole (Daubenmire 1968). Also, although these rather large plots cannot provide the precision available when using many smaller plots, they can be sampled quickly and enclose many plants with low coverage. Coverage can be accurately estimated for these plots when cover classes are used.

Site factors. Investigators recorded general descriptors such as location, plot number, aerial photograph number, dominants, and observations at each sample plot. A color photograph of each plot was taken with the plot number appearing in the picture. These slides proved to be a useful reference during classification.

The investigators sampled the upper 4 inches (10 cm) of the soil at three locations in each plot using a 1.5 inch (4 cm) diameter tubular sampling device. The three samples from each plot were grouped into a single sample. A soil scientist later determined the texture of each sample by the feel method. Mechanical analysis of forty-six soil samples indicated that the accuracy of the feel method was adequate.

This determination of surface texture leaves much to be desired. A soil profile description of textures to the rooting depth would be preferable. However, work on the soil component of the baseline study has not been initiated to date.

The slope aspect of each plot was measured by facing in the direction in which water would run off the plot and shooting azimuth with a compass.

Slope was measured in degrees normal to the contour using a clinometer or a abney level.

The horizontal configuration was recorded as convex, straight, undulating, or concave.

Slope position was recorded as bottom, low, mid, upper, or top.

Grazing pressure, which is simply a subjective estimate of intensity or current livestock use and does not necessarily reflect past use, was recorded at each plot. Ratings of light, moderate or heavy were planned, but the additional categories of light moderate, moderate-heavy, and severe appeared on some data forms, reflecting a continuum of grazing intensities.

The distance in air kilometers livestock would actually have to travel to get water under average precipitation conditions was measured for each plot.

Precipitation was to be taken from 1:250,000 precipitation maps, but it was not used because it seems that, in the study area, precipitation extremes have a greater effect on vegetation than average precipitation. Annual precipitation over the study area is highly erratic as Figure 1 shows. Lomnasson (1947) documents the variation of precipitation in eastern Montana.

Coverage data. Each plot was examined closely and all species present were recorded. Plants were identified to species except for mosses, which were simply listed as mosses, and lichens, which were identified simply as crutose, foliose, or ephphytic. Species not readily identifiable were collected along with a card indicating plot number, and an identifying letter if more than one unknown was collected from a single plot.

After all species were listed, the plot was further examined and the coverage of each species, as well as the coverage of litter, bare soil and bare rock was recorded using cover classes (after Daubenmire, 1959), with a trace category for species having less than one percent coverage. Daubenmire, (1959, 1968) and Bannister (1966) note the effectiveness of using coverage to concisely express some important attributes of the species in a community. Appendix C addresses problems associated with quantitatively measuring the presence, but not absence of species.

Productivity Data

After classification, the major community types of the proposed mine area, which was revised to 11.5 square miles (29.8 km²), were identified. Thirteen major community types were recognized. Exclosure locations for these types were identified by finding relatively homogeneous stands of vegetation which were similar to the community type as characterized on the Constancy and Average Coverage tables (Appendix A). The tentative exclosure sites were visited by Dennis Hemmar of the Department of State Lands, and Dr. Jack Taylor of Montana State University. The thirteen most suitable sites were chosen and exclosure boundaries were staked by the Department of Natural Resources and Conservation (DNRC) staff.

Exclosures were constructed of steel fence posts with wood posts for corner and gate braces prior to any livestock grazing in spring 1977. Fencing consists of woven wire with two strands of barbed wire on top. With one exception, each exclosure has two gates at opposite ends of the enclosure. The gates can be left open to allow grazing in the exclosure to prevent succession away from community type species composition. All exclosures are over one acre in size with the exception of the Distichlis stricta community type exclosure.

A grid was superimposed on the exclosure and numbered reference stakes for each row were placed at the fence. Plot locations were selected using random numbers. Numbered stakes identified the plots that were to be clipped. Exclosures were divided normal to the contours into two replicates so that they could be tested for homogeneity.

Twenty-three to twenty-five 5.38 square feet (0.5 m²) circular plots were clipped in each exclosure. A Montana State University clipping crew clipped six exclosures in late July, consisting of the Distichlis stricta, Stipa comata/Bouteloua gracilis - Carex filifolia, Agropyron spicatum/Bouteloua gracilis - Carex filifolia, Bouteloua gracilis - Carex filifolia, Stipa comata community types and Distichlis stricta - Agropyron smithii ecotone exclosures. Cool season dominants characterize these communities. The seven remaining communities were expected to reach peak productivity

somewhat later and they were clipped in late August. These exclosures contained the Andropogon scoparius, Juniperus horizontalis/Andropogon scoparius - Agropyron spicatum, Andropogon scoparius - Agropyron spicatum, Bouteloua gracilis, Bouteloua gracilis/Agropyron smithii-Bouteloua gracilis, and Artemisia cana/Agropyron smithii - Bouteloua gracilis community types. Whitman (1975) described the average time of peak production for some species found in the study area. He reported that thirty percent of the seasonal aerial production was achieved by May 20, eighty percent by June 1, ninety-three percent by July 31, and about ninety-seven percent by August 31. Appendix C mentions a few of the shortcomings of this method of measuring grassland productivity.

Grasses were clipped to ground level. Plant matter was sorted by species for the dominant species, and by life form for other species. Litter was also collected. The material was oven-dried and weighed at Montana State University. Statistical summaries were provided by the DNRC.

CLASSIFICATION

Cluster Analysis

The DNRC is aware of the controversy surrounding the classification of vegetation (See Appendix C), but it seems that classification is best suited to meeting the objectives of the study. The Department of State Lands requires that vegetation types be defined on the basis of dominance, and so a number of criteria for classification such as this, using fidelity or constancy, for example, did not have to be considered. (Whittaker (1962) thoroughly discusses classification schemes.) However, all floristic data from the samples were used, which should better express the relationship of communities to one another and to environment than using only dominants.

The sample plot data were agglomeratively clustered by the pair group method and average linkage using Sorenson's (1948) index of similarity. The technique is briefly explained below.

Each sample from the reconnaissance data was compared to every other sample using Sorensen's index of similarity. The midpoint values of the cover classes were used in the index. Sorensen's index offers the advantage (over Jaccard's (1928) or Gleason's (1926) for example) of equating two plots with the same recorded coverages.

The most similar samples were then grouped, their coverages averaged, and the resulting data compared with all other samples. The process was repeated until all samples joined all others.

Species were not weighted prior to clustering because weighting adds an unnecessary element of subjectivity into the analysis and can obscure relationships inherent in the data. This is not to say, however, that weighting is inherently bad. Since species have neither identical ecological amplitudes nor ranges, weighting could be valuable, but unfortunately, the autecologies of virtually all species under study are not sufficiently understood to allow reliable a priori weighting.

The samples were clustered using a computer using a program written by the DNRC and a rather awesome forty-six foot dendrogram was constructed by hand. In order to aid interpretation, the dominant species and their cover classes were entered on one axis along with plot numbers. The dendrogram showed both discrete types and areas of gradation.

This dendrogram is too large to be included in this publication. It may be found in DNRC files in Helena.

Interpretation

Sokol and Sneath (1963) recognize the advantage of a program that, for given data, yields an unequivocal similarity scheme, but this should not be confused with a thoroughly objective process. Anyone using the same data and techniques in this study, could produce a dendrogram identical to the one used for classification. It would be possible to pick one or more similarity levels and conclude that there are as many types as there are stems intercepted by a line cutting across that similarity level. The argument for doing so would be to maintain the objectivity of the data analysis.

Due to the number of choices necessary for sampling and data analysis, however, the supposed objectivity of the data analysis is not there to maintain. (Appendix C contains a discussion of this topic.) And so it seems that the major advantage of the multivariate analysis is that choices and assumptions are closely presented, and the data are graphically portrayed.

In practice, the dendrogram guided the making of a preliminary classification, and was used as a reference for any revisions. In comparing clusters, the significance of changes in coverage or dominance had to be considered along with the possibility of associated changes in site, productivity, structure, or diversity. No single similarity level is appropriate for classification; rather, the similarity levels were most meaningful in the context of the clusters being considered. Vegetation authorities at Montana State University and the University of Montana reviewed the preliminary classification and eventually a classification for the grassland types was chosen.

Samples with shrub layer presented a special problem because the understory was often similar to other types, but the addition of a shrub layer seemed to be important not only from a phytosociological standpoint, but also from the aspect of animal ecologists and managers who might use the vegetation classes. For example, the Symphoricarpos occidentalis - Rosa arkansana community type is very similar floristically to the Shepherdia argentea/Symphoricarpos occidentalis - Rosa arkansana community type but for the addition of Shepherdia argentea. They may share over one hundred percent (absolute coverage) of their species in common. A similar situation occurs when Cornus stolonifera, Fraxinus pennsylvanica, or Populus deltoides are added. These species represent important additions to the lower strata of plants. Daubenmire (1968) emphasizes the importance of taking synusia (or layers) into account.

Consequently, samples with shrub or tree dominants (cover class 2 or greater) were segregated hierarchically. The order of segregation was: Populus deltoides, Fraxinus pennsylvanica, Juniperus scopulorum, Shepherdia argentea and associated (Prunus virginianus, Cornus stolonifera, Amelanchier alnifolia), Symphoricarpos occidentalis, Artemisia tridentata, and Artemisia cana. Samples with these dominants were separately clustered, and the result compared with the original dendrogram.

The classification resulted in recognition of twenty-seven community types and one phase containing 452 (eighty-two percent) of the sample plots. The remaining plots contained vegetation that was not recognized to form discernable units repeated on the landscape. More sampling may have resulted in recognition of more types or other revisions.

SPECIES COMPOSITION

The species composition of the twenty-seven community types has been summarized in a constancy and average coverage table (Appendix A). Constancy refers to the percent of reconnaissance samples in which a species is found for a given community type. Average coverage is based on absolute coverage as taken from the midpoints of cover classes in reconnaissance samples constituting a type.

SITE DESCRIPTIONS

Data collected in the vegetation reconnaissance were summarized for form site descriptions for each type. The data are usually given in percentages by category or in means ($\bar{X}$), standard deviations (s), and ranges. Site descriptions will be useful in reclamation, especially if native species are used. The Department of State Lands requires a discussion of environmental factors for species and types. Site requirements for dominant species can be inferred from these site descriptions. Unfortunately, the soil series for the samples were not obtained.

The only derived descriptor for each site is the slope-slope aspect value. It is commonly recognized that slope aspect is of little descriptive value if the slope is not also known. Stage (1976) describes a useful index for combining both factors.

The expression, $\tan(\text{slope}) (\sin \text{aspect} + \cos \text{aspect})$, where slope and slope aspect are measured in degrees, results in positive values for cool aspects and negative values for warm aspects. Level ground results in a value of zero. A slope of 45° is taken to be the coolest slope aspect and 225° the warmest slope aspect. This equation works well for the slopes encountered in the study area.

By examining the slope-slope aspect value in conjunction with slope values, one can determine whether a low mean slope-slope aspect value is the result of low slopes and consistent slope aspects, or steeper slopes and random slope aspects. The slope-slope aspect values, together with the soil texture data are judged to be the most important site descriptors of those evaluated.

Measuring slope-slope aspect, horizontal configuration, and slope position can present problems in coulees and on ridges, which are not bottom or top slope positions. This can be explained in field notes but does not make for neat summaries.

SPECIES DIVERSITY

A rough measure of species diversity has been formulated for the community types using reconnaissance data. The data were collected between mid-June and late August in 1976. Although diversity can change noticeably from spring to summer (Munshower and De Puit, 1975), the data are adequate for comparing community types.

Diversity was expressed three ways. Richness is simply the number of plant species encountered in standard size plots. Means and standard deviations are given.

The Simpson index is basically a measure of dominance:

$$C = \sum \frac{n_i^2}{N}$$

where C = index of dominance;

n_i = value (coverage) for the i th species; and

N = total value (coverage) for all species.

Resulting values are between zero and one, and high values indicate that most coverage is concentrated in one or a few species.

The Shannon-Wiener index can be thought of as a measure of equitability:

$$H = -\sum (P_i \log P_i)$$

where H = index of equitability; and

$$P_i = \frac{n_i}{N} \text{ as in the preceding equation.}$$

This scale is open-ended and high values indicate that similar coverages are shared by many species.

STRUCTURE

Plant community structure is useful in comparing community types and for making reclamation baseline. Structure is often related to animal abundance and diversity and these data have been used in the wildlife study. Raunkier's (1934) life forms were used as primary structure categories.

Raunkier's life form system is based on the height of the perennating bud above the ground surface. This classification reflects the exposure of the perennating bud to direct action environmental factors during the most unfavorable season. In order of increasing height of the perennating bud, the life forms used in this paper are therophytes, geophytes (cryptophytes), hemicryptophytes, chamaephytes, microphanerophytes and mesophanerophytes. In general, this ordering reflects the suitability for plant growth of sites associated with community types. Life forms can be used to evaluate ecological dominance, susceptibility to disturbance, and successional status (Arnold 1955). In addition to life forms, structure categories include crustose lichens, foliose lichens, mosses, lianas and epiphytes, litter, bare soil and bare rock.

MAPPING

Vegetation Maps

Using the definitions of Kuchler (1969), the vegetation maps portray cultural vegetation, primarily actual semi-natural vegetation and actual mesic vegetation.

Three vegetation maps have been made as part of the baseline vegetation study; a 1:24,000 scale map of the entire reconnaissance area, a 1:12,000 scale map of the 75 square mile (194.3 km²) mine study area proposed earlier, and a 1:4800 scale map of the currently proposed 11.5 square mile (29.8 km²) mine area. The classification of vegetation was designed to be sufficiently precise for the large scale mapping.

The general technique for constructing the three vegetation maps was the same, although the imagery and amount of ground truth for mapping varied. First, the location of the vegetation reconnaissance samples was indicated on the imagery being used for mapping. In some cases it was possible to associate a certain imagery signature with a certain community type and map on that basis. In cases where the signature was not obvious or did not reliably indicate a specific community type and ground truth was absent, community type site factor descriptions were used to infer which community types would most likely occur in the area under examination.

The mapping categories used were community types identified in this report and, where vegetation does not predominate, other physical features e.g. water, cropland, or badland. More than one mapping category often appears in a single mapping unit. This seems to be unavoidable except in a very simple vegetation or at a very large scale.

The maps were drawn on overlays to aerial photographs, corrected, and transferred to, in most cases topographic base maps. In areas where adequate base maps were unavailable, 1:25,000 scale aerial photographs served as base maps. In the case of the 1:4800 vegetation map, the aerial photographs were enlarged to base scale and the topographic map and ground truth were simultaneously overlaid on the air photos.

The 1:4800 scale vegetation map, an extremely accurate map, prepared to meet the Department of State Lands requirements, was based on perhaps two thousand observations as ground truth. These observations consisted of recording the dominant community type and marking the location on a map. The base map used a scale of 1:4800 and had 10 foot (3.0 m) contour intervals. The aerial photographs were taken in 1975. Color infra-red transparencies were enlarged to 1:4800 scale prints.

The 1:12,000 scale vegetation map was based on approximately 225 reconnaissance plots, 1:12,000 color infra-red transparencies and true color prints taken in 1975. Additional field observations were used as ground truth. The base map was a 1:24,000 topographic map enlarged to 1:12,000. When they were available, 7.5' topographic maps were used as a base. For the unmapped portions of McCone County, the vegetation was mapped on overlap to 1:25,000 panchromatic air photos taken in 1974-1975.

The 1:24,000 scale vegetation map was based on approximately 325 reconnaissance samples which served as ground truth and a variety of panchromatic imagery. The scales and dates of the aerial photographs were: McCone County 1:40,000 1970; Garfield County 1:21,000 1968; Roosevelt County 1:21,000 1967 and Valley County 1:40,000 1969.

Copies of the maps made as a result of this study are available from the DNRC, Helena.

Range Condition

The Department of State Lands suggests in its vegetation guidelines submission of range trend and range condition as determined by the Soil Conservation Service range site system or a comparable method although the Soil Conservation Service range site system is primarily designated to be a tool for range management. Hemmer has stated that range trend need not be determined in this case.

The Soil Conservation Service system of range evaluation has been outlined by Dyksterhuis (1949, 1958), and more recently by Shiflet (1973). The Soil Conservation Service National Range Handbook (USDA 1976) is definitive in this respect.

The range site is the basis of this system. "A range site is a distinctive kind of rangeland that differs from other kinds of rangeland in its ability to produce a characteristic natural plant community. A range site is the product of all the environmental factors responsible for its development.* It is capable of supporting a native plant community typified by an association of species that differs from that of other range sites in the kind or proportion of species or in total production." (USDA 1976). The statistical considerations raised by the latter part of this definition are not addressed (See Appendix C for a discussion of problems in classification). In fact, range sites are usually identified on the basis of soils and moisture.

* This raises the question of what non-living entity is not the product of all the environmental factors responsible for its development.

Range condition refers to the state of vegetation on a range site relative to the theoretical climax association for that range site. For each range site, the Soil Conservation Service has identified species that decrease, increase and then decrease, or invade under grazing. The relative percentage by weight of plants in these categories determines the condition of a range site, or its subdivision.

Estimates of species composition by dry weight* made at the time of reconnaissance sampling, and other reconnaissance data were used for determining range condition. Range sites were taken from the ongoing Soil Conservation Service soil mapping effort in McCone county. Range condition mapping was done on an overlay to the soil map at a scale of 1:24,000.

* Estimating weight is hazardous (Daubenmire 1968), but estimating each species contribution relative to the total weight may be more reliable.

RESULTS

COMMUNITY TYPES

The previously described cluster analysis and classification resulted in the identification of twenty-seven community types whose names, along with their abbreviations are listed in Table 1. Figure 3 shows the general results of the dendrogram and classification. The types are discussed in general followed by separate discussions of species composition, sites, species diversity, and productivity.

Figure 3 is a rendition of the dendrogram as classified. "ZAP Plots", which appear in the figure, refer to floristic data for the study sites in the Zonal Air Pollution System (Taylor et al. 1975). These data were used in the cluster analysis in the hope that, based on their similarity to other communities, impact predictions could be based in part upon studies near Colstrip. Unfortunately, the ZAP communities were segregated from the types in the study area on the basis of their high coverages of Bromis tectorum and B. japonicus.

The term community type refers to an abstract grouping of communities which are similar enough in their species composition to warrant recognition as a class. Community types are not habitat types or units of land named for the climax plant association. Although speculation is sometimes made about successional status, no study of population dynamics or successional trends has been made.

General Discussion of Community Types

Scirpus americanus Community Type (Scam c.t.). The Scam c.t., a minor type having a restricted extent within the study area, is a monoculture, or nearly so, occurring on alkaline areas that are flooded at least part of the year, and on heavy soils along salty streams. The soils of the Scam c.t. have low redox potential. Soil moisture at rooting depth is seldom below field capacity and at other times S. americanus is emergent. Sites for the Scam c.t. are moister than sites for the Distichlis stricta community type, which can often be found adjacent to Scam c.t. sites.

The Scam c.t. appears to be similar to the S. paludosus (S. maritimus L.) community type of Ungar (1974). Coupland (1950) notes S. paludosus dominance in the moister or better drained parts of salt flats. Stewart and Kantrud (1972) identified S. americanus as a dominant associated with grazing and sandy soil in moderately brackish, shallow marshes in North Dakota.

Communities of Juncus, Carex, and Eleocharis are occasionally found along brackish streams near the Scam c.t. Triglochin maritimum and Schedonnardus paniculatus are sometimes present in this type.

Figure 3
Generalized results of cluster
analysis and classification

Figure 3 (Cont'd.)

Table 1. Community Type Names and Abbreviations

<u>Scirpus americanus</u>	Community Type (Scam c.t.)
<u>Distichlis stricta</u>	Community Type (Dist c.t.)
<u>Bouteloua gracilis</u>	Community Type (Bogr c.t.)
<u>Agropyron smithii/Bouteloua gracilis</u>	Community Type (Agsm/Bogr c.t.)
<u>Bouteloua gracilis/Agropyron smithii</u>	Community Type (Bogr/Agsm c.t.)
<u>Stipa comata/Bouteloua gracilis-Carex filifolia</u>	Community Type (Stco/Bogr-Cafi c.t.)
<u>Bouteloua gracilis-Carex filifolia/Stipa comata</u>	Community Type (Bogr-Cafi/Stco c.t.)
<u>Stipa comata-Agropyron smithii/Bouteloua gracilis</u>	Community Type (Stco-Agsm/Bogr c.t.)
<u>Bouteloua gracilis-Carex filifolia/Agropyron smithii-Stipa comata</u>	Community Type (Bogr-Cafi/Agsm-Stco c.t.)
<u>Stipa viridula-Agropyron smithii/Bouteloua gracilis</u>	Community Type (Stvi-Agsm/Bogr c.t.)
<u>Andropogon scoparius</u>	Community Type (Ansc c.t.)
<u>Andropogon scoparius-Calamovilfa longifolia</u>	Community Type (Ansc-Calo c.t.)
<u>Andropogon scoparius-Agropyron spicatum</u>	Community Type ((Ansc-Agsp c.t.)
<u>Agropyron spicatum/Bouteloua gracilis-Carex filifolia</u>	Community Type (Agsp.Bogr-Cafi c.t.)
<u>Muhlenbergia cuspidata-Agropyron spicatum</u>	Community Type (Agsp-Mucu c.t.)
<u>Juniperus horizontalis/Andropogon scoparius-Agropyron spicatum</u>	Community Type (Juho/Ansc-Agsp c.t.)
<u>Calamovilfa longifolia</u>	Community Type (Calo c.t.)
<u>Yucca glauca</u>	Community Type (Yugl c.t.)
<u>Juniperus scopulorum/Agropyron spicatum</u>	Community Type (Jusc/Agsp c.t.)
<u>Artemisia cana/Agropyron smithii/Bouteloua gracilis</u>	Community Type (Arca/Agsm/Bogr c.t.)
<u>Artemisia cana/Stipa viridula-Agropyron smithii</u>	Community Type (Arca/Stvi-Agsm c.t.)
<u>Artemisia tridentata/Agropyron smithii/Bouteloua gracilis</u>	Community Type (Artr/Agsm/Bogr c.t.)
<u>Artemisia tridentata</u>	Badland Community Type (Artr Badland c.t.)

