CUSHION-PLANT VEGETATION ON PUBLIC LANDS IN THE BLM ROCK SPRINGS FIELD OFFICE, WYOMING

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ABSTRACT

Cushion-form forbs contribute substantial cover to short, often sparse vegetation along windblown rims and on rock outcrops in southwestern Wyoming. Botanical survey had shown that rare plant species grow in the cushion-plant vegetation in some areas, and had led to the suggestion that the vegetation in those areas represents unusual plant communities. This conclusion, though, was formed with little information about cushion-plant vegetation in that part of the state.

The present study was undertaken to document the variability in species composition of the cushion-plant vegetation in southwestern Wyoming, to look for relationships between that variation and geographic or geologic factors, and to find out if the rims and outcrops provide habitat for cushion-plants that are absent from the surrounding shrub-steppe vegetation. Fifty-three sample plots were used in ten areas to collect data on plant canopy cover, ground cover, and other habitat variables. Half of the plots were placed immediately along rims to sample the cushion-plant vegetation and the other half were placed at some distance from the rims in an attempt to sample the surrounding shrub-steppe.

The vegetation along rims differs from vegetation away from rims mainly in the relative amounts of different kinds of plants: cushion-plants contributed nearly twice the proportion of cover to plots along rims as they did to plots back from rims, while shrubs and graminoids contributed more cover to the plots away from rims. But vegetation along rims and vegetation away from rims share the same species: of the 138 plant taxa documented in the 53 plots, only a handful of incidental taxa were found exclusively along rims or away from rims. *Arenaria hookeri* was present in all but one sample plot and was common along rims. In the northern and eastern parts of the study area, it was joined by *Phlox muscoides* and *Poa secunda* as co-dominants; elsewhere, *Astragalus spatulatus* and *Poa secunda* were co-dominants with *Arenaria hookeri* or secondary to it, and *Phlox muscoides* was all but absent. *A. hookeri*, *Tetraneuris torreyana* (another cushion-plant), and *Arenaria nuttallii* (a non-cushion forb) dominated plots from the western part of the study area.

Boundaries between cushion-plant vegetation and adjoining shrub-steppe or grass vegetation are diffuse, and with increasing distance from rims, the dominance of cushion-plants is diluted by greater cover of shrubs and grasses. The dominant species in the plots away from rims were *A. tridentata* ssp. *wyomingensis*, *Poa secunda*, *Pseudoroegneria spicata*, and *Elymus lanceolatus* ssp. *lanceolatus*.

Most of the cushion-plant vegetation types identified in cluster analysis classification of the plot data occurred at several of the sampling locations, so neither geographic location nor geologic substrate are good predictors of which type of cushion-plant vegetation is found at a sampling point. Composition of the vegetation also shows no relationship to aspect. The cushion-plant vegetation sampled in southwestern Wyoming is not closely related to any vegetation types in the National Vegetation Classification.

Two-track roads and vehicle tire tracks were common in the sampling plots along rims, but the impacts of vehicle traffic are unclear. No exotic plant species were documented in the sample plots, so vehicles apparently have not been a vector for weeds.

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The assistance of all of these people was invaluable and is greatly appreciated.

INTRODUCTION

In September 2001, the Bureau of Land Management's Rock Springs Field Office entered into a cooperative agreement with the University of Wyoming's Natural Diversity Database (WYNDD) to survey vegetation dominated by cushion-form forbs on public lands managed by the Bureau's Rock Springs, Kemmerer, and Pinedale Field Offices. This project was undertaken because botanical studies in the past had suggested that cushion-plant vegetation in specific areas (especially near Kemmerer) is unusual and worthy of special management, but little information was available that could provide a frame of reference for the vegetation in specific areas. Potential sampling locations for the project were selected in winter 2001 - 2002 and spring 2002, and field work was conducted during the following June.

Three questions whose answers are important to BLM biologists and managers were posed at the beginning of the project. First, do the cushion-plants that seem so obvious in the short, often sparse vegetation along rims occur only there, or are they also present in the nearby, taller, grass and shrub vegetation? If cushion-form forbs are largely restricted to the windblown rims and rock outcrops, then land managers might need to pay special attention to those habitats to assure that healthy populations of the plants persist in the region.