Table 1. Community Type Names and Abbreviations

<u>Symphoricarpos occidentalis-Rosa arkansana</u>	Community Type (Syco-Rosa c.t.)
<u>Shepherdia argentea/Symphoricarpos occidentalis-Rosa arkansana</u>	Community Type (Shar/Syoc-Rosa c.t.)
<u>Fraxinus pennsylvanica/Rosa arkansana-Symphoricarpos occidentalis</u>	Community Type (Frpe/Rosa/Syoc c.t.)
<u>Populus deltoides/Rosa arkansana-Symphoricarpos occidentalis</u>	Community Type (Pode/Rosa-Syoc c.t.)

Distichlis stricta Community Type (Dist c.t.). The Dist c.t. may be a near monoculture. Occasionally other salt tolerant grasses such as Puccinellia nuttalliana, Poa juncifolia, Spartina gracilis, or Muhlenbergia asperifolia in small amounts. In some communities, P. juncifolia may be co-dominant, but its abundance appears to be related to soil disturbance. The Dist C.T. occurs on alkali bottoms near water courses. Dist c.t. appears to be similar to the Distichlis stricta communities of Ungar (1974) and Dodd and Coupland (1966).

The transition from the Dist c.t. to mixed prairie communities may be abrupt or gradual. If gradual, coenoclinal associates of D. stricta are Agropyron smithii and some bluegrasses, including Poa juncifolia, P. Scabrella, and possibly P. gracillima,* although the latter species would seem to be off-site. The proposed mine area contains some bottomland that was plowed over thirty years ago and now has a community of D. stricta, A. smithii, Poa spp., and to a lesser extent Bromus tectorum, Plantago spp., and some members of the Chenopodiaceae family. An identical community could not be found outside the mine area and so a D. stricta - A. smithii community was sampled for productivity. Dodd and Coupland (1966) identified a Distichlis-Agropyron community, and Smoliak et al. (1976) identified a type dominated by A. smithii, D. stricta, Artemisia cana, and Sarcobatus vermiculatis.

D. stricta can be found with the typical prairie species in areas of gradual transition, progressing outward from the Dist c.t. D. stricta can act as an increaser species in some situations.

The occasional occurrence of D. stricta in badlands should not be confused with the Dist c.t., which occurs in lowland saline areas.

Bouteloua gracilis Community Type (Bogr c.t.). The Bogr c.t., seems to be a grazing disclimax on a number of sites. Soil texture ranges from loams to silty clay loams. Field observations suggest that parent community types can be Bouteloua gracilis/Agropyron smithii community type (Bogr/Agsm c.t.), the Agropyron spicatum/Bouteloua gracilis - Carex filifolia community type (Agsp/Bogr-Cafi c.t.), and to a lesser extent other types. Poa sandbergii is commonly present in this community type.

Carex filifolia and B. gracilis dominated a few reconnaissance plots which may represent a severe grazing disclimax on sites once dominated by Stipa comata. The loss of S. comata due to grazing seems to be rare, however, and sheep appear to favor C. filifolia.

B. tectorum and B. japonicus are absent or very rare even on the most heavily grazed areas. Although this results from the precipitation pattern, the species can prosper on abandoned cultivated land, suggesting that soil disturbance is involved.

* Hitchcock (1951) notes, "There are several groups of Poa that present many taxonomic difficulties." One of the groups cited as an example is Scabrellae, which contains P. scabrella, P. gracillima, P. secunda, and P. canbyi. Hitchcock et al. (1969), in referring to Poa, notes "Taxonomically, the genus is notoriously difficult, particularly because many of the species reproduce in large measure by other than true sexual means..." They note that due to the high variability involved, keys must accomodate exceptions under more than one lead. They discuss further problems in identifying reliable characters in the P. sandbergii complex.

Agropyron smithii/Bouteloua gracilis Community Type (Agsm/Bogr c.t.). The Agsm/Bogr c.t., a major community type in the study area, usually occupies low to mid slope positions. Coupland (1961) identified a Bouteloua-Agropyron faciation suggested the impermeable subsoils associated with this faciation are unsuited to Stipa dominance.

Hanson and Whitman (1938) identified a western wheatgrass-grama-sedge type which typically contains more Carex than the Agsm/Bogr c.t. The authors noted heavier soils in their wheatgrass-grama-sedge type than in their grama-needlegrass-sedge type. They suggest that the western wheatgrass-grama-sedge type is successional to the grama-needlegrass-sedge type and is especially sensitive to drought.

It is often said that an A. smithii is found on heavier soils than Stipa comata. As a generalization this may be true; however, there is a good deal of overlap in this respect, and it may be that generalizations oversimplify the complex interactions involved. Morris (1976) has indicated that soil color and texture, precipitation, and grazing should be taken into account in summarizing the relative order of plant dominance. The existence of ecotypes might make interpretations even more difficult.

Stipa comata/Bouteloua gracilis-Carex filifolia Community Type (Stco/Bogr-Cafi c.t.). The Stco/Bogr-Cafi c.t. and the Bogr-Cari/Stco c.t. are the most abundant types in the study area as reflected by the number of reconnaissance samples falling into these categories. It is similar to the grama-needlegrass-sedge type of Hanson and Whitman (1938), which they consider to be the stabilized type on uplands given the climatic fluctuation of the area. Coupland (1961) identified a Stipa-Bouteloua faciation and noted that perhaps Carex should be added to the name. Coupland's (1950) Stipa-Bouteloua faciation appears to be similar to, but moister than this type, as evidenced by the abundance of S. spartea and A. dasytachyum in his faciation. He suggests it is post climax to his Bouteloua-Stipa faciation.

Wright and Wright (1948) recognize a B. gracilis-S. comata type with larger amounts of C. filifolia on the sandier sites. Mueggler and Handl (1974) identified a S. comata/B. gracilis habitat type for western Montana. Smoliak et al. (1976) identified a Stipa - Bouteloua type associated with medium textured soils in the drier Brown zone, coarser soils of the Dark Brown zone and on sandy loam solonchic soils. In our study area, the Stco/Bogr-Cafi c.t. occurs mainly on loams and on mid to upper slope positions.

Coryphantha vivipara exhibited fidelity for the S. comata dominated community types. (Fidelity was rarely observed for any species in this study). Agropyron dasytachyum was sometimes present in the Stco/Bogr-Cafi c.t.

Bouteloua gracilis-Carex filifolia/Stipa comata Community Type (Bogr-Cafi/Stco c.t.). The Bogr-Cafi/Stco c.t. is distinguished by a greater coverage of B. gracilis and C. filifolia than S. comata. This shift in dominance is probably the result of grazing (Smoliak 1965, 1974, Smoliak et al. 1976), although S. comata can persist under heavy grazing (Peterson 1962) through selection of grazing resistant ecotypes. This may not be true in all habitats, however.

While grazing may cause the reversal of dominants in this and other community types, weather may also be a strong determinant (Houston and Woodward, 1966). Reed and Peterson (1961) observed that major weather cycles set major trends in mixed prairie vegetation characteristics, while grazing intensity determines the rate of change within trends. Coupland (1950) associated his Bouteloua-Stipa faciation with drier sites than the Stipa-Bouteloua faciation.

Poa sandbergii was more abundant in the Bogr/Agsm, Bogr-Cafi/Stco, and Bogr-Cafi/Agsm-Stco c.t.'s than in the Agsm/Bogr, Stco/Bogr-Cafi, and Stco-Agsm/Bogr c.t.'s.

Stipa comata-Agropyron smithii/Bouteloua gracilis Community Type (Stco-Agsm/Bogr c.t.) In the Stco-Agsm/Bogr c.t. the two midgrasses share dominance, with S. comata usually having the higher coverage. The Stco-Agsm/Bogr c.t. perhaps represents an area of gradation between the Stco/Bogr-Cafi and Agsm/Bogr c.t.'s. If so, the Stco-Agsm/Bogr c.t. is a fairly constant and recognizable area of gradation.

Coupland (1961) recognized a Stipa-Bouteloua-Agropyron faciation, and Smoliak et al. (1976) identified a Stipa-Agropyron type. Morris (1976) recognized the unequally shared dominance of S. comata and A. smithii on both sandy and clay loams under moderate grazing. The Stco-Agsm/Bogr c.t. may also be related to the A. smithii-A. dasytachyum phase of the S. comata/B. gracilis habitat type of Mueggler and Handl (1974).

Bouteloua gracilis-Carex filifolia/Agropyron smithii-Stipa comata Community Type (Bogr-Cafi/Agsm-Stco c.t.). The Bogr-Cafi/Agsm-Stco c.t. is identified by a greater coverage of B. gracilis and C. filifolia than A. smithii and S. comata, and occupies warmer sites than sites for the Stco-Agsm/Bogr c.t. This type may represent a heavily grazed phase of the Stco-Agsm/Bogr c.t. Stipa-Carex-Agropyron dominated climax stands became dominated by Carex and Bouteloua under grazing (Coupland et al. 1960).

The simultaneous increase in abundance of C. filifolia and reversal of dominance between S. comata and A. smithii raises a problem in interpretation if A. smithii is taken to be suggestive of heavy soils and C. filifolia of light soils. The western wheatgrass-grama-sedge type of Hanson and Whitman (1938) may indicate that the association of C. filifolia and A. smithii is not unusual, but Morris (1971) associated the species with different soils.

Stipa viridula - Agropyron smithii/Bouteloua gracilis Community Type (Stvi-Agsm/Bogr c.t.). The Stvi-Agsm/Bogr c.t. is generally found in areas with above average moisture and heavier than average soils. A depression of soil carbonate levels might also be associated with S. viridula. It is not restricted to vertisols in the study area. This type is often found in swales and coulees. Morris (1971) associated communities of S. viridula, A. smithii, and variable amounts of B. gracilis, with moderately developed soils on benches and near level plateaus in southeastern Montana. Echinacea pallida and Ratibida colunifera, usually associated with moister than average sites, are sometimes present in the Stvi-Agsm/Bogr c.t.

Field observations suggest that this type would be more widespread if grazing were less intensive. Reed and Peterson (1961) notes that while the response of most vegetation to grazing is variable, S. viridula consistently decreases with increased grazing.

Andropogon scoparius Community Type (Ansc c.t.). The Ansc c.t. is most common on cool, well-drained uplands, although found on many different kinds of sites, Hanson and Whitman (1938) associate a similarly named type with areas where snow accumulates. They feel that this type is successional on eroded soils. These authors note that A. scoparius is an important species because it stabilizes runoff and erosion, holds drifting snow, and hastens soil development. White (1961) suggests that A. scoparius may be associated with low soil fertility on clay-textured soils.

Hanson and Whitman (1938) suggest that A. scoparius is little grazed except in time of drought, but many consider it to be a decreaser under grazing and it is noticeably scarce on overgrazed range. Because cattle graze mostly the leaves of this species until late August, when they begin to graze the stalks (Jameson and Huss 1959), the Ansc c.t. appears to be little grazed even when it is being used by cattle.

Psoralea esculenta, and to a lesser extent Echinacea pallida, are associated with A. scoparius dominance. Some species associated with above average soil moisture, such as Psoralea argophylla, Solidago missouriensis, and Cirsium undulatum, are often a component of the Ansc c.t. Other minor associates are Asclepias verticillata, Antennaria spp., Artemisia dracuncul, and Yucca glauca.

Andropogon scoparius - Calamovilfa longifolia Community Type (Ansc-Calo c.t.). Many Ansc c.t. communities contain C. longifolia, but stands must contain over 5% absolute coverage of C. longifolia to be a member of the Ansc-Calo c.t. The average from reconnaissance plots contained 17.5% absolute coverage of C. longifolia. Typically this species becomes a dominant with erosion and a reduction in A. scoparius coverage. The amount of bare soil for this type is over twice the amount of bare soil for the Ansc c.t. and average soils are a bit lighter in texture.

Slope-slope aspect values for the Ansc-Calo c.t. sites indicate decidedly warmer sites than values for the Ansc c.t. sites. This can be taken at face value, or it may be that livestock use is intensified on the warmer aspects in the Ansc c.t. sites especially when snow is present resulting in habitats better suited to C. longifolia. Soil Ph may be low on Ansc-Calo c.t. sites, and plant nutrition can be a problem.

The genera Astragalus and Petalostemon are usually present in Ansc-Calo c.t. Aristida longiseta was present in about half the stands sampled. Lygodesmia juncea, found usually on light soils, was most constantly present in this type. Juniperus horizontalis and some Ansc c.t. associates were usually present.

Andropogon scoparius - Agropyron spicatum Community Type (Ansc-Aqsp c.t.) The Ansc-Aqsp c.t. is often found on warm aspects of scoria hills

having modest soil development. It can also occur in badlands, usually on ridgetops or upper slopes where erosion is evident.

Because of the low number of sample stands for this type, every species encountered in a sample plot found its way into the Constancy and Average Coverage Tables (Appendix A). This makes compositional comparisons difficult. Most Ansc c.t. associates are present. Hedeoma spp., Astragalus striatus, and Echinacea pallida are often found in this type. Artemisia frigida was encountered in all samples, and the equally ubiquitous Gutierrezia sarothrae and Phlox hoodii were encountered in three out of four samples.

Agropyron spicatum/Bouteloua gracilis-Carex filifolia Community Type Agsm/Bogr-Cafi c.t.). A. spicatum is primarily a foothill grassland species in Montana, and it is possible that the A. spicatum in the study area may demonstrate some ecotypic variation. A small percentage of the A. spicatum in the study area is awnless. McMillan (1959, 1969) has substantiated the likelihood of ecotypes in Agropyron spicatum.

Morris (1971) suggested that in southeastern Montana A. spicatum is found on ridgetops where rocky subsoil and parent material permit better moisture penetration than on well developed soils. Reduced competition on these sites may also be a factor favoring A. spicatum.

The Agsp/Bogr-Cafi c.t. is usually found on ridgetops and on upper slopes of a cool aspect, and may be associated with a stony substrate. The abundance of B. gracilis and C. filifolia is rather clearly related to grazing, which in turn may be related to topography. C. filifolia may also be associated with soils of limited pedogenic development.

Chamaephytes such as Artemisia frigida, Eurotia lanata, and Gutierrezia sarothrae are frequently found in the Agsp/Bogr-Cafi c.t. Agropyron dasystachyum may be present.

The Agsp/Bogr-Cafi c.t. seems to be similar to the A. spicatum-C. filifolia-B. gracilis type of Wright and Wright (1948). They suggest that A. spicatum extends into the Great Plains on sandy soils with above average moisture infiltration. The A. spicatum/B. gracilis habitant type, Liatris punctata phase (Mueggler and Handl 1974) is a similar type found in western Montana.

Muhlenbergia cuspidata-Agropyron spicatum Community Type (Mucu-Agsp c.t.) The Mucu-Agsp c.t., a type, is found in sites similar to those of the Agsp/Bogr-Cafi c.t., but soils are more immature and stony. M. cuspidata is less frequently associated with Andropogon scoparius, Stipa comata, and even Bouteloua curtipendula.

In southeastern Montana, Morris (1971) associated M. cuspidata with undeveloped soils in grasslands, particularly on dry stony slopes. He noted that M. cuspidata is non-aggressive and is typically found in areas with low ground cover. Coupland (1950) associated M. cuspidata with dry, eroded hill-sides where the A horizon has been lost.

Some minor members of this community type are Comandra umbellata, Echinacea pallida, Eriogonum pauciflorum, Gaura coccinea, Petalostemon spp., Liatris punctata, and Yucca glauca.

Juniperus horizontalis/Andropogon scoparius-Agropyron spicatum Community Type (Juho/Ansc-Agsp c.t.). The Juho/Ansc-Agsp c.t. is frequently found on cool aspects of scoria hills and also in badlands, but not badlands of the Bear Paw formation. J. horizontalis can also be found in coulees on light soils. Livestock use is light, but deer browse on the juniper. J. horizontalis can be an important species in prevention of erosion on steep slopes.

This type and the Ansc-Agsp c.t. are dominant on scoria hills. Yucca glauca is occasionally a dominant on warm aspects. Ribes cereum is sometimes found on outcrops.

Hanson and Whitman (1938) observed a Mentzelia decapetala*-Juniperus horizontalis type on scoria buttes and identified the grass dominants as Agropyron spicatum and Muhlenbergia cuspidata, with a number of shrubs also occurring on the scoria buttes. The authors suggested that as the scoria buttes weathered into scoria hills, grasses would become more abundant while shrubs would decrease.

J. horizontalis has a definitely contagious population dispersion. A. spicatum is most often found interspersed with juniper, and Andropogon scoparius is usually the dominant grass in areas not containing juniper. J. horizontalis apparently hybridizes with J. scopulorum. Some secondary species found in the Ansc-Agsp c.t. are Solidago missouriensis, Echinacea pallida, Linum perenne, Petalostemon purpureum and Artemisia dracunculus. Bouteloua curtipendula may be present in this type, but it has not been found in the proposed mine area.

Calamovilfa longifolia Community Type (Calo c.t.). The Calo c.t., a very uncommon type, can be found on eroded, coarse textured soils on warm aspects. On better developed soils Asclepias verticillata is a major associate. The Calo c.t. shows some secondary species with A. scoparius dominated community types, and may also contain Chenopodium leptophyllum, Astragalus missouriensis, and Petalostemon candidum.

Yucca glauca Community Type (Yugl c.t.). The Yugl c.t. occurs on sites similar to Ansc-Caló c.t. sites, though soils are usually courser. Calamovilfa longifolia, Andropogon scoparius, and to a lesser extent Carex filifolia and Stipa comata, are frequent associates, and Muhlenbergia cuspidata may be a co-dominant. Possibly Y. glauca acts as an increaser species on these latter sites. Y. glauca may also be associated with the outcrops of bedrock material.

Chrysopsis villosa was present in all samples. Solidago missouriensis, Artemisia dracunculus, Aristida longiseta, Cirsium undulatum, Petalostemon spp., and Ratibida columnifera are minor associates. Melilotus officinalis and Agropyron spicatum turned up in a few samples.

* Mentzelia decapetala was found only twice on scoria hills in the study area.

Juniperus scopulorum/Agropyron spicatum Community Type (Jusc/Agsp c.t.)
The Jusc/Agsp c.t. is a minor type in the study area, is found mainly in the vicinity of Fort Peck on cool aspects and on grey-black soils often derived from shale. Like other tall shrub types, it provides important wildlife cover. Brown (1971) identified a Juniperus-Agropyron community in badlands on clayey soils with low sodium content. Similar communities can be found in Montana on a variety of substrates (See for example, DNRC 1976).

The Jusc/Agsp c.t. shares some subordinate species with the Juho/Ansc-Agsp c.t. Other distinctive associates are Melilotus officinalis, Comandra umbellata, Solidago missouriensis, Achillea millefolium, Chrysopsis villosa, Artemisia tridentata, Juniperus communis, Rosa spp., and Prunus virginiana. Artemisia frigida was present in all stands. Species diversity is quite high.

Artemisia cana/Agropyron smithii/Bouteloua gracilis Community type (Arca/Agsm/Bogr c.t.). The Arca/Agsm/Bogr c.t., is found in areas with the above average moisture and is associated with a low slope position. It is important to a variety of animal species. Productivity is noticeably higher than for adjacent grassland types. Cattle grazing may favor A. cana, but heavy sheep grazing can result in a decrease of this species. Houston (1961) noted that light stocking of livestock can favor A. cana abundance.

Species diversity values suggest that this type and the Artr/Agsm/Bogr c.t. involve more than the addition of a shrub, Artemisia, to the Agsm/Bogr c.t. The sites involved may permit a richer flora, or it may be that the presence of a shrub layer provides special niches for other species.

The frequent presence of Achillea millefolium, Ratibida columnifera, and Symphoricarpos occidentalis supports the hypothesis that this community type is associated with above average moisture. Gaura coccinea was sometimes present.

Artemisia cana/Stipa viridula Agropyron smithii Community Type (Arca/Stvi-Agsm c.t.). The relation of this type to the Arca/Agsm/Bogr c.t. is similar to the relationship of the Stvi-Agsm/Bogr c.t. to the Agsm/Bogr c.t. It might be considered a phase of the Arca/Agsm/Bogr c.t. occurring under an above average moisture regime and light-moderate livestock use.

The Arca/Stvi-Agsm c.t. typically contains more moist site indicators than the Arca/Agsm/Bogr c.t. Some understory associates are Artemisia ludoviciana, Psoralea argophylla, Achillea millefolium, Poa canbyi, Ratibida columnifera, and Symphoricarpos occidentalis.

Artemisia tridentata/Agropyron smithii/Bouteloua gracilis Community Type (Artr/Agsm/Bogr c.t.). A principal stand distribution of A. tridentata spp. wyomingensis lies on the western edge of the study area (Morris et al. 1976). The Artr/Agsm/Bogr c.t. is most abundant in the area along and west of Highway 24.

The Artr/Agsm/Bogr c.t. is found mainly on uplands, in contrast to the Arca/Agsm/Bogr c.t. A. tridentata spp. wyomingensis may be intolerant of high soil moisture. Neither A. smithii nor B. gracilis has 100% constancy for this type and occasionally upland grasses such as Stipa comata are among the dominants. Aristida longiseta and Selaginella densa may be present.

Using data from the Constancy and Average Coverage tables (Appendix A) and Sorensen's similarity index, the Artr/Agsm/Bogr and Arca/Agsm/Bogr c.t.s have a similarity of 42%. This rather low similarity is in part due to the different dominants, and if the shrubby Artemisias are not considered, the types are 68% similar. If, in addition to the Artemisias, the shared dominants Agropyron smithii and Bouteloua gracilis are not considered, the types have a similarity of 51%.

The reconnaissance data suggested the possibility of A. tridentata/A. spicatum type, but too few samples (4) fell into this cluster to warrant designation of a community type given the variable floristic composition of the Artr/Agsm/Bogr c.t. Mueggler and Handl (1974) identified an A. tridentata/A. spicatum habitat type in western Montana.

Artemisia tridentata Badland. Badlands and scablands may partially be mosaics of community types, but they also contain vegetational complexes which are not amenable to classification.

The cluster analysis grouped a number of these plots on the basis of A. tridentata dominance. Agropyron spicatum, with an average coverage of nine and six tenths percent and constancy of sixty-seven percent, is the next most abundant species. Other associated species are Eriogonum pauciflorum, Grindelia squarrosa, and Atriplex confertifolia. E. pauciflorum and A. spicatum are frequently present in badlands. Bronson et al. (1970) identified a buckwheat community in a glaciated area near the study area. Distichlis stricta was present in about a fifth of the plots.

Artemisia tridentata badland, often restricted to certain strata within badlands, is usually associated with some soil development, e.g. 6 to 10 inches (15.24 cm to 25.4 cm) of regolith over bedrock.

Brown (1971) identified some Artemisia dominated badland communities, including an Artemisia tridentata-Agropyron spicatum community.

Symphoricarpos occidentalis-Rosa arkansana Community Type (Syoc-Rosa c.t.). Syoc-Rosa c.t. sites are similar to but moister than most Arca/Agsm/Bogr c.t. sites. Typical members of the Arca/Agsm/Bogr c.t. are often present, but S. occidentalis and R. arkansana dominate. Coupland (1950) identified a coulee type dominated by Rosa spp. and Symphoricarpos occidentalis.

Some species typically found in decidedly moist sites first appear in this type. Among these species are Arctium minus, Asclepias speciosa, Panicum virgatum, Solidago rigida, Urtica dioica, Elymus canadensis, Glycyrrhiza lepidota, and Rhus radicans. Artemisia ludoviciana and Ratibida columifera are often present in this type.

Sufficient attention was not paid to rose identification, and R. acicularis sometimes may have been identified as R. arkansana on some reconnaissance plots.

Shepherdia argentea/Symphoricarpos occidentalis-Rosa arkansana Community Type (Shar/Syoc-Rosa c.t.). Sites for the Shar/Syoc-Rosa c.t., usually more protected than Syoc-Rosa c.t. sites, are usually found in the bottom of steep-banked coulees where a combination of runoff, drifted snow, shade, and decreased wind velocity combine to make a habitat suitable to tall shrubs.

Many associate species of the Syoc-Rosa c.t. are found in the Shar/Syoc-Rosa c.t. Other distinctive secondary species are Monarda fistulosa and Ribes aureum. Bromus inermis and Poa canbyi were sometimes present.

Prunus virginiana is co-dominant on the moister and/or most protected sites. It was present in forty-eight percent of the reconnaissance plots comprising the Shar/Syoc-Rosa c.t. P. virginiana is susceptible to tent caterpillar infestation and grazing, while the well-armed S. argentea frequently has a fungus pathogen. Porcupines may significantly damage all tall shrubs (except S. argentea) and trees. On the driest sites with S. argentea, snowberry and rose may be absent; such communities are not members of this type.

With increasing moisture and protection, Cornus stolonifera, Rhus radicans, Ribes spp., and to a lesser extent Amelanchier alnifolia join the Shar/Syoc-Rosa c.t. These highly diverse and productive communities, both from a floristic and wildlife viewpoint seem to warrant recognition and have been designated the C. stolonifera phase. The fauna, too, is diverse.

Some moist site indicators were more abundant in the C. stolonifera phase than in the rest of the Shar/Syoc-Rosa c.t. Some of these species are Artemisia ludoviciana, Solidago rigida, Achillea millefolium, Glycyrrhiza lepidota, Rhus radicans, Ribes spp., and Prunus virginiana. In contrast, Melilotus spp. seldom occurred in the Cost phase, perhaps because of the characteristically heavy grazing. Rhus radicans, Stipa viridula, Ribes spp., and Rhus trilobata were present in all samples, and Elymus canadensis was often present.

A comparison of the Cost phase and the rest of the Shar/Syoc-Rosa c.t. using Sorensen's index showed only a forty percent similarity.

Fraxinus pennsylvanica/Rosa arkansana-Symphoricarpos occidentalis Community Type (Frpe/Rosa-Syoc c.t.). A site description has not been worked up for the Frpe/Rosa-Syoc c.t. which is clearly tied to high moisture areas. It is found along streams and in the moistest draws. Diversity, productivity, and animal use are high. A Fraxinus-Acer type is mentioned by Hanson and Whitman (1938).

Many associates of the Syoc-Rosa and Shar/Syoc-Rosa c.t.s are found in this type. Poa pratensis often had modest coverage. Smilacina stellata and Clematis lingusticifolia were present in half the sample stands, as were Taraxacum officinale and Rhus radicans. Ribes spp. was present in all samples. Amelanchier alnifolia, Cornus stolonifera, Crataegus douglasii, Shepherdia argentea, Prunus virginiana, and Salix spp. were often present.

Populus deltoides/Rosa arkansana-Symphoricarpos occidentalis Community Type (Pode/Rosa-Syoc c.t.). The Pode/Rosa-Syoc c.t., chiefly found along the Missouri River and a few other waterways, although scattered individuals occasionally occurs in coulees. It can be identified by overstory dominance of P. deltoides, though ash may be a subdominant. Understory species composition varies due to land use, grazing, and flooding, which has been reduced by Fort Peck Dam. P. deltoides appears to be phreatophyte.

The Poda/Rosa-Syoc c.t. often shares some secondary species with the Syoc-Rosa, Shar/Syoc-Rosa, and Frpe/Rosa-Syoc c.t.s, Rhus radicans was sometimes an understory co-dominant, and Glycyrrhiza lepidota and Elymus canadensis often attained most coverage with the microphanerophytes, only Salix spp., Shepherdia argentea, and Prunus virginiana were often present. The introduced species, Bromus inermis, Agropyron intermedium and Melilotus officinalis, were also often present.

SPECIES COMPOSITION

Species composition of the community types is summarized in Appendix A. Only species with an average coverage of more than one tenth of one percent are listed.

Many species play a dominant role in some communities and a secondary role in others. Examples of this behavior are Agropyron smithii, Calamovilfa longifolia, Distichlis stricta, Agropyron spicatum, Andropogon scoparius, Bouteloua gracilis, Carex filifolia, Koeleria cristata, Stipa comata, Stipa viridula, and Artemisia cana. Other species are typically present in modest quantities in a number of community types. Some species exhibiting this behavior are Tragopogon dubius, Sphaeralcea coccinea, Polygala alba, Artemisia frigida, Gutierrezia sarothrae, Opuntia polyacantha, Phlox hoodii, and Rhus trilobata.

These species have some indicator value, especially when abundant, but they also have a rather broad ecological amplitude. Some of the more interesting and less ubiquitous associates of the community types are mentioned in the section on community types.

SITE DESCRIPTIONS

The sites of the community types are described below using tables and short discussions.

TABLE 2. *Scirpus americanus* Community Type Site Description

SOIL TEXTURE:	20% fine sandy loams; 20% loams; 20% silt loams; 40% clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.0$
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Standard deviation:	$S = 0.0$
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Range:	0.0
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Sites having:

Positive slope-slope aspect values:	0
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Slope-slope aspect values of 0:	0
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Negative slope-slope aspect values:	100
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SLOPE

Mean:	$\bar{X} = 0.0$
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Standard deviation:	$S = 0.0$
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HORIZONTAL CONFIGURATION:	100% straight
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SLOPE POSITION:	100% bottom
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GRAZING PRESSURE:	20% light; 20% moderate; 60% high
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.1$ mi. (0.1 km)
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Standard deviation:	$S = 0.1$ mi. (0.1 km)
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Scam c.t. sites are similar to the Dist c.t. sites but are much moister. Tests run on two soil samples from this type gave average electrical conductivity values in excess of 10^{-3} mhos/cm and an average sodium-absorption ration of 52. Some soil properties of selected communities are given in table 3. Grazing pressure is hard to determine because of trampling caused by proximity to water; utilization is low.

Table 3. Laboratory Analysis of the Upper Four Inches of Soil for Selected Plant Communities

Dominants (cover class)	pH	EC (mmhos/cm)	SAR
<u>Stipa comata</u> (4), <u>Carex filifolia</u> (2)	7.8	0.60	0.5
<u>Bouteloua gracilis</u> (4), <u>Agropyron smithii</u> (3), <u>Distichlis stricta</u> (2)	7.8	0.62	0.6
<u>Bouteloua gracilis</u> (3), <u>Stipa comata</u> (2), <u>Distichlis stricta</u> (2)	7.4	0.85	5.3
<u>Distichlis stricta</u> (3), <u>Stipa comata</u> (2), <u>Bouteloua gracilis</u> (2)	7.6	1.11	8.0
<u>Agropyron spicatum</u> (3), <u>Distichlis stricta</u> (2), (upland site)	7.9	2.20	0.2
<u>Distichlis stricta</u> (4)	8.4	46.7	58
<u>Distichlis stricta</u> (4)	9.8	29.7	268
<u>Distichlis stricta</u> (3) (no other species present)	10.1	61.8	922
<u>Scirpus americanus</u> (5)	8.2	8.50	60
<u>Scirpus americanus</u> (4)	8.6	19.7	45

In evaluating these data, the following remarks of Sandoval et al. (1973) may be useful: Productive soil have pH values between 6.0 and 8.0. EC values between 2 and 4 are considered slightly saline; 4 to 8 is moderate; 8 to 16 is severe. SAR values greater than about 12 indicate potential problems in structural stability and permeability.

See Dodd et al. (1964) for a discussion of saline soils and plant communities, some of which are similar to the communities mentioned here. Ungar et al. (1969) discusses some plant communities and associated soil characteristics for saline areas in Nebraska. Hayward and Bernstein (1958) reviewed the salt tolerance of many plants.

Table 4. Distichlis stricta Community Type Site Description

SOIL TEXTURE:	5% sandy loams; 5% fine sandy loams; 37% silt loams; 5% sandy clay loams 21% silty clay loams; 11% clay loams; 16% clays
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = -0.01$
Standard deviation:	$S = 0.03$
Range:	-0.11 -0.04
Sites having:	
Positive slope-slope aspect values:	5%
Slope-slope aspect values of 0:	11%
Negative slope-slope aspect values:	84%
SLOPE	
Mean:	$\bar{X} = 0.7^{\circ}$
Standard deviation:	$S = 1.9^{\circ}$
HORIZONTAL CONFIGURATION:	100% straight
SLOPE POSITION:	95% bottom; 5% low
GRAZING PRESSURE:	11% light; 53% moderate; 32% high; 5% severe
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.3$ mi (0.5 km)
Standard deviation:	$S = 0.7$ mi (1.1 km)

The typical Dist c.t. site is a salty flat above a creek, though it can sometimes be found in coulees, especially below ponds. Soil electrical conductivity values of greater than 10^{-3} mhos/cm are common. Sodium absorption ratios of three soil samples from this community ranged from 58 to 922. Soil texture is variable, but the absence of loams is odd.

Ugar et al. (1969) found D. stricta to have a very wide salt tolerance. While D. stricta does not require excessive salts for normal growth, it apparently is not a good competitor in areas of low salinity.

Distichlis stricta can be found in uplands, often in badlands and sometimes in association with Agropyron spicatum, Eriogonum pauciflorum or some Chenopods, but Distichlis stricta presence should not be confused with Distichlis stricta c.t.

Table 5. *Bouteloua gracilis* Community Type Site Description

SOIL TEXTURE:	17% fine sandy loams; 42% loams; 33% silt loams; 8% silty clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = -0.03$
Standard deviation:	$S = 0.05$
Range:	-0.12-0.03
Sites having:	
Positive slope-slope aspect values:	17%
Slope-slope aspect values of 0:	42%
Negative slope-slope aspect values:	42%

SLOPE

Mean:	$\bar{X} = 2.0^\circ$
Standard deviation:	$S = 2.2^\circ$
HORIZONTAL CONFIGURATION:	100% straight
SLOPE POSITION:	67% low; 3% mid; 25% upper

GRAZING PRESSURE:	17% light; 50% moderate; 25% high; 8% severe
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.5$ mi (0.8 km)
Standard deviation:	$S = 0.3$ mi (0.4 km)

Soil texture indicates that the Bogr c.t. could be a grazing disclimax of a number of types. Slope-slope aspect values do not differ at a significant probability level of 0.5 from either Bogr/Agsm c.t. or the Agsm/Bogr-Cafi c.c. sites, both thought to be major sources of this type. Straight, nearly level slopes predominate.

Table 6. *Agropyron smithii/Bouteloua gracilis* Community Type Site Description

SOIL TEXTURE:	3% fine sandy loams; 54% loams; 2% silt loams; 7% silty clay loams; 7% clay loams
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = -0.02$
Standard deviation:	$S = 0.13$
Range:	-0.38-0.16
Sites having:	
Positive slope-slope aspect values:	40%
Slope-slope aspect values of 0:	46%
Negative slope-slope aspect values:	14%
SLOPE	
Mean:	$\bar{X} = 4.8^{\circ}$
Standard deviation:	$S = 3.7^{\circ}$
HORIZONTAL CONFIGURATION:	4% convex; 85% straight; 7% undulating; 4% concave
SLOPE POSITION:	7% bottom; 30% low; 44% mid; 15% upper; 4% top
GRAZING PRESSURE:	25% light; 7% light-moderate; 39% moderate; 21% high; 7% severe
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.6 \text{ mi (0.9 km)}$
Standard deviation:	$S = 0.4 \text{ mi (0.6 km)}$

Soils in Agsm/Bogr c.t.'s are often heavier than soils for the Stco/Bogr-Cafi and Bogr-Cafi/Stco c.t.'s, but there is plenty of room for overlap. This type is often found lower on slopes than *Stipa comata* community type sites and is frequently found in swales and coulees.

Table 7. *Bouteloua gracilis*/Agropyron *smithii* Community Type Site Description

SOIL TEXTURE:	39% loams; 43% silt loams; 12% silty clay loams; 6% clay loams
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = 0.00$
Standard deviation:	$S = 0.09$
Range:	-0.34 ± 0.19
Sites having:	
Positive slope-slope aspect values:	33%
Slope-slope aspect values of 0:	35%
Negative slope-slope aspect values:	32%
SLOPE	
Mean:	$\bar{X} = 3.1^{\circ}$
Standard deviation:	$S = 3.3^{\circ}$
HORIZONTAL CONFIGURATION:	3% convex; 91% straight; 3% undulating; 3% concave
SLOPE POSITION:	19% bottom; 44% low; 28% mid; 6% upper; 3% top
GRAZING PRESSURE:	3% light; 3% light-moderate; 31% moderate; 16% moderate high; 47% high
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.3 \text{ mi (0.5 km)}$
Standard deviation:	$S = 0.3 \text{ mi (0.5 km)}$

Soils in Bogr/Agsm c.t.'s are similar to soils of the Agsm/Bogr c.t.'s. Slope-slope aspect values do not differ significantly from values for the Agsm/Bogr c.t.'s even at the 0.5 probability level. Grazing pressure is higher than for the Agsm/Bogr c.t.'s and distance to livestock water is very significantly shorter (.01 probability level).

Table 8. *Stipa comata/Bouteloua gracilis-Carex filifolia* Community Type Site Description

SOIL TEXTURE:	92% loams; 8% silt loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.02$
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Standard deviation:	$S = 0.09$
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Range:	-0.20 to 0.20
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Sites having:

Positive slope-slope aspect values:	51%
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Slope-slope aspect values of 0:	6%
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Negative slope-slope aspect values:	53%
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SLOPE

Mean:	$\bar{X} = 4.6^\circ$
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Standard deviation:	$S = 3.7^\circ$
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HORIZONTAL CONFIGURATION:	4% convex; 78% straight; 8% undulating; 10% concave
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SLOPE POSITION:	15% low; 54% mid; 29% upper; 2% top
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GRAZING PRESSURE:	23% light; 10% light-moderate; 48% moderate; 15% moderate-high; 4% high
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.6$ mi (1.0 km)
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Standard deviation:	$S = 0.5$ mi (0.8 km)
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The Stco/Bogr-Cafi c.t. is the major community type on well drained soils in uplands. It can occur in flat bottom coulees derived from sandstone.

Table 9. *Bouteloua gracilis*-*Carex filifolia*/*Stipa comata* Community Type Site Description

SOIL TEXTURE:	17% fine sandy loams; 73% loams; 10% silt loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = -0.03$
Standard deviation:	$S = 0.11$
Range:	-0.27-0.12

Sites having:

Positive slope-slope aspect values:	24%
Slope-slope aspect values of 0:	52%
Negative slope-slope aspect values:	24%

SLOPE

Mean:	$\bar{X} = 4.6^\circ$
Standard deviation:	$S = 4.0^\circ$

HORIZONTAL CONFIGURATION:	19% convex, 65% straight, 8% undulating, 8% concave
---------------------------	---

SLOPE POSITION:	4% bottom; 22% low; 30% mid; 26% upper; 19% top
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GRAZING PRESSURE:	7% light; 4% light-moderate; 37% moderate; 26% moderate-high; 19% high; 7% severe
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.6$ mi (1.0 km)
Standard deviation:	$S = 0.4$ mi (0.6 km)

Sites for the Bogr-Cafi/Stco c.t. are warmer (.05 probability level) and tend to be a bit drier than Stco/Bogr-Cafi sties. Grazing pressure is generally greater.

Table 10. *Stipa comata*-*Agropyron smithii*/*Bouteloua gracilis* Community Type Site Description

SOIL TEXTURE:	4% fine sandy loams; 68% loams; 24% silty loams; 4% silty clay loams
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = 0.01$
Standard deviation:	$S = 0.07$
Range:	-0.14+0.15
Sites having:	
Positive slope-slope aspect values:	44%
Slope-slope aspect values of 0:	36%
Negative slope-slope aspect values:	20%
SLOPE	
Mean:	$\bar{X} = 3.0^{\circ}$
Standard deviation:	$S = 2.4^{\circ}$
HORIZONTAL CONFIGURATION:	4% convex; 76% straight; 4% undulating; 16% concave
SLOPE POSITION:	8% bottom, 21% low; 46% mid; 25% upper
GRAZING PRESSURE:	26% light; 17% light-moderate; 43% moderate; 4% moderate-high; 13% high
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.5$ mi (0.8 km)
Standard deviation:	$S = 0.4$ mi (0.6 km)

The obvious phytosociological interpretation for the Stco-Agsm/Bogr c.t. is that it is part of a continuum between the Stco/Bogr-Cafi and Agsm/Bogr c.t.'s. This hypothesis is supported by a comparison of sites. Soil textures are intermediate between the Stco/Bogr-Cafi and Agsm/Bogr c.t.'s with a good deal of overlap.

Slope-slope aspect values are intermediate and are not significantly different from Stco/Bogr-Cafi site values and are significantly cooler from the Agsm/Bogr c.t. site values only at the 0.2 probability level. There is plenty of overlap. Somewhat suprisingly, slopes for this type are significantly less than slopes for both other types at the 0.05 probability level.

Horizontal configuration for this type is not much different than for the Stco/Bogr-Cafi c.t. or Agsm/Bogr c.t. Slope position is generally slightly higher than the Agsm/Bogr c.t.'s slightly lower than Stco/Bogr-Cafi c.t.'s. Differences in livestock use are not significant.

Table 11. *Bouteloua gracilis*-*Carex filifolia*/*Agropyron smithii*-*Stipa comata* Community Type Site Description

SOIL TEXTURE:	92% loams; 8% silt loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = -0.04$
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Standard deviation:	$S = 0.08$
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Range:	$-0.15-0.11$
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Sites having:

Positive slope-slope aspect values:	17%
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Slope-slope aspect values of 0:	50%
---------------------------------	-----

Negative slope-slope aspect values:	33%
-------------------------------------	-----

SLOPE

Mean:	$\bar{X} = 3.2^\circ$
-------	-----------------------

Standard deviation:	$S = 2.7^\circ$
---------------------	-----------------

HORIZONTAL CONFIGURATION:	17% convex; 85% straight
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SLOPE POSITION:	9% bottom; 36% low; 27% mid; 27% upper
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GRAZING PRESSURE:	75% moderate; 8% moderate-high; 17% high
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.4 \text{ mi (0.6 km)}$
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Standard deviation:	$S = 0.5 \text{ mi (0.8 km)}$
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The Bogr-Cafi/Agsm Stco c.t. sites are warmer and drier in general than Stco/Agsm/Bogr c.t. sites. Slope-slope aspect values for these sites are significantly warmer than Stco-Agsm/Bogr c.t. site values at the 0.1 probability level. Slope-slope aspect values are not significantly different from Bogr-Cafi/Stco c.t. site values and are significantly warmer than Bogr-Agsm c.t. site values at only the 0.2 probability level.

Slope-slope aspect values for the Bogr/Cafi/Stco, Bogr/Agsm, and Bogr/Cafi/Agsm Stco c.t. sites are warmer respectively than slope-slope aspect values for the Stco/Bogr-Cafi, Agsm/Bogr, and Stco-Agsm/Bogr c.t. sites. This might indicate more grazing and/or slower plant recovery on the warmer exposures.

These sites are similar to Bogr-Cafi/Stco and Bogr/Agsm c.t. sites and are usually intermediate between the two.