Second, how variable in species composition is the cushion-plant dominated vegetation in southwestern Wyoming? If the vegetation varies little from place to place, then protection of this resource on BLM lands might be accomplished through special management of only a few sites. If, on the other hand, many types of cushion-plant vegetation occur in the area, management of more areas might be necessary to maintain the variety of vegetation types on public lands.

Third, is the variability in cushion-plant vegetation related to differences in geographic location or geologic substrate? Plant species in the vegetation at a particular location are drawn from the regional flora, and heterogeneity in that flora might well be reflected in heterogeneity in the cushion-plant vegetation among locations. Regarding geologic substrate, even casual observation shows that cushion-plants are most obvious along rims formed on resistant bedrock. Beyond that, though, do different cushion-plant species occur or dominate on different types of resistant rock?

For this project, "cushion-plant" was defined as a prostrate, acaulescent, tap-rooted forb that typically grows in a dense mat. Examples can be found in a number of plant families and include *Arenaria hookeri* (Caryophyllaceae), *Astragalus drabelliformis* (Fabaceae), *Erigeron compositus* (Asteraceae), *Eriogonum acaule* (Polygonaceae), *Draba oligosperma* (Brassicaceae), and *Phlox muscoides* (Polemoniaceae). By "cushion-plant vegetation", we mean short, often sparse vegetation on rims and outcrops formed in resistant bedrock, where cushion-plants contribute a major proportion of the plant canopy cover. Our concept of cushion-plant vegetation excludes sparse vegetation dominated by non-cushion forbs or subshrubs (such as *Atriplex nuttallii* or *Artemisia pedatifida*) that occurs on soft bedrock. In the field, we defined cushion-plant vegetation as vegetation in which we estimated that cushion-plants contributed at least 50% of the canopy cover and the grasses and shrubs common in the surrounding shrub-steppe vegetation contributed < 50% of the canopy cover.

METHODS

SAMPLE AREA SELECTION

Through observations over the last decade by BLM and WYNDD botanists, vegetation apparently dominated by cushion-form forbs was known to grow along rims and on rock outcrops at various places in southwestern Wyoming, usually in bands or patches up to ca. 100 meters wide. These bands and patches are too small to appear on vegetation maps, so potential sampling locations known from previous botanical work (Fertig *et al.* 1998) or otherwise noted by WYNDD and BLM biologists were marked on 1:100,000-scale topographic maps. Approximately a dozen areas thought to have vegetation suitable for this study were so identified. Black-and-white digital orthophotoquad quarters (i.e., digital black-and-white photographs) of those areas were obtained from the web site of the University of Wyoming's Geographic Information Science Center (<http://www.wygisc.uwyo.edu/doqq/search.html>) and were incorporated into an ArcView 3.0 geographic information system project (ESRI, Redlands CA, USA) and then examined for features that corresponded to the known locations of the cushion-plant vegetation. In almost every case, the orthophotoquads showed pale strips or patches along rims that differed markedly in appearance from the surrounding landscape.

Narrow polygon features were then digitized in ArcView atop those bands and patches on the orthophotoquads. A grid of random points was laid over the polygons, and the points that intersected the polygons were selected and numbered. From this subset of points, a second and smaller subset of points was randomly selected to serve as potential sampling points, with the requirement that the potential sampling points at a location be several hundred meters apart. For each potential sampling point, the UTM coordinates (NAD27, Zone 12 North) were determined from ArcView. The list of potential sampling points was taken to the field for reconnaissance at several of the areas, to see if cushion-plant vegetation actually grew at those points. At least one of the areas was eliminated from study because the reconnaissance showed that the patches on the orthophotoquad were sparsely vegetated shale bedrock, rather than cushion-plant vegetation on resistant bedrock.

A two- or three-person field crew used maps and a geographic positioning system receiver (Trimble GeoExplorer 2, Trimble Navigation Ltd., Sunnyvale CA, USA) to navigate to each of the potential sampling points. If the vegetation at or close to that point met the definition of cushion-plant vegetation, then a sampling plot was laid out and data collected. If not, then the crew moved to the next point.