Table 12. Stipa viridula-Agropyron smithii/Bouteloua gracilis Community Type Site Description

SOIL TEXTURE:	23% loams; 46% silt loams; 23% silty clay loams; 8% clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.0$
Standard deviation:	$S = 0.04$
Range:	-0.06 to 0.11

Sites having:

Positive slope-slope aspect values:	15%
Slope-slope aspect values of 0:	46%
Negative slope-slope aspect values:	38%

SLOPE

Mean:	$\bar{X} = 3.1^\circ$
Standard deviation:	$S = 2.1^\circ$

HORIZONTAL CONFIGURATION:	15% convex; 31% straight; 54% concave
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SLOPE POSITION:	8% bottom; 54% low; 23% mid; 15% upper
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GRAZING PRESSURE:	33% light; 17% light-moderate; 33% moderate; 17% heavy
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.8$ mi (1.3 km)
Standard deviation:	$S = 0.4$ mi (0.6 km)

The Stvi-Agsm/Bogr c.t. are often found in coulees and depressions where the moisture regime is well above average. With this extra moisture, Stipa viridula can apparently withstand grazing fairly well.

Soils for this type are not the dense clayey range soils often associated with S. viridula (White and Lewis, 1969), nor are they necessarily vertisols. Indeed, in some coulees Andropogon scoparius can be found in close proximity to S. viridula, although this does not imply that the substrates are identical.

In comparison to Agsm/Bogr c.t. sites, these sites are moister, have a somewhat heavier soil and are not grazed as heavily.

Table 13. *Andropogon scoparius* Community Type Site Description

SOIL TEXTURE:	7% fine sandy loams; 59% loams; 19% silt loams; 7% silty clay loams; 7% clay loams
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = .05$
Standard deviation:	$S = .62$
Range:	-0.56-0.29
Sites having:	
Positive slope-slope aspect values:	59%
Slope-slope aspect values of 0:	37%
Negative slope-slope aspect values:	4%
SLOPE	
Mean:	$\bar{X} = 4.4^{\circ}$
Standard deviation:	$S = 4.4^{\circ}$
HORIZONTAL CONFIGURATION:	38% convex; 38% straight; 15% concave
SLOPE POSITION:	8% low; 38% mid; 50% upper; 4% top
GRAZING PRESSURE:	58% light; 8% light-moderate; 27% moderate; 4% moderate-high; 4% high
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.8$ mi (1.3 km)
Standard deviation:	$S = 0.5$ mi (0.8 km)

The Ansc c.t. is most commonly found on cool, well drained uplands, but also in rugged sites where competition with other plants is slight. Thus it can be found in badlands and also in sandstone coulee bottoms where coulee bank erosion is quite noticeable. Moreover, it occurs in swales where greater than average moisture is available despite heavy soils.

Table 14. Andropogon scoparius-Calamovilfa longifolia Community Type Site Description

SOIL TEXTURE:	11% sandy loams; 33% fine sandy loams; 33% loams; 11% silt loams; 11% silty clay loams
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = -0.14$
Standard deviation:	$S = 0.13$
Range:	-0.34-0.0
Sites having:	
Positive slope-slope aspect values:	0%
Slope-slope aspect values of 0:	78%
Negative slope-slope aspect values:	22%
SLOPE	
Mean:	$\bar{X} = 9.1^{\circ}$
Standard deviation:	$S = 9.0^{\circ}$
HORIZONTAL CONFIGURATION:	33% convex; 44% undulating; 22% concave
SLOPE POSITION:	11% low; 33% mid; 44% upper; 11% top
GRAZING PRESSURE:	44% light; 56% moderate
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.6$ mi (1.0 km)
Standard deviation:	$S = 0.4$ mi (0.6 km)

Forty-four percent of the Ansc c.t. samples contained some amount of Calamovilfa longifolia ($\bar{X} = 1.0\%$ coverage) and there was some question of whether the Ansc-Calo communities were different enough to constitute a separate type. However, slope-slope values are significantly warmer (0.02 probability level) for the Ansc-Calo c.t. sites, although slopes are not significantly different. Soil textures for this type are lighter than Ansc c.t. soil textures.

Table 15. Andropogon scoparius-Agropyron spicatum Community Type Site Description

SOIL TEXTURE:	100% loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = -0.14$
Standard deviation:	$S = 0.25$
Range:	-0.51-0.05
Sites having:	
Positive slope-slope aspect values:	25%
Slope-slope aspect values of 0:	75%
Negative slope-slope aspect values:	0%

SLOPE

Mean:	$\bar{X} = 10.2^\circ$
Standard deviation:	$S = 8.7^\circ$
HORIZONTAL CONFIGURATION:	25% convex; 75% straight
SLOPE POSITION:	50% mid; 50% top
GRAZING PRESSURE:	75% light; 25% light-moderate

DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.5 \text{ mi (0.8 km)}$
Standard deviation:	$S = 0.7 \text{ mi (1.1 km)}$

The Ansc-Agsp c.t. is found chiefly on scoria and, to a lesser extent, badlands. Although the Ansc-Agsp c.t. might phytosociologically be interpreted as being part of a continuum between the Ansc c.t. and the Agsp/Bogr Cafi c.t. and a close relative of the Juho/Ansc-Agsp c.t., it seems to be found on decidedly warmer sites. Slope-slope aspect values are significantly different than Juho/Ansc-Agsp c.t. site values at the 0.05 probability level and different than the Ansc c.t. site values at the 0.2 probability level. Slope-slope aspect values for this type are most similar to Agsp/Bogr-Cafi c.t. site values. There is no significant difference using all data, but a significant difference appears at the 0.1 probability level if one atypical value is dropped from the Agsp/Bogr-Cafi site values.

Table 16. *Agropyron spicatum*/*Bouteloua gracilis*-*Carex filifolia* Community Type Site Description

SOIL TEXTURE:	8% fine sandy loams; 58% loams; 25% silt loams; 8% silty clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = -0.02$
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Standard deviation:	$S = 0.35$
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Range:	-1.02-0.30
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Sites having:	
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Positive slope-slope aspect values:	58%
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Slope-slope aspect values of 0:	33%
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Negative slope-slope aspect values:	8%
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SLOPE

Mean:	$\bar{X} = 9.0^{\circ}$
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Standard deviation:	$S = 9.4^{\circ}$
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HORIZONTAL CONFIGURATION:	25% convex; 42% straight; 25% undulating; 8% concave
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SLOPE POSITION:	8% low; 25% mid; 58% upper; 8% top
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GRAZING PRESSURE:	25% light; 17% light-moderate; 42% moderate; 8% heavy; 8% severe
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.6$ mi (0.9 km)
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Standard deviation:	$S = 0.3$ mi (0.5 km)
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The Agsp/Bogr-Cafi c.t. site is generally found on upper slopes and ridge-tops. Despite a negative slope-slope aspect value, repeated field observation suggest that this type is not most often found in cooler situations. By dropping a single atypical slope-slope aspect value, the mean becomes .09, and the standard deviation 0.15. These values are thought to more accurately describe sites for this type. Using all the data, slope-slope aspect values for these sites are significantly different than values for the Ansc c.t. sites only at the 0.2 probability level. However, if that same atypical value is dropped, the values are more similar with no significant difference for the Ansc c.t. sites and a significant difference at the 0.1 probability level for the Juho/Ansc-Agsp c.t. sites.

Table 17. *Muhlenbergia cuspidata*-*Agropyron spicatum* Community Type Site Description

SOIL TEXTURE:	10% sandy loams; 50% loams; 30% silt loams; 10% clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.12$
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Standard deviation:	$S = 0.35$
---------------------	------------

Range:	-0.54-0.73
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Sites having:

Positive slope-slope aspect values:	73%
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Slope-slope aspect values of 0:	27%
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Negative slope-slope aspect values:	0%
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SLOPE

Mean:	$\bar{X} = 15.4^0$
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Standard deviation:	$S = 11.3^0$
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HORIZONTAL CONFIGURATION:	55% convex; 36% straight; 9% concave
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SLOPE POSITION:	9% low; 27% mid; 64% upper
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GRAZING PRESSURE:	30% light; 60% moderate; 10% high
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.6$ mi (1.0 km)
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Standard deviation:	$S = 0.6$ mi (1.0 km)
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The site descriptions for the Agsp-Mucu c.t. and those for the Agsp/Bogr-Cafi c.t. do not point to any conclusive difference. These two sites for the two types differ most noticeably in their slope-slope aspect values, but these do not differ significantly if the atypical value is dropped from the Agsp/Bogr-Cafi c.t. site data, and only at the 0.5 probability level if all the data are used. Perhaps the best explanation is that substrates for this type are more gravelly than Agsp/Bogr-Cafi c.t. substrates.

Table 18. *Juniperus horizontalis/Andropogon scoparius-Agropyron spicatum* Community Type Site Description

SOIL TEXTURE:	17% fine sandy loams; 57% loams; 13% silt loams; 9% clay loams; 4% clay.
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.26$
Standard deviation:	$S = 0.34$
Range:	-0.46+0.94

Sites having:

Positive slope-slope aspect values:	91%
Slope-slope aspect values of 0:	9%
Negative slope-slope aspect values:	0%

SLOPE

Mean:	$\bar{X} = 17.6^{\circ}$
Standard deviation:	$S = 7.7^{\circ}$

HORIZONTAL CONFIGURATION:	22% convex; 22% straight; 35% undulating; 22% concave
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SLOPE POSITION:	9% low; 39% mid; 52% upper
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GRAZING PRESSURE:	70% light; 4% light-moderate; 26% moderate
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.8 \text{ mi (1.3 km)}$
Standard deviation:	$S = 0.5 \text{ mi (0.8 km)}$

The Juho/Ansc-Agsp c.t. is found in cool moist areas with high moisture penetration; the north face of scoria hills, steep coulee banks and sometimes bottoms, and badlands.

Table 19. Calamovilfa longifolia Community Type Site Description

SOIL TEXTURE:	33% fine sandy loams; 50% loams; 17% silty clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{x} = -2.20$
Standard deviation:	$s = 0.45$
Range:	$-1.09-0.12$

Sites having:

Positive slope-slope aspect values:	33
Slope-slope aspect values of 0:	50%
Negative slope-slope aspect values:	17%

SLOPE

Mean:	$\bar{x} = 9.5^\circ$
Standard deviation:	$s = 14.2^\circ$

HORIZONTAL CONFIGURATION:	33% convex; 33% straight; 17% undulating; 17% concave
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SLOPE POSITION:	50% mid; 33% upper; 17% top
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GRAZING PRESSURE:	67% light; 33% moderate
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DISTANCE TO STOCK WATER

Mean:	$\bar{x} = 0.5 \text{ mi (0.8 km)}$
Standard deviation:	$s = 0.6 \text{ mi (1.0 km)}$

Sites for the Calo c.t. are similar to Ansc-Caló c.t. sites. Grazing pressure is slightly lower, distances to water is a bit farther, and the sites may be somewhat drier, but no site differences are conclusive. Slope-slope aspect values and slope do not differ significantly for those two sites.

Table 20. Yucca glauca Community Type Site Description

SOIL TEXTURE:	17% loamy sands; 33% fine sandy loams; 33% loams; 17% silt loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = -0.09$
Standard deviation:	$S = 0.63$
Range:	-0.76-0.75

Sites having:

Positive slope-slope aspect values:	33%
Slope-slope aspect values of 0:	50%
Negative slope-slope aspect values:	17%

SLOPE

Mean:	$\bar{X} = 25.5^{\circ}$
Standard deviation:	$S = 13.3^{\circ}$

HORIZONTAL CONFIGURATION:	17% convex; 50% straight; 33% concave
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SLOPE POSITION:	33% mid; 50% upper; 17% top
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GRAZING PRESSURE:	50% light; 50% moderate
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.8 \text{ mi (1.3 km)}$
Standard deviation:	$S = 0.7 \text{ mi (1.1 km)}$

The Yugi c.t. site occurs on usually steep, warm, well drained uplands. Y. glauca distribution may be related to the presence of indurated bedrock and soils showing little expression of pedogenic activity. Soil parent materials are often sandstone or scoria. More samples might have led to a warmer average slope-slope aspect value.

Frequent associates with Yucca glauca are Calamovilfa longifolia and Andropogon scoparius, and the Ansc-Calo c.t. may be most closely associated with this type. Slope-slope aspect values for the two type sites do not differ significantly. Most other site factors for the two type sites are similar, but slopes are significantly steeper (0.02 probability level) for the Yugi c.t. sites.

Table 21. Juniperus scopulorum/Agropyron spicatum Community Type Site Description

SOIL TEXTURE:	20% sandy loams; 20% fine sandy loams; 60% clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.59$
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Standard deviation:	$S = 0.53$
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Range:	0.19-1.42
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Sites having:

Positive slope-slope aspect values:	100%
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Slope-slope aspect values of 0:	0%
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Negative slope-slope aspect values:	0%
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SLOPE

Mean:	$\bar{X} = 26.2^\circ$
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Standard deviation:	$S = 13.9^\circ$
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HORIZONTAL CONFIGURATION:	25% straight; 75% concave
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SLOPE POSITION:	80% mid; 20% upper
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GRAZING PRESSURE:	25% light; 25% light-moderate; 50% moderate
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.9 \text{ mi (1.4 km)}$
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Standard deviation:	$S = 0.7 \text{ mi (1.1 km)}$
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The Jusc/Agsp c.t., a minor community type, is found on cool and moist mid to upper slopes, sometimes in coulees. Soils are derived from shale and are grey-black in color.

Table 22. Artemisia Cana/Stipa Viridula-Agrocyron smithii Community Type Site Description

SOIL TEXTURE:	33% loams; 42% silt loams; 8% silty clay loams; 17% clay loams
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = 9.0$
Standard deviation:	$S = 0.03$
Range:	-0.05-0.09
Sites having:	
Positive slope-slope aspect values:	17%
Slope-slope aspect values of 0:	17%
Negative slope-slope aspect values:	67%
SLOPE	
Mean:	$\bar{X} = 1.2'$
Standard deviation:	$S = 1.6'$
HORIZONTAL CONFIGURATION:	33% straight; 67% concave
SLOPE POSITION:	67% bottom; 33% low
GRAZING PRESSURE:	18% light; 27% moderate; 9% moderate-high; 18% severe
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.4$ mi (0.6 km)
Standard deviation:	$S = 0.5$ mi (0.8 km)

Like the Arca/Agsm/Bogr c.t. sites, the Arca/Stvi-Agsm c.t. is found in coulees, swales, and on flats above creeks. These moist and/or protected sites are now always well portrayed by the slope-slope aspect and horizontal configuration descriptions. It is found in uplands even less often than the Arca/Agsm/Bogr c.t.

Soils are often heavier than Arca/Agsm/Bogr c.t. soils, but sites are otherwise similar. It is suspected that this type was once more prevalent, but has been reduced by livestock grazing.

Table 13. Archa/Agsm/Bogr c.t. with 17 coulees and 115 Community Type Site Description

SOIL TEXTURE: 4% sandy loam; 6% fine sandy loam; 45% loam; 23% silt loam; 3% silty clay loam; 16% clay loam

SLOPE-SLOPE ASPECT

Mean: $\bar{X} = -0.01$
 Standard deviation: $S = 0.06$
 Range: $-0.24, .9$

Sites having:

Positive slope-slope aspect values: 10
 Slope-slope aspect values of 0: 29
 Negative slope-slope aspect values: 54

SLOPE

Mean: $\bar{X} = 2.0^\circ$
 Standard deviation: $S = 3.0^\circ$

HORIZONTAL CONFIGURATION: 14% convex; 57% straight; 7% undulating; 21% concave

SLOPE POSITION: 38% bottom; 40% low; 7% mid; 7% upper

GRAZING PRESSURE: 11% light; 4% light-moderate; 52% moderate; 4% moderate high; 1% severe

DISTANCE TO STOCK WATER

Mean: $\bar{x} = 0.1 \text{ mi } (0.6 \text{ km})$
 Standard deviation: $S = 0.4 \text{ mi } (0.6 \text{ km})$

Archa/Agsm/Bogr c.t. is most often found in coulees, swales and on flats above creeks. The extra moisture and protection afforded by such sites tend to discount the importance of a slope-slope aspect calculation. Furthermore, the horizontal configuration of large flat bottom coulees is straight (and was so recorded) although the coulee itself is of course concave. These sites receive more moisture than most Agsm-Bogr c.t. sites, and soils are heavier on the average.

Table 24. *Artamusia tridentata*/Agropyronsmithii/*Bootteloua gracilis* Community Type Site Description

SOIL TEXTURE:	14% fine sandy loams; 33% loams; 24% silt loams; 29% clay loams
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.02$
Standard deviation:	$S = 0.10$
Range:	-0.12 to 0.28

Sites having:

Positive slope-slope aspect values:	44%
Slope-slope aspect values of 0:	48%
Negative slope-slope aspect values:	5%

SLOPE

Mean:	$\bar{X} = 5.2^\circ$
Standard deviation:	$S = 4.0$

HORIZONTAL CONFIGURATION:	32% convex; 36% straight; 32% concave
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SLOPE POSITION:	11% low; 53% mid; 32% upper; 5% top
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GRAZING PRESSURE:	12% light; 50% moderate; 12% moderate-heavy; 18% heavy
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.7$ mi (1.1 km)
Standard deviation:	$S = 0.5$ mi (0.8 km)

Sites for the Artr/Agsm/Bogr c.t. might best be compared to sites of the Agsm/Bogr, Bogr/Agsm, and Arca/Agsm, and Arca/Agsm/Bogr c.t.'s. The most noticeable difference between sites for the Artr/Agsm/Bogr c.t. and the Agsm/Bogr and Bogr/Agsm c.t.'s is in slope position. The Artr/Agsm/Bogr c.t. is found more often on the higher slope positions. Slope-slope aspect values are cooler for the Artr-Agsm/Bogr c.t. sites, but the difference is significant only at the 0.2 probability level. Artr/Agsm/Bogr c.t. slopes are steeper than Bogr/Agsm c.t. slopes (.05 probability level), but not significantly steeper than Agsm/Bogr c.t. slopes. Horizontal configuration is more often straight for the Agsm/Bogr and Bogr/Agsm c.t. than for the Artr/Agsm/Bogr c.t. Soils of the Agsm/Bogr and Bogr/Agsm c.t.'s often have less clay than Artr/Agsm/Bogr c.t. soils. More intensive grazing is indicated on the Bogr/Agsm c.t. than on the Artr/Agsm/Bogr c.t.

The most striking difference between sites for the Artr/Agsm/Bogr and Arca/Agsm/Bogr c.t.'s is once again slope position, with Arca/Agsm/Bogr c.t.'s being found at much lower slope position. In fact, when both communities exist in an area, the Arca/Agsm/Bogr c.t. is generally found in coulees and on flats above creeks while the Artr/Agsm/Bogr c.t. is found on slopes above the flat or coulee. Partly as a consequence of this, the Arca/Agsm/Bogr c.t. is usually closer to a watering source.

Table 25. *Artemisia tridentata* Badland Site Description

SOIL TEXTURE:	11% loams; 22% silt loams; 22% silty clay loams; 33% clay loams; 11% clay
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SLOPE-SLOPE ASPECT

Mean:	$\bar{X} = 0.04$
Standard deviation:	$S = 0.57$
Range:	-0.66-0.81

Sites having:

Positive slope-slope aspect values:	44%
Slope-slope aspect values of 0:	44%
Negative slope-slope aspect values:	11%

SLOPE

Mean:	$\bar{X} = 19.9^{\circ}$
Standard deviation:	$S = 13.6^{\circ}$

HORIZONTAL CONFIGURATION:	22% straight; 44% undulating; 33% concave
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SLOPE POSITION:	11% bottom; 22% low; 44% mid; 22% upper
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GRAZING PRESSURE:	43% light; 43% moderate; 14% high
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DISTANCE TO STOCK WATER

Mean:	$\bar{X} = 0.7$ mi (1.1 km)
Standard deviation:	$S = 0.3$ mi (0.5 km)

Soil (often parent material) texture is the major site factor that determines the distribution of the Artr Badland. Sometimes this type occurs as a band along a particular soil strata. Other site factors are decidedly subordinate in accounting for this type.

Table 46. *Symphoricarpos occidentalis*-*Rosa arkansana* Community Type Site Description

SOIL TEXTURE:	23% loams; 31% silt loams; 38% silty clay loams; 8% clay loams
SLOPE-SLOPE ASPECT	
Mean:	$\bar{X} = 1.2^\circ$
Standard deviation:	$S = 1.6^\circ$
Range:	
Sites having:	
Positive slope-slope aspect values:	
Slope-slope aspect values of 0:	
Negative slope-slope aspect values:	
SLOPE	
Mean:	
Standard deviation:	
HORIZONTAL CONFIGURATION:	33% straight; 67% concave
SLOPE POSITION:	67% bottom; 33% low
GRAZING PPESSURE:	18% light; 27% moderate; 9% moderate-high; 27% high; 18% severe
DISTANCE TO STOCK WATER	
Mean:	$\bar{X} = 0.4 \text{ mi (0.6 km)}$
Standard deviation:	$S = 0.5 \text{ mi (0.8 km)}$

Sites for the Syoc-Rosa c.t. are similar to, but moister than, Arca/Agsm/Bogr and Arca/Stvi-Agsm c.t. sites in coulees and swales. This type is generally not found in the steep banked, flat bottomed coulees typical of Arca c.t.'s. Sites for this type are more specifically concave and lack steep embankments.

Table 27. *Shepherdia argentea* *Emmenanthe occidentalis* - *Rosa arkansana* Community Type, *Shepherdia argentea* *Symphoricarpos occidentalis* Community Type, and *Cornus stolonifera* Phase Site Description

SOIL TEXTURE: 40% sandy loams; 4% fine sandy loams; 41% loams; 18% silt loams; 7% silty clay loams; 22% clay loams; 4% clay

SLOPE-SLOPE ASPECT

Mean:

Standard deviation:

Range:

Sites having:

Positive slope-slope aspect values:

Slope-slope aspect values of 0:

Negative slope-slope aspect values:

SLOPE

Mean:

Standard deviation:

HORIZONTAL CONFIGURATION: 100% concave

SLOPE POSITION: 100% coulees

GRAZING PRESSURE:

DISTANCE TO STOCK WATER

Mean:

Standard deviation:

The Shar/Syoc-Rosa c.t. and Cost phase are found usually in steep-banked coulees where special conditions exist. These coulees not only receive extra moisture from over-ground runoff during and after rains, but they also catch a very significant amount of drifting snow. Factors which cause drying are reduced due to shading and greatly reduced wind velocities. This type most often occurs in the upper reaches of coulees where embankments are steeper and where flash flooding is not so severe. Soils tend to be heavy.