DATA COLLECTION

The nested vegetation-sampling plots developed by Stohlgren *et al.* (1995) were used to estimate canopy cover of plants. This plot design features a macroplot (in this case, measuring 10 m x 25 m) with 13 sub-plots inside it (Figure 1). The field crew placed the starting corner for the macroplot close to the sampling location, then used a GPS receiver (Trimble GeoExplorer 2, Trimble Navigation Ltd., Sunnyvale CA, USA) to determine the UTM coordinates (NAD27, Zone 12 North) of the corner's actual location. UTM coordinates were recorded by hand. The azimuth of the macroplot's long axis was determined with a sighting compass.

Sampling began with the microplots: in each, the percentage of the microplot beneath the canopy of each species was estimated, and was recorded as the mid-point of the appropriate cover range (Table 1). The canopy cover of a plant was defined (following Daubenmire 1959) as the polygon described by a line drawn around the leaf tips of the undisturbed above-ground portion of the plant. After canopy cover had been estimated in the 10 microplots, the two corner sub-plots were searched for species that had not been recorded in the microplots, and their presence was noted. The center sub-plot was next searched for species that had not been recorded in the microplots or in the corner sub-plots, and finally, the area of the macroplot outside of the microplots and the corner and center sub-plots was searched for new species. With this procedure, canopy cover was recorded only for the plants in the microplots, and presence alone was recorded for species in the larger sub-plots and in the macroplot. Specimens of plants that could not be identified to species, or for which identification was uncertain, were collected, pressed, and identified later.

The values for a species from the 10 microplots were then averaged to give an estimate of the species's cover for the entire macroplot, and that estimate was converted to the mid-point of the appropriate cover range. For example, suppose that the 10 values for species A (each a mid-point value from a microplot) averaged 7.6, which average falls within the 5% - 15% cover range (Table 1). The value for species A for the macroplot then was given as 10, the mid-point of that range. Any species that was not found in a microplot but was found in one of the corner plots, or in the center plot, or in the macroplot was assumed to have a canopy cover of less than 1%, and was assigned a value of 1 for the macroplot. This method of estimating canopy cover allows one to say that the canopy cover for a given species in a macroplot falls within a range. It does not yield a precise, point estimate of canopy cover for the species.

The vegetation at the sampling location was briefly described and a photograph was taken of the macroplot. The percentage of the ground surface in the macroplot covered by each of 12 categories of material (Table 2) was estimated. Selected environmental variables were recorded, including type of surface material (residual, colluvial, alluvial, or aeolian), soil texture (based on one hand texture of the top 10 cm of soil, made near the starting corner), slope steepness, and aspect.

DATA ANALYSIS

-- Classification of Plots

The sample plots were classified into groups using several types of analysis[1], as a way to identify cushion-plant vegetation types. Classification was done with cluster analysis, a procedure that combines individual plots into groups, and small groups into larger groups, until all of the plots are combined into one large group. In cluster analysis, the similarity in species composition between each pair of plots is calculated (in this case, using Sorensen's coefficient) and then is converted to a measure of dissimilarity, or distance in species space, between stands. The plot-to-plot distances are stored in a matrix, and the combining of plots starts with the closest plots and proceeds to the most distant plots. When plots are combined into a group, the distance from the centroid of the group to each remaining plot or to the centroid of every other group is calculated. The classification performed here used flexible-beta linkage (beta = -0.25) to combine plots and groups.

A classification resulting from cluster analysis typically is displayed in a dendrogram that shows how the plots are combined into groups, and how those groups are combined with one another (e.g., Figure 8). The final form of the classification depends on where the branches of the dendrogram are cut. Cutting the dendrogram close to its beginning gives a classification with many, usually small and relatively homogeneous, groups. If the dendrogram is cut too close to the beginning, the resulting classification does a poor job of summarizing the wealth of information present in the data. Cutting the dendrogram farther out toward its end produces a classification with few, but larger and more heterogeneous, groups. A classification with a few large groups can be difficult to interpret because a large group often contains disparate plots.

Generally, the goal in cutting the classification dendrogram is to produce a classification with enough groups that the variability in the original plot data can be summarized and explained, without having groups so large that the ecological differences between them is obscured. PC-ORD provides two scales by which to judge the effect of combining plots and groups (McCune and Mefford 1999, McCune and Grace 2002). Combining plots into a group results in the loss of some of the original information about how dissimilar the plots are from one another, and when all the plots have been combined into one group, all of that information has been lost. PC-ORD includes on the dendrogram a scale showing the amount of that information remaining in the data at each step in the classification, as a percentage of the information on plot-to-plot distances that was present in the original data matrix. A second scale on the dendrogram, the objective function, shows the amount of variability among the plots within the groups, calculated as the sum of squares of the distance between each plot and the group centroid. This variability increases as plots are added to groups, because the closest (that is, most similar) plots are combined first, and the most distant (that is, most dissimilar) plots and groups are combined later. In terms of these scales, the goal of cutting the classification dendrogram is to have a classification with low variability within groups and that retains a large amount of the information present in the original data set.