The Cost phase is found only in the more moist and most protected of sites. Coulee banks are always steep and usually are on a cool aspect.

Many site descriptors useful in characterizing range sites do not serve well for Shar/Syoc-Rosa c.t. sites. Slopes and aspect are impossible to determine for a community that covers both sides of a coulee and bottom. Grazing use and history are difficult to determine and seem to be little related to this type's occurrence.

SPECIES DIVERSITY

The community types cover a ten-fold range of richness. Somewhat surprisingly, the tall shrub types are more diverse than the tree dominated types. The Scam, Dist, and Bogr c.t.'s stand apart from the other types with respect to dominance and equitability due to intensive selective pressure caused by soil salts and grazing.

Figure 4 shows the relationships among the community types with respect to species diversity.

The community types are ordered according to richness. Dominance and equitability generally follow this order, with a few interesting deviations. The Calo and Ansc c.t.'s have higher dominance and lower equitability than their richness might suggest. This is due to the fact that these types have a single dominant.

A similar deviation might be expected for the Yugi c.t., but this is not the case. A few grasses are usually codominant with *Yucca glauca*, and field observations suggest that this type might better be called the Yugi/Calo-Ansc c.t. and *Muhlenbergia cuspidata* was co-dominant in some stands. More samples would be necessary to determine if this is true generally.

An opposite deviation is found in the Pode/Rosa-Syoc c.t. The structure graphs show that the coverage of a nanophanerophytes exceeds that of the trees. The result is lower dominance and higher equitability than the richness would suggest.

PRODUCTIVITY

Productivity data, expresses as means ($\bar{x}$) and standard deviations (s), are given in kilograms per hectare. Coefficients of variation (CV) are presented as decimals. The two replicates of each enclosure were compared for homogeneity using total productivity data, not biomass. The .05 probability level was used for this comparison. The number of samples (N) necessary to give a sampling accuracy of $\pm 20\%$ at the 0.2 probability level have been calculated. This represents a minimal requirement.

The effects of drought and grasshoppers, which are discussed below, should be considered before evaluating the productivity data.

Drought

Reed and Peterson (1961) noted that the major trends in mixed prairie vegetation are set by major weather cycles, while the range of change within trends are set by grazing intensity. Clark et al. (1943) also found that grazing had less than climate in modifying plant cover. Coupland (1959) found that during a period of 12 years characterized by moist, cool weather, the yield capacity of the same stands sampled earlier increased by an average of one hundred and thirty-seven percent.

Figure 4
 Species diversity of community types

Figure 4 (Cont'd.)

Species formerly found only in especially favorable sites became more abundant on typical sites, and species usually found in dry situations decreased in the communities once dominated. Coupland noted that the same area of grassland could change dominance from *Bouteloua-Stipa-Boutela* to *Stipa-Agropyron* (Coupland 1959).

In 1977 rainfall distribution in the study area was more erratic than usual due to the absence of wide scale synoptic systems. Instead, most of the precipitation came from thunderstorms, resulting not only in a spotty distribution but also increased overground flow and less water in the sub-soil. Duley (1939) and Duley and Kelly (1939) have pointed out that not only are the timing and amount of precipitation important, but so are the intensity of rainfall, topography, and condition of the soil and ground cover. An inch of effective precipitation might account for eighty to one hundred pounds of production (Whitman and Hauge 1972, Smoliak 1956).

Precipitation data are not available for the productivity sampling area. Platt and Griffiths (1964) point out that environmental data for any but the area under study cannot be used directly, but precipitation data from three areas surrounding the sampling area can give a general indication of possible precipitation at the sampling area. Table 28 shows the 1977 precipitation at three sites, identified by their location relative to the productivity sampling area.

Table 28 1977 Precipitation at Three Sites

Location Relative to Productivity Sampling Area

	<u>23 km SW</u>	<u>60 km NNW</u>	<u>35 km ESE</u>
May-June			
Precipitation	6.65 cm (2.62 in)	8.71 cm (3.43 in)	12.42 cm (4.89 in)
April-July			
Precipitation	11.56 cm (4.55 in)	10.29 cm (4.05 in)	15.57 cm (6.13 in)

The mean precipitation and confidence limits (0.1) for the May-June precipitation data shown above are 3.65 in. $\pm$ 1.93 in. (9.26 cm. $\pm$ 4.93 cm.) and the coefficient of variation is thirty-two percent.

Weaver and Albertson (1956) note that if spring-summer rainfall is reduced to less than seventy percent of normal, which is about 6.9 inches (17.6 cm) in this case, "the effects upon vegetation are usually so serious as to cause a drought." Using this definition, the productivity sampling area experienced a drought during 1977. The growing period terminated by exhaustion of available soil moisture (Whitman, 1975) ended quite early in 1977.

Smoliak (1956) found that May plus June precipitation accounted for seventy-four percent of the variation in forage yield in Alberta prairie dominated by *Stipa Comata*, *Agropyron smithii*, *Bouteloua gracilis*,

and *Koeleria cristata*. Using Smoliak's (1956) regression equation for yield and 3.65 inches (9.27 cm) of May-June precipitation, one would expect about 313 lb./acre (351 kg/hectare) of forage for the Stco-Agsm/Bogr c.t. This compares with a productivity sample value for the Stco-Agsm/Bogr c.t. of 298 lb./acre (334 kg/hectare).

Redmann (1975) reviews and contributes some herbage production data for some plant communities which can be compared to the productivity data presented here.

Grasshoppers

Grasshopper infestation frequently accompanies drought (Weaver & Albertson 1956).

Grasshoppers reached epidemic proportions in some locales in 1977. Unfortunately, one of these locales was the bottomland along Nelson Creek in the vicinity of most of the exclosures. No study of grasshopper density was made, but biologists working and living in the productivity sampling area estimated grasshopper densities in the lowlands to be 4-10 or more per square meter. Although this was much less than the densities of 50-100 grasshoppers per square foot of Allred (1941), it did significantly lower productivity measurements. In hot dry weather when productivity is low, the effect of grasshoppers can be especially significant.

Parker (1952) found that seven grasshoppers per square yard consume ten percent of the forage for one cow. Grasshoppers at densities of .9/square foot ($10/m^2$) to 1.9/square foot ($20/m^2$) can account for thirty to forty percent of the peak standing crop during the three weeks of life in the adult instar (Mitchell and Pfadt 1974). Anderson (1961, 1964), however, found little correlation between grasshopper density and vegetation loss. Mulkein (1967) discusses several problems with comparing the results of various experiments.

Grasshopper feeding can be especially detrimental to grasses because grasshoppers eat the plants lower than livestock (Parker & Connin 1964). Countering this trend is the fact that most grasshopper defoliation can occur after the active growth period for cool season grasses (Burleson 1976).

Grasshopper damage was most severe in the exclosures with an abundance of warm-season short grasses such as *Bouteloua gracilis*. In the Bogr/Agsm c.t. exclosure *B. gracilis* was cropped to the point where it was generally too short to clip. The Stco/Bogr-Cafi c.t. was also hard hit. The Agsm/Bogr and Bogr-Cafi/stco c.t.'s were damaged somewhat less. The Arca/Agsm/Bogr c.t. was not badly infested. The Dist c.t. exclosure had a moderate grasshopper density, but it was not obvious that much damage was done. The Dist-Agsm ecotone exclosure experienced somewhat more damage, usually to species other than *D. stricta*. Other types sampled for productivity did not have epidemic populations.

The combined effects of drought and grasshoppers were striking. One pasture containing several exclosures was not grazed by livestock until

mid August, yet it had the barren look of a pasture that had been heavily grazed since spring. Few grass inflorescences appeared and the height of bunchgrasses (Stco, Bogr, Cafi) was reduced to an inch or two. The productivity data should be evaluated with consideration of the combined effects of drought and grasshoppers.

Productivity Tables

Means and standard deviations are in kilograms per hectare. For pounds/acre multiply by 0.892. N is number of plots necessary for a sample mean within twenty percent of the true mean eighty percent of the time.

Following oven-drying, samples of the dominant species in each enclosure have been ground, screened, and preserved for possible later analysis of chemical composition.

Table 29 Distichlus stricta Community Type Productivity

	Dist	Litter	Σ Productivity
$\bar{X}$	970	430	970
S	272	182	272
CV	.28	.42	.28
N	4		4
Homogeneous	(.05)		yes

Table 30 Distichlus stricta, Agropyron smithii Ecotone Productivity

	Dist	Agsm	Geo	Hemi	Cham	Litter	Σ Prod.
$\bar{X}$	676	72	5.2	51	5.8	1071	813
S	394	60		56.2		558	348
CV	.58	.83		1.10		.52	.43
N	14	29					8
Homogenous	(.05)						no

Table 31 Bouteloua gracilis Community Type Productivity

	Bogr	Geo*	Litter	Σ Productivity
$\bar{X}$	170	29	38	198
S	42		125	74
CV	.25		3.28	.37
N	3			6
Homogeneous	(.05)			yes

* Primarily Agropyron smithii

Table 32 Agropyron smithii/Bouteloua gracilis Community Type Productivity

	Agsm	Bogr	Hemi	Litter	Σ Productivity
$\bar{X}$	144	44	0.2	578	202
S	136	40		506	144
CV	.89	.90		.87	.72
N	33	34			21
Homogeneous	(.05)				yes

Table 33 Bouteloua gracilis/Agropyron smithii Community Type * Productivity

	Bogr	Agsm	Litter	Σ Productivity **
$\bar{X}$	12	3.6	38	16
S	11	6.4	29	18
CV	.89	1.77	77	1.07
N	32	129		47
Homogeneous	(.05)			yes

* Severe grasshopper damage.

** Opuntia polyacantha was not slipped in any enclosure.

Table 34 Stipa comata/Bouteloua gracilis-Carex filifolia Community
Type Productivity *

	Stco	Bogr	Hemi	Cham	Litter	Σ Productivity
$\bar{X}$	189	22	2	4	162	218
S	71	19			88	75
CV	.38	.88			.54	.35
N	6	31				5
Homogeneous	(.05)					yes

* Heavy grasshopper damage

Table 35 Bouteloua gracilis-Carex filifolia/Stipa comata
Community type Productivity*

	Bogr	Cafi	Stco	Geo	Hemi	Cham	Litter	Σ Prod.
$\bar{X}$	131	95	138	6	4	32	247	406
S	84	44	80				145	119
CV	.64	.47	.58				.59	.29
N	17	9	14					4
Homogeneous	(.05)							yes

* Heavy grasshopper damage

Table 36 Stipa comata-Agropyron smithii/Bouteloua gracilis
Community type Productivity

	Stco	Agsm	Bogr	Cafi	Hemi	Cham	Litter	Σ Prod.
$\bar{X}$	97	68	70	37	19	43	417	334
S	47	70	58	42			214	115
CV	.48	1.03	.82	1.15			.51	.34
N	10	43	28	54				5
Homogeneous	(.05)							yes

Table 37 Andropogon scoparius Community Type Productivity

	Ansc	Geo	Hemi	Cham	Litter	Σ Prod.
$\bar{X}$	800	26	68	10	1084	840
S	486	58	63		602	444
CV	.61	2.32	1.00		.55	.53
N	15					12
Homogeneous	(.05)					no

Table 38 Andropogon scoparius-Agrophyron spicatum Community Type Productivity

	Ansc	Agsp	Geo	Hemi*	Cham	Litter	Σ Prod.	Σ Prod.**
$\bar{X}$	102	182	16	208	32	946	787	560
S	196	116		110	30	552	1156	223
CV	1.92	.64		.53	.93	.58	1.47	.40
N	151	17		12			88	7
Homogeneous	(.05)						yes	no

* It is possible that some Andropogon scoparius is in this category. Aristida longiseta is a major species in this category.

** One plot contained some 300 grams of Juniperus horizontalis. This column omits that plot, which actually reflected biomass.

Table 39 Agropyron spicatum/Bouteloua gracilis-Carex filifolia Community Type Productivity

	Agsp	Bogr	Cafi	Hemi*	Cham**	Litter	Σ Prod.
$\bar{X}$	116	39	36	44	142	727	372
S	66	47	31	43	202	481	129
CV	.57	1.22	.85	.98	1.42	.66	.51
N	14	60	31	42			11
Homogeneous	(.05)						yes

* Primarily Stipa comata.

** Primarily Gutierrezia sarothrae. The data probably refers to biomass.

Table 40 Juniperus horizontalis/Andropogon scoparius-Agropyron spicatum
Community Type Productivity

	Juho*	Ansc	Agsp	Hemi	Cham	Σ Biomass excluding litter
$\bar{X}$	5894	2	7.2	12	16	5930
S	4580		8.3	19	22	4572
CV	.78		1.15	1.59	1.38	.77
N	25		55			25
Homogeneous (.05)						yes

* This data refers to biomass.

Litter data was incredible and therefore omitted.

Table 41 Artemisia cana/Agropyron smithii/Bouteloua gracilis
Community Type Productivity

	Arca	Agsm	Bogr	Hemi	Cham	Litter	Σ Productivity
$\bar{X}$	398	115	134	80	26	753	800
S	465	84	106	95		748	492
CV	1.17	.73	.79	1.19		1.00	.62
N	56	22	26				16
Homogeneous (.05)							yes

Shepherdia argentea/Symphoricarpos occidentalis-Rosa arkansana Community Type Productivity. This type is minor on the square mile (29.8 km²) section proposed mine area, but is important to wildlife and is very diverse. Productivity sampling of this type poses many problems in sampling design and execution. For this reason, it was not sampled for productivity.

It was hoped that productivity could be estimated for the microphanerophyte dominants using the works of Brown (1976) and Ohmann et al. (1976). Although neither paper mentions S. argentea, and DNRC researchers hoped that productivity could be estimated using a similar species, none of the species in these papers is morphologically similar to S. argentea, which has a determinate growth form. Moreover, none of the species studied approximates the large diameters often found in S. argentea. Therefore, no attempt at estimating productivity has been made for this species.

Brown (1976) lists regression equations for Prunus virginiana; leaf weight and total above ground weight have been estimated for this species.

Site quality has not been taken into account in using these equations.

The Department of State Lands requested some quantitative description of the shrub dominant of this community type. The Shar/Syoc-Rosa c.t. exhibits a good deal of variability with respect to site and floristic composition. Two samples of the Shar/Syoc-Rosa c.t. were taken on very different sites. The first sample was taken at the head of a coulee finger on a north aspect. The coulee there was shallow and not steep banked, and affording S. argentea little protection or extra moisture relative to the typical Shar/Syoc-Rosa c.t. site. Very little snowberry and rose were present on this dry site.

The second sample was taken in a steep banked coulee about 20 feet deep which afforded excellent protection and received above average moisture. A few small cottonwoods near the sample site suggest an excellent soil moisture regime. This sample also contained some P. virginiana.

Because it is exceedingly well armed, S. argentea is a different shrub to work around. Height was measured to the nearest decimeter. Crown area was estimated by measuring live crown width at the widest point and normal to that line. Basal diameter was measured as low as possible, usually a few centimeters above ground. If a major portion of the plant was dead, diameter was measured above the fork where the dead trunk split from the live one.

Table 42 Dimensions of Some Shrubs

	Species	Diameter (cm.)		Height (m)		Crown Area (m ²)	
		$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
Sample 1	Shar	10.3	3.9	2.4	0.6	3.2	1.8
Sample 2	Shar	6.6	1.3	2.2	0.4	2.0	0.9
	Prvi	2.1	0.4	1.8	0.4	0.6	0.5

Estimated leaf weight for P. virginiana is 36.4g (S=13.3g) and estimated above ground weight is 275.4g (S=148.8g).

In S. argentea, diameter and crown area are linearly correlated, but not strongly. In Sample 1, the correlation is significant at the five percent probability level and $r^2 = .32$. In Sample 2, the correlation is significant at the 1% probability level and $r^2 = .44$. Diameter was correlated with height in the Sample 1 at the five percent probability level ($r^2 = .34$), but in Sample 2, diameter and height were negatively correlated, but not significantly so. Height and area were not well correlated.

Somewhat better correlations exist for P. virginiana. Diameter and crown area are significantly correlated at the five percent probability level and $r^2 = .48$. Diameter and height are also significantly correlated at the five percent probability level and $r^2 = .46$.

S. argentea measurements in samples 1 and 2 differ significantly in height at the 0.2 probability level, in crown area at the .02 probability level, and in diameter at the .001 probability level.

These data are intended only to give some shrub size characteristic on two sites on the mine area. The shrubs were not aged, therefore productivity on the two sites cannot be calculated.

Mortality in S. argentea is apparently due to drought, flooding, and fungus. Mortality in P. virginiana is attributable to drought, flooding, porcupines and tent caterpillars.

STRUCTURE

Table 42 allows comparison of the community types with respect to structure.

SPECIES LISTS

The Department of State Lands requires a complete listing of species. Since plants have been collected in this study area for two years, the species list can be considered complete for the proposed mining area. No doubt species living in the larger study area do not appear on the list. No attempt was made to list ornamentals or species not found naturally in the area.

Plants were collected in all phases of study. Collected specimens of nearly all species may be found at the DNRC in Helena.

Two species lists have been compiled (Appendix B). One lists species alphabetically by family. The other lists species by life form.

Hitchcock and Cronquist (1973) was used for nomenclature whenever possible. Other sources used were Hitchcock et al. (1969), Hitchcock (1951), Hahn (1973), Booth (1972), Van Bruggen (1976) and Booth and Wright (1959).

TABLE 43 Average Community Structure Expressed
As Percentage Of Absolute Coverage

Community Composition Category	Scam	Dist	Bogr	Agsm/ Bogr	Bogr/ Agsm	Stco/ Bogr- Cafi	Bogr- Cafi/ Stco	Stco- Agsm/ Bogr	Bogr- Cafi/ Agsm- Stco	Stvi- Agsm/ Bogr	Ansc	Ansc- Calo	Ansc- Agsp	Agsp/ Bogr- Cafi
Lianas and Epiphytes	-	-	-	-	-	-	-	-	-	<1	-	-	-	-
Meso- phanerophytes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Micro- phanerophytes	-	-	-	-	-	-	-	-	-	<1	<1	-	-	-
Nano- phanerophytes	-	-	<1	-	<1	<1	<1	<1	<1	<1	1	2	2	1
Chamae- phytes	-	<1	6	4	7	2	5	3	3	5	2	5	2	5
Hemi- cryptophytes	11	6	84	39	69	88	88	62	79	60	74	56	57	62
Geophytes	80	61	<1	56	24	2	3	29	15	25	2	18	2	3
Therophytes	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1
Mosses	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Foliose Lichens	-	-	<1	-	<1	<1	2	<1	<1	-	-	<1	-	<1
Crustose Lichens	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Litter	46	29	24	30	24	70	12	45	22	40	48	25	18	26
Bare Soil	5	25	4	7	3	5	8	3	6	2	9	21	10	16
Bare Rock	<1	-	-	-	-	-	-	-	-	-	<1	<1	15	5

Community Type

Table 43 (Cont'd.)

[illegible]

DATA ADEQUACY, RECOMMENDATIONS FOR FUTURE MONITORING AND ENDANGERED SPECIES

DATA ADEQUACY

The baseline study is thought to be adequate. The 1:4800 vegetation map, for example, represents a very high standard of accuracy, and the classification goes far beyond the usual effort. Drought and grasshopper damage, however, did influence the data.

As pointed out in the Section IV-E and Appendix C, the productivity data does not reflect normal conditions unless the effects of grasshoppers are eliminated from both exclosures and reclaimed land. Also, a much better baseline could be produced from more than two years of productivity data given the yearly variation in precipitation. The problem of yearly variation in precipitation could, however, be alleviated if both reclaimed land and the exclosures are sampled the same year.

FUTURE MONITORING OF EXCLOSURES

The exclosures will be clipped again in the summer of 1978. At that time, coverage estimates and pictures will be taken of certain randomly picked, unclipped plots. The plots will be excluded from clipping now and in the future.

The vegetation of the exclosures was chosen for productivity sampling because it typified a community type. A major concern is that the vegetation of the productivity exclosures, which is in some cases seral, will change with time as a result of the exclosures and cease to be indicative of the community type it presently represents. These plots should be re-sampled every few years and if a significant change is detected, the appropriate action such as opening the exclosure for grazing by cattle, should be taken to maintain the community initially in the exclosure. Of course, it is imperative that the exclosure be kept free from all unmonitored disturbances.

FACILITY-RELATED MONITORING

It is possible that a coal conversion facility will have an impact which is subtle and insidious. Since this baseline study is not adequate for detecting subtle changes in communities, species, or individuals resulting from air pollution, the baseline information necessary to detect such an impact will have to be in the form of permanent monitoring stations located in relation to the facility with regard to pertinent meteorological considerations and the pattern and distribution of plant communities.

This monitoring will have to evaluate possible impacts at the level of the community (e.g. productivity and species composition), and the species, ecotype, or individual (e.g. phenology, population structure, physiology,

chemical composition). The study will require meticulous sampling and appropriate statistical evaluation. The actual study design should be developed by the researcher involved.

ENDANGERED SPECIES

Rare or endangered species are a special concern, but none have yet been found in the study area. Ayensu and De Filipps (1978) were used as authorities for this determination.

Using Du Mond's definition of rareness, some species such as Cystopteris fragilis could be considered rare, but no plant species yet identified in the study area is officially rare or endangered.

SUMMARY

The vegetation baseline study was designed to provide information necessary for the prediction and measurement of possible impacts to vegetation resulting if a strip mine and a coal conversion facility is located in the area in and surrounding the Dreyer Brothers Ranch near Circle, Montana. The Department of Natural Resources and Conservation (DNRC) was contracted to gather this information, although the Department of State Lands is the responsible state agency administering Montana's Strip Mine Reclamation Act. Although this baseline study will provide the information necessary to adequately evaluate strip-mine reclamation and the widespread vegetation-related consideration of a coal conversion facility located in the study area, this broad baseline work may not be adequate to evaluate the impacts on vegetation in the immediate area of a coal conversion facility. More vegetation baseline work may have to be completed under the Major Facility Siting Act to evaluate the local vegetation-related impacts, once a specific site for a coal conversion facility has been selected.

In 1976 a reconnaissance sampling of vegetation in the study area was undertaken, with emphasis on the vegetation on and near the Dreyer Brothers, Inc. ranch. These data were used to develop a classification of vegetation using cluster analysis, a technique which graphically portrays affinities and groupings of vegetation samples based on their floristic similarities.

The classification resulted in recognition of twenty-seven community types, or grouping of communities based on species composition as measured by coverage. Each type was discussed with respect to species composition, structure, species diversity and site. Techniques and results were explained. In addition, productivity data was gathered and summarized for the major community types found in the proposed mine area.

The community types were also used as mapping units for vegetation maps, which have been prepared at a scale of 1:12,000 and 1:4800 for the area in and near the Dreyer Bros., Inc. ranch. A range condition map has been made for the proposed mine area. Although these maps have not been distributed with this report because of the expense of reproducing them and the limited number of potential users, copies have been provided to Dreyer Bros, Inc. The DNRC will provide copies to other interested individuals upon request.

A list of plant species encountered in the study area with the exception of cultivated and ornamental plants has been compiled, and may be found in Appendix B.

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APPENDICES

	SCAM	DIST	BOGR	AGSM/ BOGR	BOGR/ AGSM	STCO/ BOGR- CAFI	BOGR- CAFI/ STCO	STCO- AGSM/ BOGR	BOGR- CAFI/ AGSM- STCO	STVI- AGSM/ BOGR	ANSC	ANSC- CALO	ANSC- AGSP	AGSP/ BOGR- CAFI
number of stands +	5	19	12	28	33	49	29	25	12	12	27	9	4	12
SPECIES BY LIFE FORM														
THEROPHYTES														
Arctium minus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brunus tectorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodium album	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodium leptophyllum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cirsium vulgare	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriogonum cernuum	-	-	-	-	-	-	-	-	-	-	-	(22)0.1	-	-
Erysimum cheiranthoides	-	-	-	-	-	-	-	-	-	-	-	(22)0.1	(50)0.3	-
Hedeoma hispida	-	-	-	-	-	-	-	(20)0.1	-	-	-	(22)0.1	-	-
Kochia scoparia	-	(42)0.3	-	-	-	-	-	-	-	-	-	-	-	-
Lappula echinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lappula redowskii	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Linum rigidum	-	-	(25)0.1	-	-	-	(24)0.1	-	-	-	-	(33)0.2	-	-
Melilotus alba	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melilotus officinalis	-	-	-	-	(18)0.2	-	-	-	-	-	-	-	-	-
Plantago patagonica	-	-	-	-	(24)0.2	-	-	(40)0.2	(42)0.4	(25)0.1	-	(22)0.1	(25)0.1	(25)0.1
Rumex salicifolius	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sisymbrium altissimum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thlaspi arvense	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tragopogon dubius	-	-	-	(37)0.2	(21)0.1	(20)0.1	-	(40)0.2	(25)0.1	(33)0.2	-	-	(25)0.1	(25)0.1
Verbena bracteata	-	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
GEOPHYTES														
Agropyron dasytachyum	-	-	-	-	-	(19)0.3	-	-	-	-	-	-	-	(17)2.5
Agropyron smithii	-	(26)0.5	(50)0.7	(100)54.0	(100)23.2	(57)1.0	(48)0.8	(100)27.7	(100)15.0	(92)23.2	(15)0.4	-	-	(25)0.3
Allium textile	-	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
Artemisia ludoviciana	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asclepias speciosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asclepias verticillata	-	-	-	-	-	-	-	-	-	-	(22)0.1	-	-	-
Aster falcatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bouteloua curtipendula	-	-	-	-	-	-	-	-	-	-	-	(11)1.7	-	-
Brunus inermis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buchloe dactyloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis neglecta	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamovilfa longifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex eleocharis	-	-	-	-	-	-	(14)0.3	(12)0.6	-	(17)0.3	(44)1.0	(100)17.5	(50)0.9	-
Distichlis stricta	(20)0.6	(100)58.0	-	-	-	-	(14)0.7	(8) 0.1	(8) 1.3	(17)0.3	-	-	-	(8) 0.3
Comandra umbellata	-	-	-	-	-	(3) 0.5	-	-	-	-	-	-	-	-
Helianthus laetiflorus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helianthus rigidus	-	-	-	-	-	-	-	-	-	(17)0.3	(7)0.1	-	-	-
Medicago sativa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum virgatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa pratensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Putentilla anserina	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psoralea argophylla	-	-	-	-	-	-	-	-	-	(17)0.3	(33)0.2	(33)0.2	(25)0.1	-
Psoralea esculenta	-	-	-	-	-	-	-	-	-	(22)0.1	(22)0.1	(22)0.1	(25)0.3	-
Psoralea lanceolata	-	-	-	-	-	-	-	(8) 0.3	-	-	-	-	-	-
Scirpus americanus	(100)78.5	(5) 0.2	-	-	-	-	-	-	-	-	-	-	-	-
Sisyrinchium angustifolium	-	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
Smilacina stellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solidago missouriensis	-	-	-	-	-	-	-	-	-	-	(44)0.3	(44)0.2	(25)0.1	-
Solidago rigida	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spartina gracilis (pectinata)	(20)0.1	(16)2.2	-	-	-	-	-	-	-	-	-	-	-	-
Sphaeralcea coccinea	-	-	(58)0.3	(30)0.2	(45)0.2	(49)0.5	(24)0.1	(44)0.3	(33)0.2	(58)0.3	-	-	-	(33)0.2
Thalictrum venulosum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thermopsis rhombifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triglochin maritimum	(40)0.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viola nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HEMICRYPTOPHYTES														
Achillea millefolium	-	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
Agropyron caninum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agropyron cristatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agropyron intermedium	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agropyron spicatum	-	-	-	(7) 0.1	-	-	-	-	-	(25)0.5	-	-	(100)20.6	(100)24.6
Andropogon scoparius	-	-	(8) 0.3	-	-	-	-	(8) 0.1	-	(33)1.6	(100)64.4	(100)38.1	(100)26.3	(25)0.1
Antennaria parvifolia	-	-	-	-	-	-	-	-	-	(22)0.1	(22)0.1	(22)0.1	(50)0.3	-
Antennaria rosea	-	-	-	-	-	-	-	-	-	(26)0.1	-	-	-	-
Aristida longiseta	-	-	-	-	-	-	-	-	-	-	-	(33)0.2	(50)0.3	-
Astragalus gilviflorus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Astragalus missouriensis	-	-	-	-	-	-	-	-	-	-	-	(22)0.1	-	-
Astragalus spatulatus	-	-	-	-	-	-	-	-	-	-	-	(22)0.1	-	-
Astragalus strictus	-	-	-	-	-	-	-	-	-	-	-	(55)0.3	(50)0.3	-
Bouteloua gracilis	(5) 0.2	(100)84.2	(96)27.0	(100)60.8	(100)16.8	(100)56.4	(100)15.7	(100)44.8	(83)18.9	(33)2.3	(55)2.7	(75)4.6	(83)20.8	-
Campanula rotundifolia	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-	-
Carex filifolia	-	-	(33)0.8	(63)7.7	(45)5.1	(90)13.5	(93)19.3	(56)4.8	(75)16.8	(33)3.3	(56)2.2	(89)5.1	(75)2.3	(92)16.0
Chrysopsis villosa	-	-	-	-	-	(2) 0.3	(14)0.2	-	-	-	(11)0.2	-	-	-
Cirsium undulatum	-	-	-	-	-	-	-	-	-	-	(37)0.3	-	(25)0.1	-
Coryphantha vivipara	-	-	-	-	-	(22)0.1	(21)0.1	(20)0.1	(25)0.1	-	-	-	-	-

number of stands *

SPECIES BY LIFE FORM

THEROPHYTES

Arc min
Bru tec
Che alb
Che lep
Cir vul
Eri cer
Ery che
Hed his
Kuc sco
Lap ech
Lap red
Lin rig
Mel alb
Mel off
Pla lat
Rum sal
Sis alt
Thl arv
Tra dub
Ver bra

GEOPHYTES

Agr Jas
Agr sm.
All tex
Art lud
Asc spe
Asc ver
Ast fal
Buu cur
Bru ine
Buc dac
Cal neg
Cal lon
Car ele
Dis str
Cum umb
Hel lae
Hel rig
Med sat
Pan vir
Poa pra
Pot ans
Poa erg
Poa esc
Poa lan
Sci ame
Sis ang
Smi ste
Sul mis
Sul rig
Spa gra (pec)
Sph cuc
Tha ven
The rho
Tri mar
Urt diu
Viu nut

HEMICRYPTOPHYTES

Ach mil
Agr can
Agr cri
Agr int
Agr spi
Aiid sco
Ant par
Ant ros
Ari lon
Ast gil
Ast mis
Ast spa
Buu gra
Cam rot
Car fil
Chr vil
Cir und
Cor viv

MUCU- AGSP	JUHO/ AMSC- AGSP	CALO	YUGL	JUSC/ AGSP	ARCA/ AGSM/ BOGR	ARCA/ STVL- AGSM	ARTP/ AGSM/ BOGR	ARTP/ BADLAND	SYOC- ROSA	SHAR/ SYOC- ROSA	SHAR/ SYOC- ROSA COST PHASE	FRPE/ ROSA- SYOC	POOF/ ROSA- SYOC
11	23	6	6	5	31	12	22	9	13	23	4	6	5
-	-	-	-	-	(6) 0.5	-	-	-	(3) 0.2	-	(25)0.1	(17)0.5	(20)0.1
-	-	-	-	-	-	-	-	-	-	(9) 0.2	-	-	-
-	-	(33)0.2	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	(20)0.1	-	-	-	-	(8) 0.2	-	-	-	-
-	-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	(33)0.6	-
-	-	-	-	-	-	-	-	-	-	(4) 0.1	-	-	-
-	(26)0.1	-	(33)0.2	(40)0.2	(19)0.1	-	(32)0.2	-	-	-	(25)0.1	-	-
-	-	-	-	(20)0.6	-	-	-	-	-	-	-	-	-
-	-	-	(50)0.7	(60)4.2	-	(33)0.4	(23)0.2	(33)0.4	(38)1.7	(43)1.7	-	(50)0.7	(80)6.2
-	-	-	-	-	-	-	-	-	(8) 0.2	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	(33)0.2	-
-	-	-	-	-	(45)0.2	(25)0.1	-	-	(38)0.2	-	(25)0.1	-	(20)0.1
-	-	-	-	-	-	-	-	-	-	-	-	-	(20)0.1
-	(4) 0.1	-	-	-	-	-	(11)0.3	-	-	-	-	-	-
(9) 1.4	-	-	-	(20)0.1	(81)21.9	(92)16.3	(86)11.0	(56)2.2	(77)14.8	(70)7.4	(50) 4.5	(33)3.0	(80)16.5
-	-	-	-	-	-	(25)0.3	-	-	(68)2.0	(26)0.5	(75)1.0	-	-
-	-	(33)5.0	-	-	-	-	-	-	(15)0.3	-	(50)0.3	(17)0.5	-
-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-	-
(27)6.1	(17)4.0	-	-	-	-	-	-	-	(15)0.3	(22)0.3	-	(17)0.5	-
-	-	-	-	-	(3) 0.5	-	-	-	-	(13)1.8	-	-	(40)8.1
-	-	-	-	-	-	-	-	-	-	-	-	-	(20)3.0
(9) 0.3	(57)2.7	(100)58.3	(83)15.6	(100)7.8	(39)6.2	(42)0.4	(14)0.2	(11)0.3	(38)6.1	(57)1.5	(50)0.9	-	-
-	-	-	-	(80)1.9	-	(8) 1.3	-	-	-	-	-	-	-
(36)0.2	(26)0.4	-	-	(40)0.2	-	-	(9) 0.8	(22)1.7	(8) 0.2	(4)0.1	-	-	(20)3.0
-	-	-	-	-	-	-	(18)0.2	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	(4) 0.1	-	-	-
-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-	-
-	-	-	-	-	-	-	-	-	(15)2.9	-	-	(17)0.5	(40)0.2
-	-	-	-	-	-	(8) 3.1	-	-	(8) 2.9	-	-	(33)8.8	(20)3.0
-	-	-	-	-	-	-	-	-	(8) 0.2	-	-	-	(20)0.6
-	(26)0.4	-	-	(80)0.4	(10)0.1	(25)0.3	-	-	(15) 0.3	(26)0.1	-	-	-
-	-	-	-	-	(6) 0.1	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	(20)3.0
-	-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-
-	(39)0.4	(33)0.2	(33)0.2	(60)0.3	-	-	-	-	(4) 0.7	(13)0.1	(50)0.3	(20)0.1	(20)0.1
-	-	-	-	-	-	-	-	-	(22)0.9	(25)0.2	-	-	-
-	-	-	-	-	-	-	-	-	(23)0.1	(35)0.4	(75)1.0	-	-
(27)0.1	-	-	(33)0.2	-	(35)0.2	(25)0.1	(45)0.3	-	-	-	-	-	(20)0.6
-	-	-	-	-	-	-	-	-	-	-	-	(33)0.2	-
-	-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	(23)0.1	-	(25)0.1	(33)0.6	-
-	-	-	-	-	-	-	-	-	-	-	(25)3.8	-	-
-	-	-	-	(60)0.3	(26)0.29	(50)0.9	-	-	(69)0.3	(35)0.4	(75)0.4	(67)0.3	-
-	-	-	(33)0.2	-	-	-	-	-	(23)3.4	(9) 0.2	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	(17)0.5	-
-	-	-	-	-	-	-	-	(11)0.3	-	-	-	-	(60)1.3
(100)22.1	(78)11.3	-	(50)3.1	(100)33.0	(6) 2.0	(8)0.3	(18)0.8	(67)9.6	-	(26)1.0	-	-	-
(45)3.6	(87)17.3	(17)0.5	(67)11.3	(60)6.1	(6) 0.2	(42)5.1	(9) 0.7	(11)0.3	(15)1.2	(52)2.5	(75)4.6	-	-
-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-	-
-	-	(33)0.17	-	-	-	-	-	-	-	-	-	-	-
(20)0.1	(13)0.80	-	(33)1.0	-	-	-	(23)0.5	-	-	-	-	-	-
(27)0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
-	(30)0.8	(67)0.3	-	-	(6) 0.1	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-
(55)6.7	(17)0.9	(67)3.6	(67)3.2	-	(61)20.0	(58)7.2	(86)25.2	-	(23)1.4	(30)0.4	(25)0.1	-	(20)0.1
-	-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-
(55)6.0	(87)4.7	(50)1.1	(50)5.6	-	(16)3.5	-	(59) 3.6	(11)1.7	-	-	-	-	-
-	(30)0.2	-	(100)0.5	(60)0.30	(10)0.1	-	-	(11)1.7	-	-	(25)0.1	-	-
-	-	(33)0.2	(50)0.3	-	-	-	-	-	-	(22)0.1	(50)0.3	(33)0.2	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-

	SCAM	DIST	BOGR	AGSM/ BOGR	BOGR/ AGSM	STCO/ BOGR- CAF1	BOGR- CAF1/ STCO	STCO- AGSM/ BOGR	BOGR- CAF1/ AGSM- STCO	STV1- AGSM/ BOGR	ANSC	ANSC/ CALO	ANSC- AGSP	AGSP/ BOGR- CAF1
number of stands +	5	19	12	28	33	49	29	25	12	12	27	9	4	12
<u>SPECIES BY LIFE FORM</u>														
HEMICRYPTOPHYTES (Cont'd.)														
Echinacea pallida	-	-	-	-	-	-	-	-	-	(25)0.1	(44)0.3	(33)0.2	(50)0.3	-
Elymus canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elymus glaucus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erigeron pumilus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriogonum flavum	-	-	-	-	-	-	-	-	-	-	-	-	-	(25)0.1
Eriogonum pauciflorum	-	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
Glycyrrhiza lepidota	-	(5) 0.2	-	-	-	-	-	-	-	-	-	-	-	-
Grindelia squarrosa	-	(16)0.3	-	-	(12)0.1	-	-	-	-	-	-	-	-	-
Gaura coccinea	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haplupappus nuttallii	-	-	-	-	-	-	-	-	-	-	-	(22)0.1	-	-
Hordeum jubatum	-	(26)0.3	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
Hymenopappus filifolius	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Koeleria cristata	-	-	-	-	-	(39)0.6	-	(36)0.3	-	(25)0.1	(44)0.9	(67)0.9	(25)0.1	(58)0.7
Liatris punctata	-	-	-	-	-	-	-	-	-	-	-	(22)0.1	-	-
Linum perenne	-	(5) 0.2	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
Lygodesmia juncea	-	-	-	-	-	(35)0.2	-	(20)0.1	(25)0.1	-	(26)0.1	(55)0.3	-	-
Monarda fistulosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muhlenbergia cuspidata	-	-	-	(7) 0.2	(6) 0.6	(10)0.2	(14)0.7	-	(8) 1.3	(17)0.3	(52)1.4	(67)2.5	-	(25)0.5
Oenothera caespitosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthocarpus luteus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxytropis lambertii (besseyi)	-	-	-	-	-	-	-	-	-	-	(19)0.2	-	-	-
Penstemon gracilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petalostemon candidum	-	-	-	-	-	-	-	-	-	-	-	(33)0.2	-	-
Petalostemon purpureum	-	-	-	-	-	-	-	-	-	-	-	(44)0.2	-	-
Poa canbyi (spp.)	-	(11)1.0	-	-	-	-	-	-	-	(8) 0.3	-	-	-	-
Poa cusickii	(20)3.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa juncifolia	(20)7.5	(21)2.4	-	-	-	-	-	-	-	-	-	-	-	-
Poa sandbergii	-	-	(42)0.4	-	(9) 0.1	-	(14)0.6	-	(8) 0.3	-	-	-	-	-
Polygala alba	-	-	-	-	(30)0.2	-	-	(36)0.3	-	-	(48)0.2	(78)0.4	(50)0.3	(50)0.3
Puccinellia airoides	-	-	(11)1.0	-	-	-	-	-	-	-	-	-	-	-
Ratibida columnifera	-	-	(22)0.1	-	-	-	-	-	-	(33)0.2	-	-	-	-
Schedonnardus paniculatus	(40)0.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Sitanion hystrix	-	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-
Sporobolus airoides	-	(5) 0.2	-	-	-	-	-	-	-	-	-	-	-	-
Sporobolus cryptandrus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stipa comata	-	-	(25)0.1	(63)1.2	(45)0.6	(100)54.5	(90)9.2	(100)38.2	(100)13.8	(8) 1.3	(58)4.5	(22)0.2	(33)1.0	(50)0.3
Stipa viridula	-	-	-	-	-	(8) 0.5	-	(16)1.0	(100)28.3	(100)28.3	(11)0.2	-	-	(50)1.3
Taraxacum officinale	-	-	-	-	-	-	-	-	(25)0.1	-	-	-	(25)0.1	-
Vicia americana	-	-	-	-	-	-	-	-	-	(25)0.1	-	-	-	-
CHAMAEPHYTES														
Apocynum androsaemifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apocynum cannabinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artemisia dracunculifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artemisia frigida	-	-	(42)3.5	(37)2.0	(84)3.5	(39)1.0	(45)2.2	(44)1.5	(42)1.6	(67)3.2	(26)0.2	(22)0.1	-	-
Atriplex nuttallii	-	(11)0.8	-	-	(15)0.6	(12)0.1	(14)0.2	-	-	-	(78)0.5	(55)2.2	(100)0.5	(83)1.0
Eurotia lanata	-	-	(31)0.4	(26)0.4	-	(39)0.8	(34)1.5	(20)0.1	(25)0.1	(25)0.5	-	-	(25)0.1	(50)0.7
Gutierrezia sarothrae	-	-	-	-	(27)0.4	-	-	-	(8) 0.3	(25)0.1	(48)0.2	(55)0.6	(75)0.4	(75)0.4
Juniperus horizontalis	-	-	-	-	-	-	-	-	-	(8) 1.3	(15)0.4	(22)0.7	-	-
Opuntia Polyacantha	-	-	(50)0.5	(44)0.2	-	(57)0.4	(66)0.5	(52)0.4	(75)0.4	-	-	(44)0.2	-	(33)0.2
Phlox hoodii	-	-	(25)0.5	-	-	(33)0.4	(28)0.8	(20)0.1	(17)0.3	-	(63)0.4	(55)0.6	(75)0.4	(33)1.4
Rhus radicans	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selaginella densa	-	-	-	(11)1.2	(12)1.7	-	(7) 0.1	(12)1.2	(8) 0.3	-	-	-	-	-
NANOPHANEROPHYTES														
Artemisia cana	-	-	(33)0.2	-	-	(6) 0.1	-	(8)0.2	(17)0.5	(33)0.4	(15)0.1	(22)0.4	-	(25)0.5
Artemisia tridentata	-	-	(8) 0.3	-	-	-	-	-	-	-	(11)0.2	-	-	-
Atriplex confertifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysothamnus nauseosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juniperus communis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribes aureum (americanum)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribes spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribes montigenum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhus trilobata	-	-	-	-	-	-	-	-	-	-	(7) 0.1	(11)0.3	-	-
Rosa acicularis (arkansana)	-	-	-	-	-	-	-	-	-	-	(26)0.3	-	-	-
Symphoricarpos occidentalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yucca glauca	-	-	-	-	-	-	-	-	-	-	(15)0.3	-	(25)0.8	-
MICROPHANEROPHYTES														
Amelanchier a nifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cornus stolonifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crataegus douglasii	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juniperus scopulorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prunus virginiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia argentea	-	-	-	-	-	-	-	-	-	-	(4) 0.1	-	-	-
Salix Spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	MUCU- AGSP	JUHO/ ANSC- AGSP	CALO	YUGL	JUSC/ AGSP	ARCA/ AGSM/ 80GR	ARCA/ STV1- AGSM	ARTR/ AGSM/ 80GR	ARTR/ BAOLAND	SYOC- ROSA	SHAR/ SYOC- ROSA	SHAR/ SYOC- ROSA COST PHASE	FRPE/ ROSA- SYOC	POOE/ ROSA- SYOC
number of stands +	11	23	6	6	5	31	12	22	9	13	23	4	6	5
SPECIES BY LIFE FORM														
HEMICRYPTOPHYTES (Cont'd.)														
Ech pal	(36)0.2	(43)0.4	-	-	-	-	-	-	-	-	(30)0.2	-	-	-
Ely can	-	-	-	-	(20)0.1	-	-	-	-	(31)1.5	(39)0.3	(50)0.3	(33)0.2	(40)6.0
Ely gla	-	-	-	-	-	-	(8) 0.3	-	-	-	-	-	-	-
Eri pum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eri fla	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eri pau	(27)0.1	-	-	-	-	-	-	-	(44)0.2	-	-	-	-	-
Gly lep	-	-	-	-	(20)0.1	-	-	-	-	(23)0.3	(43)1.0	(75)1.0	-	(60)3.7
Gri squ	-	-	-	-	-	-	(3) 0.3	-	(78)2.8	(31)0.2	-	(25)0.1	-	-
Gau cuc	(36)0.2	-	-	-	-	(23)0.1	-	-	-	(8)0.2	-	-	-	-
Hap nut	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hor jub	-	-	-	-	-	(6) 0.1	-	-	-	(8) 0.2	-	(25)0.1	-	(20)0.1
Hym fil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Koe cri	(45)0.7	(61)0.5	-	-	(40)0.2	(26)0.2	-	(50)0.8	(33)0.4	-	-	-	-	-
Lia pun	(36)0.2	(22)0.1	-	-	(20)0.1	-	-	-	-	-	-	-	-	-
Lin per	-	(22)0.1	-	-	(20)0.1	-	-	-	-	-	-	(25)0.1	-	-
Lyg jun	-	-	(33)0.2	-	-	-	-	-	-	-	-	-	-	-
Mun fis	-	-	-	-	-	-	-	-	-	-	(13)0.8	-	-	-
Muh cus	(100)33.6	(43)0.5	(17)2.5	(83)12.3	-	(10)0.5	-	(36)2.8	(33)1.8	(15)1.2	(13)0.2	(25)0.1	-	-
On cae	-	-	-	-	-	-	-	-	(22)0.1	-	-	(25)0.1	-	-
Ort lut	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Day lam (bes)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pen gra	-	-	-	-	(20)0.1	-	-	-	-	-	-	-	-	-
Pet can	(27)0.1	-	(50)0.3	(33)0.2	(40)0.2	-	-	-	-	-	-	-	-	-
Pet pur	(27)0.1	(39)0.2	-	(33)0.2	-	-	-	-	-	-	-	-	-	-
Pua can (spp.)	-	-	-	-	-	-	(17)1.3	-	-	(8)1.2	(21)2.1	-	-	(20)0.1
Pua cus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pua san	-	-	-	-	-	-	-	-	(22)1.8	(8) 0.2	(9)0.2	-	-	-
Pul alb	(27)0.4	(35)0.2	-	-	(20)0.1	(13)0.2	-	(5) 0.1	-	(8) 0.2	(9)0.2	-	-	-
Puc air	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rat cul	-	-	-	(33)0.6	-	(19)0.1	(33)0.2	-	-	(69)0.7	(70)0.6	(75)0.4	-	(20)0.1
Sch pan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sit hys	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spo air	-	-	-	-	-	-	-	-	-	-	-	-	(33)0.2	-
Spo cry	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sti com	-	(22)1.0	(33)5.0	(17)6.3	-	(13)0.2	(32)3.3	(42)1.8	(77)6.5	(22)2.0	-	(25)0.8	-	-
Sti vir	-	-	-	-	-	(45)0.8	(100)19.8	(55)2.5	(33)2.0	(54)1.2	(35)1.0	(100)9.0	(33)2.6	(20)3.0
Tar off	-	-	-	-	-	(16)0.7	-	-	-	(15)0.3	-	(50)0.7	(20)0.1	-
Vic ame	-	-	-	-	-	-	-	-	(22)0.1	(23)0.1	-	-	-	-
CHAMAEPHYTES														
Apo and	-	-	-	-	(20)0.1	-	-	-	-	-	-	-	-	(20)0.1
Apo can	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Art dra	(9) 0.3	(26)0.3	-	(67)1.6	(40)0.2	(6) 0.1	-	-	-	-	-	-	-	(20)3.0
Art fri	(91)2.7	(65)0.4	(67)0.3	(33)0.6	(100)3.4	(61)2.1	(83)3.3	(91)4.1	(30)0.4	-	(52)0.6	-	-	(40)0.2
Atr nut	-	-	-	-	(6) 0.2	-	-	-	(11)0.3	-	-	-	-	-
Eur lan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gut sar	(82)1.4	(78)0.7	(33)0.2	(50)0.7	(40)0.2	(32)0.2	(42)0.2	(55)0.5	-	(15)0.3	(26)0.2	(75)0.4	-	-
Jun hur	-	(100)42.3	-	-	(3) 0.1	(8) 0.3	(5)0.7	(11)0.3	-	-	(52)8.7	-	-	-
Opu pol	(27)0.1	(22)0.2	(33)0.2	-	(60)0.3	(42)0.5	(25)0.3	(86)0.9	(33)0.2	-	-	-	-	-
Phi hoo	(73)3.7	(48)1.8	-	-	(40)0.2	-	-	(36)0.4	(33)0.4	-	-	-	-	-
Rhu rad	-	-	-	-	(20)0.1	-	-	-	-	(15)0.3	(48)1.3	(100)9.0	(50)2.7	(40)15.5
Sel den	-	-	-	-	-	(6) 0.5	-	(14)1.5	(11)0.3	-	-	-	-	-
NANOPHANEROPHYTES														
Art can	(9) 0.3	(9) 0.7	-	(67)8.0	(60)0.8	(100)38.3	(100)26.5	(9) 0.2	(33)5.0	(62)11.6	(70)4.7	(100)0.5	-	(60)6.6
Atr con	-	-	-	(17)2.5	(60)3.2	-	-	(100)40.2	(100)22.5	-	-	-	-	-
Chr nau	-	-	-	-	(20)0.1	-	-	-	(56)4.1	-	-	-	-	-
Jun cum	-	-	-	-	(40)15.0	-	-	-	-	-	(9) 0.2	-	-	-
Pib eur (ame)	-	-	-	-	-	-	-	-	-	-	(25)0.1	-	-	-
Rib spp.	-	-	-	-	-	-	-	-	-	-	(56)0.6	(100)1.1	(100)8.2	-
Rib mun	-	-	-	-	-	-	-	-	-	-	-	(25)0.1	-	-
Rhu tri	-	(17)0.7	-	(50)7.5	(100)11.8	(3) 0.1	(17)0.3	-	-	(15)0.3	(65)9.5	(100)3.0	(83)3.3	(40)0.2
Rus aci (ark)	-	(26)0.2	(33)0.2	(83)0.8	(80)9.1	-	-	-	(22)0.1	(85)17.5	(96)14.1	(100)1.1	(83)20.0	(100)28.5
Sym occ	-	-	-	-	(40)3.6	(23)0.3	(50)0.7	-	(22)0.1	(100)43.3	(96)28.1	(100)14.6	(100)13.0	(100)22.1
Yuc gla	(36)0.4	(22)0.3	-	(100)22.5	(20)0.1	-	-	-	-	(8) 0.2	-	-	-	-
MICROPHANEROPHYTES														
Ame aln	-	-	-	-	(40)0.2	-	-	-	-	(13)0.9	(25)3.8	(50)3.1	-	-
Cur sto	-	-	-	-	-	-	-	-	-	-	(100)31.9	(33)0.2	-	-
Cra dou	-	-	-	-	-	-	-	-	-	-	-	(20)0.5	-	-
Jun sco	-	-	-	-	(100)42.5	-	-	-	-	(8) 0.2	(4) 0.7	-	-	-
Pru vir	-	-	-	-	(40)10.5	-	-	-	-	-	(48)3.7	(100)14.6	(50)11.3	(40)3.6
She arg	-	-	-	-	(40)11.2	-	-	-	-	(8) 0.2	(100)29.4	(100)14.6	(50)7.5	(60)13.5
Sal spp.	-	-	-	-	-	-	-	-	-	-	-	-	(20)0.5	(80)4.8

number of stands =

SPECIES BY LIFE FORM

MESOPHANEROPHYTES

Ace neg
Fra pen
Pop del

LIANAS

Cle lig

MUCU- AGSP	JUHO/ ANSC- AGSP	CALO	YUGL	JUSC/ AGSP	ARCA/ AGSM/ BOGR	ARCA/ STVI- AGSM	ARTR/ AGSM/ BOGR	ARTR/ BADLANO	SYOC- ROSA	SHAR/ SYOC- ROSA	SHAR/ SYOC- ROSA COST PHASE	FRPE/ ROSA- SYOC	PODE/ ROSA- SYOC
11	23	6	6	5	31	12	22	9	13	23	4	6	5
-	-	-	-	-	-	-	-	-	-	-	-	(33)2.6	-
-	-	-	-	-	-	-	-	-	-	-	-	(100)45.8	(40)3.60
-	-	-	-	-	-	-	-	-	-	-	-	-	(100)46.0
-	-	-	-	-	-	-	-	-	-	(9) 1.8	(25)0.1	(50)0.3	(20)0.1

APPENDIX B. SPECIES LISTED BY FAMILY AND LIFE FORM

PLANT SPECIES BY FAMILY

Aceraceae

Acer negundo L.

Anacardiaceae

Rhus radicans L.

Rhus trilobata Nutt.

Apocynaceae

Apocynum androsaemifolium L.

Apocynum cannabinum L.

Asclepiadaceae

Asclepius speciosa Torr.

Asclepius syriaca L.

Asclepius verticillata L.

Boraginaceae

Cryptantha bradburiana Payson.

Hackelia floribunda (Lehm) Jtn.

Lappula echinata Gilib.

Lappula redowskii (Hornem) Greene

Lithnospermum incisum Lehm.

Cactaceae

Coryphantha vivipara (Nutt.) Britt. & Brown

Opuntia polyacantha Haw.

Campanulaceae

Campanula rotundifolia L.

Capparidaceae

Cleome serrulata Pursh.

Caprifoliaceae

Symphoricarpos occidentalis Hook.

Caryophyllaceae

Cerastium arvense L.

Paronychia sessiliflora Nutt.

Chenopodiaceae

Atriplex argentea Nutt.
Atriplex canescens (Pursh.) Nutt.
Atriplex confertifolia (Torr. & Frem.)
Atriplex dioica (Nutt.) Macbr.
Atriplex nuttallii Wats.
Bassia hyssopifolia (Pall.) Kuntze.
Chenopodium album L.
Chenopodium fremontii Wats.
Chenopodium leptophyllum (Moq.) Watts.
Eurotia lanata (Pursh) Moq.
Kochia scoparia (L.) Schrad.
Salsola Kali L.
Sarcobatus vermiculatus (Hook.) Torr.
Suaeda depressa Pursh.
Suaeda intermedia Wats.

Commelinaceae

Tradescantia occidentalis (Britt.) Smyth.

Compositae

Achillea millefolium L.
Agoseris glauca (Pursh.) Raf.
Ambrosia artemisiifolia L.
Antennaria parvifolia Nutt.
Antennaria microphylla Rydb.
Arctium minus (Hill) Bernh.
Arctium lappa L.
Artemisia cana Pursh.
Artemisia dracunculus L.
Artemisia frigida Willd.
Artemisia longifolia Nutt.
Artemisia ludoviciana Nutt.
Artemisia tridentata Nutt.
Aster falcatus Lindl.
Chrysopsis villosa (Pursh) Nutt.
Chrysothamnus nauseosus (Pall.) Britt.
Chrysothamnus viscidiflorus (Hook.) Nutt.
Cirsium arvense (L.) Scop.
Cirsium undulatum (Nutt.) Spreng.
Cirsium vulgare (Savi) Tenore
Conyza canadensis (L.) Cronq.
Echinacea pallida Nutt.
Erigeron compositus Pursh.
Erigeron pumilus Nutt.
Grindelia squarrosa (Pursh.) Dunal
Gutierrezia sarothrae (Pursh.) Britt. and Rusby
Haplopappus spinulosus (Pursh.) D.C.
Haplopappus uniflorus (Hook.) T. and G.
Helianthus annuus L.
Helianthus laetiflorus Pers.

Compositae (Cont'd.)

Helianthus maximilianii Schrad
Helianthus petiolaris Nutt.
Helianthus rigidus (Cass.) Desf.
Hymenopappus filifolius Hook
Hymenoxys acaulis (Pursh.) Parker
Hymenoxys richardsonii (Hook.) Cockerell
Iva axillaris Pursh
Lactuca pulchella (Pursh.) D.C.
Lactuca serriola L.
Liatris punctata Hook.
Lygodesmia juncea (Pursh.) D. Don
Machaeranthera canescens (Pursh) Gray
Machaeranthera grindeloides (Nutt.) Keck. and Cronq.
Machaeranthera tanacetifolia H.B.K.
Ratibida columnifera (Nutt.) Woot. & Standl.
Senecio canus Hook.
Senecio integerrimus Nutt.
Solidago missouriensis Nutt.
Solidago nana Nutt.
Solidago rigida L.
Taraxacum officinale Weber
Tetradymia canescens D.C.
Tragopogon dubius Scop.
Xanthium strumarium L.

Convolvulaceae

Convolvulus arvensis L.

Cornaceae

Cornus stolonifera Michx.

Cruciferae

Alyssum alyssoides L.
Camelina microcarpa Andrz.
Descurainia pinnata (Walt.) Britt.
Erysimum asperum (Nutt.) D.C.
Erysimum cheiranthoides L.
Lepidium densiflorum Schrad.
Lesquerella alpina (Nutt.) Wats.
Lesquerella ludoviciana (Nutt.) Wats.
Sisymbrium altissimum (L.) Britt.
Thlaspi arvense L.

Cupressaceae

Juniperus communis L.
Juniperus horizontalis Moench
Juniperus scopulorum Sarg.

Cyperaceae

Carex brevoir (Dewey) Mack.
Carex eleocharis (C. stenophylla Wahl.)
Carex filifolia Nutt.
Carex xerantica Bailey
Eleocharis palustris (L.) R. & S.
Scirpus acutus Muhl.
Scirpus americanus Pers.

Elaeagnaceae

Shepherdia argentea (Pursh.) Nutt.

Equisetaceae

Equisetum arvense L.
Equisetum fluviatile L.
Equisetum laevigatum A. Br.

Euphorbiaceae

Euphorbia robusta (Engelm.) Small
Euphorbia serpyllifolia Pers.

Gramineae

Agropyron caninum (L.) Beauv.
Agropyron cristatum (L.) Gaertn.
Agropyron dasystachyum (Hook.) Scribn.
Agropyron intermedium (Host) Beauv.
Agropyron smithii Rydb.
Agropyron spicatum (Pursh.) Scribn. & Smith
Alopecurus pratensis L.
Andropogon scoparius Michx.
Aristida longiseta Steud.
Beckmannia syzigachne (Steud.) Fernald.
Bouteloua curtipendula (Michx.) Torr.
Bouteloua gracilis (H.B.K.) Lag. ex. Steud.
Bromus inermis Leys.
Bromus japonicus Thunb.
Bromus tectorum L.
Buchloe dactyloides (Nutt.) Engelm
Calamagrostis canadensis (Michx.) Beauv.
Calamagrostis montanensis Scribn.
Calamagrostis neglecta (Ehrh.) Gaertn.
Calamovilfa longifolia (Hook.) Scribn.
Distichlis stricta (Torr.) Rydb.
Elymus canadensis L.
Elymus glaucus (Buckl.)
Festuca octoflora Watt.
Hordeum jubatum L.
Koeleria cristata (L.) Pers.
Muhlenbergia asperifolia (Nees. & Meyen.) Parodi

Muhlenbergia cuspidata (Torr.) Rydb.
Muhlenbergia racemosa (Michx.) B.S.P.
Munroa squarrosa (Nutt.) Torr.
Oryzopsis hymenoides (R. & S.) Ricker
Panicum capillare L.
Panicum virgatum L.
Phalaris arundinacea L.
Poa arida Vasey
Poa canbyi (Scribn.)
Poa cusickii Vasey
Poa gracillima Vasey
Poa juncifolia Scribn.
Poa palustris L.
Poa pratensis L.
Poa sandbergii Vasey
Polypogon monspeliensis (L.) Desf.
Puccinellia airoides (Nutt.) Wats & Coult.
Schedonnardus paniculatus (Nutt.) Trel.
Sitanion hystrix (Nutt.) Smith
Spartina gracilis Trin.
Spartina pectinata Link.
Sporobolus airoides (Torr.) Torr.
Sporobolus cryptandrus (Torr.) Gray
Stipa comata Trin. & Rupr.
Stipa viridula Trin.

Grossulariaceae

Ribes americanum Mill.
Ribes aureum Pursh.
Ribes cereum Dougl.
Ribes montigenum McClatchie

Iridaceae

Sisyrinchium angustifolium Miller
Zygadenus venenosus Wats.

Juncaceae

Juncus balticus Willd.

Juncaginaceae

Triglochin maritima L.

Labiatae

Hedeoma drummondii Benth.
Hedeoma hispida Pursh.
Monarda fistulosa L.
Nepeta cataria L.
Salvia reflexa Hornem.

Leguminosae

Astragalus canadensis L.
Astragalus crassicaupus Nutt.
Astragalus dasyglottis Fisch.
Astragalus gilviflorus Sheld.
Astragalus kentrophyta Gray
Astragalus lotiflorus Hook.
Astragalus missouriensis Nutt.
Astragalus pectinatus Dougl.
Astragalus spatulatus Sheld.
Astragalus striatus Nutt.
Glycyrrhiza lepidota (Nutt.) Pursh
Lupinus lepidus Dougl.
Medicago hispida Gaerth.
Medicago sativa L.
Melilotus alba Desr.
Melilotus officinalis (L.) Lam.
Oxytropis besseyi (Rydb.) Blank.
Oxytropis lambertii Pursh.
Petalostemon candidum Michx.
Petalostemon purpureum (Vent.) Rydb.
Psoralea argophylla Pursh.
Psoralea esculenta Pursh.
Psoralea lanceolata Pursh.
Thermopsis rhombifolia Nutt.
Trifolium repens L.
Vicia americana Muhl.

Liliaceae

Allium textile Nels. & Macbr.
Calochortus nuttallii T. & G.
Smilacina stellata (L.) Desf.
Streptopus amplexifolius (L.) D.C.
Yucca glauca Nutt.

Linaceae

Linum perenne L.
Linum rigidum Pursh.

Loasaceae

Mentzelia decapetala (Pursh) Urb. & Gilg.

Malvaceae

Sphaeralcea coccinea (Pursh) Rydb.

Oleaceae

Fraxinus pennsylvanica Marsh.

Onagraceae

Gaura coccinea (Nutt.) Pursh.
Oenothera caespitosa Nutt.
Oenothera serrulata Nutt.

Orobanchaceae

Orobanche ludoviciana Nutt.

Plantaginaceae

Plantago major L.
Plantago patagonica Jacq.
Plantago spinulosa Dcne.

Polemoniaceae

Collomia linearis Nutt.
Phlox alyssifolia Greene
Phlox hoodii Rich.
Phlox longifolia Nutt.

Polygalaceae

Polygala alba Nutt.

Polygonaceae

Eriogonum annuum Nutt.
Eriogonum cernuum Nutt.
Eriogonum flavum Nutt.
Eriogonum pauciflorum Pursh.
Polygonum aviculare L.
Polygonum persicaria L.
Rumex maritimus L.
Rumex salicifolius Weinm.

Polypodiaceae

Cystopteris fragilis (L.) Bernh.

Potamogetonaceae

Potamogeton spp.

Ranunculaceae

Anemone nuttalliana D.C.
Clematis linguisticifolia Nutt.
Delphinium bicolor Nutt.
Ranunculus cymbalaria Pursh.
Thalictrum venulosum Trel.

Rosaceae

Amelanchier alnifolia Nutt.
Crataegus douglasii Lindl.
Geum triflorum Pursh.
Geum macrophyllum Willd.
Potentilla anserina L.
Potentilla arguta Pursh.
Potentilla norvegica L.
Potentilla paradoxa Nutt.
Potentilla pennsylvanica L.
Prunus virginiana L.
Rosa acicularis Lindl.
Rosa arkansana Porter
Rosa nutkana Presl.

Rubiaceae

Galium aparine L.

Salicaceae

Populus deltoides Marsh.
Salix spp.

Santalaceae

Comandra umbellata (L.) Nutt.

Scrophulariaceae

Orthocarpus luteus Nutt.
Penstemon albidus Nutt.
Penstemon gracilis Nutt.

Selaginellaceae

Selaginella densa Rydb.

Solanaceae

Solanum rostratum Dunal

Typhaceae

Typha latifolia L.

Umbelliferae

Lomatium cous (Wats.) Coult. & Rose
Lomatium orientale Coult. & Rose

Urticaceae

Urtica dioica L.

Verbenaceae

Verbena bracteata Lag. & Redr.

Violaceae

Viola nuttallii Pursh.

PLANT SPECIES BY LIFE FORM

Therophytes

Allysum alyssoides*
 Ambrosia artemisi
 Apocynum androsaemifolium
 Arctium lappa
 Arctium minus*
 Atriplex argentea
 Atriplex dioica*
 Avena sativa
 Bassia hyssopifolia
 Bromus japonicus
 Bromus tectorum
 Camelina microcarpa
 Chenopodium album
 Chenopodium fremontii*
 Chenopodium leptophyllum
 Cirsium vulgare
 Cleome serrulata*
 Collomia linearis
 Conyza canadensis
 Descurainia pinnata
 Erysimum asperum
 Erysimum cheiranthoides
 Euphorbia serpyllifolia
 Festuca octoflora*
 Galium aparine
 Hedeoma hispida
 Helianthus annuus
 Helianthus petiolaris
 Kochia scoparia
 Lactuca serriola*
 Lappula echinata
 Lappula redowskii
 Lepidium densiflorum
 Linum rigidum
 Machaeranthera canescens
 Machaeranthera grindeloides
 Machaeranthera tanacetifolia
 Medicago hispida
 Melilotus alba
 Melilotus officinalis
 Munroa squarrosa
 Panicum capillare*
 Plantago patagonica
 Plantago spinulosa

Polygonum aviculare*
 Polypogon monspeliensis*
 Potentilla norvegica
 Potentilla paradoxa
 Rumex maritimus*
 Salsola kali
 Salvia reflexa*
 Sisymbrium altissimum
 Solanum rostratum
 Suaeda depressa
 Thlaspi arvense
 Tragopogon dubius
 Trifolium repens*
 Verbena bracteata
 Xanthium strumarium

Geophytes

Agropyron dasystachyum
 Agropyron smithii
 Allium textile
 Artemisia ludoviciana
 Asclepias speciosa
 Asclepias syriaca
 Asclepias verticillata
 Aster falcatus
 Bouteloua curtipendula
 Bromus inermis
 Buchloe dactyloides
 Calamagrostis canadensis
 Calamagrostis montanensis
 Calamagrostis neglecta*
 Calamovilfa longifolia
 Calochortus nuttalli
 Carex brevoir
 Carex eleocharis
 Carex xerantica
 Cirsium arvense
 Cystopteris fragilis
 Commandra umbellata*
 Distichlis stricta
 Eleocharis palustris
 Equisetum arvense*
 Equisetum fluviatile*
 Equisetum laevigatum
 Euphorbia robusta
 Geum triflorum
 Helianthus laetiflorus*

* Denotes not found in intensive study area

Geophytes (Cont'd.)

Helianthus maximiliana
Helianthus rigidus
Iva axillaris
Juncus balticus
Lactuca pulchella
Lomatium cous
Lomatium orientale
Lupinus lepidus*
Medicago sativa
Muhlenbergia asperifolia
Muhlenbergia racemosa*
Panicum virgatum
Phalaris arundinacea
Plantago major*
Poa arida
Poa palustris
Poa pratensis
Polygonum persicaria*
Potentilla anserina
Potentilla arguta*
Psoralea argophylla
Psoralea esculenta
Psoralea lanceolata
Ranunculus cymbalaria
Scirpus acutus
Scirpus americanus
Sisyrinchium angustifolium
Smilacina stellata
Solidago missouriensis
Solidago nana*
Solidago rigida
Spartina gracilis
Spartina pectinata
Sphaeralcea coccinea
Streptopus amplexifolius*
Thalictrum venulosum*
Tradescantia occidentalis
Thermopsis rhombifolia
Triglochin maritima
Typha latifolia*
Viola nuttallii
Zygadenus venenosus

Hemicryptophytes

Achillea millefolium
Agoseris glauca
Agropyron caninum
Agropyron cristatum
Agropyron intermedium*
Agropyron spicatum

Alopecurus pratensis
Andropogon scoparius
Anemone nuttalliana
Antennaria parvifolia
Antennaria microphylla
Aristida longiseta
Astragalus canadensis*
Astragalus crassicaulus
Astragalus dasyglottis
Astragalus gilviflorus
Astragalus kentrophyta
Astragalus lotiflorus*
Astragalus missouriensis
Astragalus pectinatus
Astragalus spatulatus
Astragalus striatus
Beckmannia syzigachne
Bouteloua gracilis
Campanula rotundifolia
Carex filifolia
Cerastium arvense*
Chrysopsis villosa
Cirsium undulatum
Convolvulus arvensis
Coryphantha vivipara
Cryptantha bradburiana
Delphinium bicolor
Echinacea pallida
Elymus canadensis
Elymus glaucus
Erigeron compositus*
Erigeron pumilus
Eriogonum anuum*
Eriogonum cernuum*
Eriogonum flavum
Eriogonum pauciflorum
Gaura coccinea
Geum macrophyllum
Glycyrrhiza lepidota
Grindelia squarrosa
Hackelia floribunda
Haplopappus nuttallii
Haplopappus spinulosa
Haplopappus uniflorus
Hedeoma drummondii
Hordeum jubatum
Hymenopappus filifolius
Hymenoxys acaulis
Hymenoxys richardsonii
Koeleria cristata
Lesquerella alpina
Lesquerella ludoviciana

* Ibid., page 1.

Hemicryptophytes (Cont'd.)

Liatris punctata
Linum perenne
Lithospermum incisum
Lygodesmia juncea
Mentzelia decapetala
Monarda fistulosa
Muhlenbergia cuspidata
Nepeta cataria
Oenothera caespitosa
Oenothera serrulata
Orobancha ludoviciana
Orthocarpus luteus
Oryzopsis hymenoides
Oxytropis besseyi
Oxytropis lambertii
Penstemon albidus
Penstemon gracilis
Petalostemon candidum
Petalostemon purpureum
Poa canbyi
Poa cusickii *
Poa gracillima
Poa juncifolia
Poa sandbergii
Polygala alba
Potentilla pennsylvanica
Puccinellia airoides
Ratibida columnifera
Rumex salicifolius *
Salvia bracteata
Schedonnardus paniculatus
Senecio canus
Senecio integerrimus
Sitanion hystrix
Sporobolus airoides
Sporobolus cryptandrus
Stipa comata
Stipa viridula
Taraxacum officinale
Urtica dioica *
Vicia americana

Chamaephytes

Apocynum androsaemifolium
Apocynum cannabinum
Artemisia frigida
Artemisia dracuncululus
Artemisia longifolia
Atriplex nuttallii

* Ibid., page 1

Eurotia lanata
Gutierrezia sarothrae
Juniperus horizontalis
Onuntia polyacantha
Paronychia sessiliflora
Phlox alyssifolia
Phlox hoodii
Phlox longifolia *
Rhus radicans
Selaginella densa
Suaeda Intermedia

Nanophanerophytes

Artemisia cana
Artemisia tridentata
Atriplex canescens
Atriplex confertifolia
Chrysothamnus nauseosus
Chrysothamnus viscidiflorus
Juniperus communis
Rhus trilobata
Ribes aureum
Ribes americanum
Ribes cereum
Ribes montigenum
Rosa acicularis
Rosa arkansana
Rosa nutkana
Sarcobatus vermiculatus
Symphoricarpos occidentalis
Tetradymia canescens
Yucca glauca

Microphanerophytes

Amerlanchier alnifolia
Cornus stolonifera
Crataegus douglasii *
Juniperus scopulorum
Prunus virginiana
Shepherdia argentea
Salix spp.

Mesophanerophytes

Acer negundo
Fraxinus pennsylvanica
Populus deltoides

Lianas

Clematis liusticifolia

APPENDIX C. CONSIDERATIONS AFFECTING STUDY PROCEDURES

PERSPECTIVES ON CLASSIFICATION

The Controversy

Man has always classified not only artifacts, but natural phenomena, and the classification of vegetation comes naturally to many--so naturally, in fact, that many classifications have been proposed without any quantitative data collection or analysis, and without stating the basis of the classification. This tendency has been particularly strong in the United States, where the broadly defined dominance types of Clements (1916, 1936) have been influential.

Ramensky (1926) and Gleason (1926) recognized the autonomous properties of species and the role of chance in species composition. They refuted the organismic theory of communities and took a more individualistic view. At the time, their thoughts had little impact in the United States. These issues resurfaced in the 1950's and 1960's.

McIntosh (1967) notes a fundamental question of classification asking "how many intermediates must be interspersed between "types" before they are lost as types and become continuous with one another". Are the classes resulting from the classification of vegetation mere artifacts, the imposition of a man-made order where there is none, or can classification be valid as well as useful? McIntosh (1967) gives a good introduction to the controversy.

These questions resulted in some mathematical techniques for comparing plant communities. Bray and Curtis (1957) started a movement toward ordination which has been taken up and refined by Beals (1960), Swan and Dix (1966), Newsome and Dix (1968) and Swan, Dix and Wehrhahn (1969), to name a few.

Whittaker, (1956, 1967) and Whittaker and Niering (1965) favor gradient analysis as an alternative to classification.

Sokol and Sneath's textbook on numerical taxonomy (1963) started a movement toward cluster analysis, which has been applied by Thelenius (1972) and West (1966).

Out of the controversy and the application of various techniques has come a better understanding of plant communities and improved methods of comparing communities through multivariate analysis. The results of ordination, gradient analysis and cluster analysis have major significance for understanding the practical problems of classification.

In addition to questions concerning the validity and appropriateness of classification, there is also the question of the need and usefulness of classification. For example, Gilmour (1951) maintains that classification is the prerequisite for all thought, Webb (1954) asserts that some system of typi-

fication and recognition of plant communities is necessary to a properly based science of vegetation, and Kucera (1973) feels that classification is necessary and valuable to ecosystem interpretation, and that without classification data become meaningless.

Synthesis

Many of the principal authors in the type-continuum controversy have moderated their views and recognize that the contributions of both the proponents of classification and those who think that vegetational continua need to be more explicitly acknowledged.

Tansley (1920) notes that classification entails imposing the constructs of human minds on nature and will not result in absolute accuracy, but he thinks that fitting investigations into a systematic framework is indispensable. He refutes any purely random explanation of vegetation, but he does not wholly rule out the role of chance and individualistic plant-environment relationships.

Daubenmire (1966) does not deny the existence of continua, but notes that some continua can form the basis for classification. (At the same time he shows how the data supporting his view might be used by an opponent of classifications to verify the continuum hypothesis.) He argues the existence of "plateau-like areas exhibiting minor gradients separated by areas of steeper gradients, with the plateau-like areas being of sufficient similarity to warrant being designated as a type" and for the "sharpening of ecotones by competitive elimination." Daubenmire advocates the system in which "the mere indication of a position in the system automatically makes possible the maximum predictions about the unit."

Anderson (1965) suggests that the appropriateness of classification depends on the type, duration, scale, and intensity of the selective processes that have operated on the vegetation. Poore (1962) states that vegetational variation is continuous, but in spite of this, well-marked communities are sufficiently alike to be conveniently considered as members of a class.

Goodall (1963) notes that the continuum concept and classification should not be considered incompatible and irreconcilable. Because subdivision of a continuous variable into classes involves a loss of information, he argues for ordination first, and subsequent classification. Whittaker (1975) admits that classification of vegetation are often needed and states that there is no real conflict between the principle that communities are generally, but not universally, continuous with one another and classification. Even McIntosh (1967) admits the utility of classification for some purposes.

MULTIVARIATE TECHNIQUES CONSIDERED

The usefulness of multivariate is recognized in portraying the relationships between communities, and the usefulness of classification in stratifying and summarizing data, and in mapping vegetation and monitoring plant communities.

Ordination, direct and indirect gradient analysis, and cluster analysis were considered.

Ordination is not well suited to data containing many stands with no species in common. Gauch and Whittaker (1972) compared several ordination techniques and the effect of beta diversity (between habitat diversity), and found that none of the techniques examined worked very well beyond about five half changes in beta diversity. The data from the reconnaissance exhibited over twelve full changes in beta diversity. Ordination endpoint selection would also be difficult for this data.

Finally, it is not at all clear that the axes of such an ordination could be defined, e.g. several axes representing various soil properties might be required. Although, an ordination of the plots of a type, or several closely related types, might be enlightening, time did not allow this in this study.

Direct gradient analysis is best suited to areas where the primary gradients can be rather easily recognized and measured, as they can be in mountains. For the most part, light, temperature, and moisture gradients are not readily discerned in the study area, while other gradients such as soil salts are important only occasionally.

Cluster analysis, having been devised to answer questions of speciation, was chosen as the appropriate multivariate technique due to its suitability for classification and its ability to handle diversity and large amounts of data.

Bonham (1974) proposed a classification of grassland vegetation with an agglomerative cluster analysis using changes in diversity rather than the usual similarity indices. Lambert and Dale (1964), Williams and Dale (1965), and Williams, Lambert and Lange (1966) have analyzed numerical classifications emphasizing cluster analysis. Everitt (1974) has reviewed the subject of cluster analysis and its application to a wide variety of subject matter.

SIMILARITY INDICES AND WEIGHTING: FLORISTICS AND SPECIATION

Similarity indices use species as the basic unit for comparing samples. The idea behind this is that stands having similar species composition can be expected to have similar ecologic sums of habitat factors as perceived by plants.

As Dubenmire (1968) points out, this notion is dependent on the species being an ecologic unit. He notes that even in adjacent habitats a species may be represented by ecotypes having mutually exclusive ecologic amplitudes. To the degree to which ecotypes exist, the species is not suitable for determining the similarity of stands.

The use of species as units in similarity indices introduces another problem parallel to that of continuum vs. type controversy which is perhaps unrecognized by continuum advocates. Just as types or classes are not equally different, so it is with species. For example, Agropyron smithii is considered to be different from Agropyron dasystachyum, and also from Cornus stolonifera. The assumption implicit in an equation such as Sorensen's is that

these species, and in fact, all species, are equally different and discrete, but this runs counter to the tenets of numerical taxonomy (Sokal and Sneath, 1963).^{*} Thus, the continuum advocates find themselves in the inconsistent position of criticizing the classification of vegetation and offering an alternative which is premised on a classification of flora which suffers some of the same criticisms.

One solution to this problem would weight species for similarity calculations. However, this would require an exhaustive knowledge of species autecologies and some sort of weighting scheme that address the pertinent factors. The alternative used for this study is to look for anomalies resulting from the multivariate analysis and try to resolve them on a case by case basis. Consideration of synusia is an example of this rectification.

QUANTITATIVE VS. PRESENCE AND ABSENCE FLORISTIC DATA

Lambert and Dale (1964) and Williams and Lambert (1965) discuss the two-fold problem of quantitative data as opposed to data for recording floristic presence or absence. Coverage, for example, measures the degree to which a species is present, but not the degree to which it is absent. Coverage also reduces both those plants that do not happen to be in the sample area and those that cannot be in the sample area to a single measure of zero.

For example, a plot in the Stco/Bogr-Cafi may fail, by chance, to contain any Carex filifolia, although it was present in 90% of the samples of this type, whereas Ginkgo biloba is also absent from the plot--though hardly by chance or to the same degree. Yet, both species are represented in the data by the identical coverage, namely zero. The aforementioned authors therefore argue for presence or absence values rather than quantitative presence data.

This argument, though valid, imposes severe limitations in practice. First, the floristic description can no longer convey an image of the samples. Second, presence-absence data gives emphasis to ubiquitous species of typically low coverage. For example, a Tragopogon dubius-Sphaeralceacoccinea community type could easily be deduced from data for the study area. Third, absence and presence are not in any case equally informative. The absence of a species from an area tells us nothing, whereas presence at least tells us that the environment there is favorable to that species or ecotype (Dubenmire 1963). Finally, the argument is partly overcome if a sampling is adequate, and if records of the species associated with types resulting from classification are kept. As sample size increases, so does the chance of observing the variety of species which can occupy similar sites.

A possible solution to these problems has been offered by Pfisher and Arnu, however, (personal communication, manuscript in progress) they suggest the use of "weighted presence", which used D cover class numbers in similarity indices. The T (< 1% coverage) class is assigned a 0.5 value.

^{*} Hull (1974) and Ruse (1973) discuss the questions of speciation from a philosophical standpoint. Some of their concerns also apply to phytosociology and classification.

ABSOLUTE VS. RELATIVIZED COVERAGE DATA FOR CLUSTER ANALYSIS

In this study, absolute coverage which was expressed as the midpoint values of cover classes was used for determining similarities. Coverage estimates were corrected, insofar as it was possible, at the time of sampling to account for recent grazing.

Gauch and Whittaker (1972) in their comparison of ordination techniques found that using absolute coverage did not produce different results than using relative coverage, except for principal component analysis. This may not be the case, at least for cluster analysis. This can best be shown using some hypothetical data.

Species	Percent Absolute Coverage				Percent Relative Coverage	
	Stand A		Stand B		Stand C	
	Absolute	Relative	Absolute	Relative	Absolute	Relative
1	65	59	50	59	64	47
2	30	27	25	29	30	21
3	15	14	10	12	15	11
4					30	21

Using Sorensen's index and absolute coverage, Stands A and C and Stands A and B have about the same similarity (eighty-eight percent and eighty-seven percent respectively) while Stands B and C are 76% similar. Using the same index and relativized coverage, Stands A and B are ninety-eight percent similar, while Stands A and C and Stands B and C are both seventy-nine percent similar.

No doubt some would say that either method is legitimate if consistently applied, but to the ecologist, they do not provide equal information. Relativizing data involves a loss of information--namely the true amount of coverage. Presumably some factor, and not necessarily grazing has caused the difference in coverage between Stands A and B, and to say that they are ninety-eight percent similar hides this fact.

On the other hand, the use of absolute coverage, while more clearly differentiating between Stands A and B, may obscure the difference between Stands A and C. However, no data have been lost. The ecologist can see that the calculated similarities for Stands A and C and Stands A and B are similar but for different reasons. It is then up to the ecologist to determine the significance of the difference in coverage between Stands A and B and also the significance of Species 4 in Stand C. Perhaps it is an invader reflecting grazing or disturbance, or is it a species of narrow ecological amplitude reflecting a significantly different site and perhaps climax community. This a posteriori weighting seems to be preferable to the de facto a priori weighting of species 4 if relativized data are used.

INTERPRETATION

It is sometimes held that multivariate analysis offers an objective alternative to traditional methods of classification. McIntosh (1967) seems to suggest for example, that ordination offers such an alternative. Lambert and Dale (1964) however, note that subjectivity cannot be avoided in multivariate analysis in either sampling or interpreting results.

In sampling, subjective choices must be made concerning which attributes of the plants and sites will be measured and how, and which areas will be sampled and how. In analysis there are many questions of technique, starting with selecting a similarity measurement. Some of these questions have been addressed in this appendix.

At the completion of the multivariate analysis then, objectivity cannot be claimed, but it produces one important advantage over some traditional classificatory techniques, which is that anyone using the same data and techniques could produce identical results. It would then be possible to pick one or more similarity levels and conclude that there are as many types as there are stems intercepted by a line cutting across that similarity level. The argument for doing so would be to maintain the objectivity of the data analysis.

It has been shown that the supposed objectivity of the data analysis is not really there to maintain. Furthermore, any supposed objectivity gained at this point is bought at a higher cost, for the ecologist must essentially ignore anything he has learned in the course of the study, both in the field and by reviewing the works of others.

The approach used in this study was to use the dendrogram as the graphic summarization of the relationships among samples, and presumably among communities. Clusters of samples suggesting community types were examined as groups, and in relation to adjacent clusters to determine such things as whether the clusters were separated on the basis of total coverage despite the fact that relative abundance of the dominance was essentially the same, or was a reversal of dominance or the addition of a new dominant involved, and if so, how could it be interpreted. The photographs of each sample were useful in this comparison because sites as well as floristics were portrayed.

Since field experience was very useful when classifying, one of the principal data gatherers worked on the classification. After its completion, the preliminary classification was discussed with local experts and compared with published studies involving classification or recognition of types. As a result, modifications were made in the classification, but the dendrogram was always the frame of reference for any revision. Multivariate analysis did not, however, supplant the ecologist, whose interpretation and understanding of the phytocoenosis finally determined the classification.

PRODUCTIVITY

The productivity measurements used for reclamation purposes are rather limited. Some definitions (Whittaker 1975) may be useful in explaining this.

Primary productivity is the rate at which energy is bound or organic matter created by photosynthesis, per unit of the earth's surface, per unit time. In contrast, the amount of organic matter present at a given time is biomass. Production of animals and a saprobes in communities is referred to as secondary productivity.

The amount of organic matter created or energy bound, per unit area and time, that is left after plant respiration is the net primary productivity. This is the amount of total (gross) productivity available for harvest by man or other animals.

Only a part of the net primary productivity of rangeland usually is measured. Often only the aerial portion of the plants are sampled, and usually only at one time per year. This aerial portion of production may be less than bellow ground net production, or about forty percent of total production (Sims and Singh 1971).

Measuring productivity at one time during the year poses some problems in measuring community productivity. The species comprising a community may have peak yearly aerial accumulations of organic matter at different times. Further, the timing of these peaks varies from year to year. Coupland's (1950) forage yield data for six years exhibited a nearly five fold variation and a coefficient of variation of 0.68. Yield of short-gross communities is variable even during a series of good years. (Albertson and Weaver, 1944). It is even possible that there may be more than one yearly peak in yield, as in, for example, years with a heavy late summer-early fall rain.

Single measurements of peak community yields are known to be an underestimate of productivity. In experiments on four grassland areas in Montana, sampling at the time of peak standing crop gave results which were, on the average, sixty-six percent of the production as measured by summing multiple samples at the species peaks (Kelly et al, 1974).

Community yield measurements made under field conditions have additional problems. Sampling must be scheduled long before the spring precipitation and plant phenologies are known. Exclosures can be made to prevent grazing by ungulates, but insects and rodents are still free to consume plants in the sampling area. Lesser amounts of yield may be lost to micioflora, and through leaching and exudation.

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