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[1] Analyses were conducted with PC-ORD, Version 4.27; MjM Software Design, Gleneden Beach OR, USA

Multiple response permutation procedures (MRPP) is a non-parametric approach for determining whether a statistically-significant difference exists between groups, and it can be useful for deciding where a classification dendrogram might be cut (McCune and Grace 2002). In MRPP, the distance (i.e., the dissimilarity) between each pair of plots in a group is calculated, the average distance among the plots within each group is calculated, and those average distances are summed into a weighted-average, within-group dissimilarity (a parameter known as "delta"). The probability of obtaining a delta value this large by chance is assessed by comparing it to a Pearson type III distribution. MRPP also calculates a measure of within-group homogeneity (the parameter "A") that is independent of sample size. Both delta and A are used to judge whether the groups differ from one another significantly (in a statistical sense).

Indicator species analysis (ISA) is a second non-parametric statistical procedure that helps in indicating where the classification dendrogram might best be cut (McCune and Grace 2002). ISA identifies the species that can be used to distinguish between groups. It starts by calculating, for each species in each group, the proportional abundance (that is, the degree of concentration of the species in the group) and the frequency (the proportion of plots in the group that contain the species). The abundance and frequency values are then combined into an indicator value for each species in each group. For each species, the indicator values for each group are compared, and the largest is saved as the final, observed indicator value for the species. Indicator values range from 0 to 100. A value of 100 for species *i* in group *j* indicates that species *i* is found only in the plots of group *j* and is found in all of those plots, and so is a perfect indicator of group *j*.

The statistical significance of each observed indicator value can be judged through a Monte Carlo test, in which the plots are randomly assigned to groups and species indicator values are calculated for those groups. This random reassignment of plots is repeated 1000 times, and the distribution of possible indicator values for a species from the Monte Carlo test allows one to calculate the probability of obtaining an indicator value as large as the one observed in the real data. ISA can help in decisions about where the classification dendrogram ought to be cut because, for any level in the dendrogram, the number of statistically-significant indicator species for all of the groups, and the average probability of the indicator values, can be calculated. The dendrogram can be cut where the groups have either a large number of significant indicator species, or a low average probability of indicator values. Once the dendrogram has been cut and the final number of groups decided upon, ISA can show which species are responsible for separating the groups from one another.

-- Comparison of Plot Groups

Parametric tests (analysis of variance with Bonferroni simultaneous tests for differences and two-sample t-tests) were used to test for differences between all plots along rims and all plots back from rims in plant canopy cover and in ground cover. The tests were performed with Minitab Release 12.21 (Minitab Inc., 1998). Kruskal-Wallis non-parametric tests (also performed in Minitab Release 12.21), followed by non-parametric multiple comparisons (Zar 1984), were used to examine differences between plot groups in numbers of species and canopy cover of plants of different plant growth-forms.

-- Geological Substrates

The geologic substrate on which each plot was located was determined from the digital geologic map of Wyoming (U.S. Geological Survey 1994). A GIS shape file of the plots (with UTM coordinates as locators) and the digital geologic map both were imported into ArcView 3.2 and a geology map unit was assigned to each plot. Nine stratigraphic units thus were selected from the geologic map (Table 3). The description of each stratigraphic unit (Table 3) was taken from Love and Christiansen (1985), the original map on which the digital geologic map was based. The assumption was made that, no matter what the stratigraphic unit, the sample plots lay on resistant rock, and each stratigraphic unit was placed into one of four substrate types based on the resistant rock type listed in its description. These substrate types were then used when relationships were explored between plots and geologic substrate.

RESULTS

FLORA AND VEGETATION

Fifty-three sample plots were located in 10 areas of southwestern Wyoming (Figure 2), 27 plots in cushion-plant vegetation along rims and 26 back from the rims for comparison (Table 4). One-hundred thirty-eight vascular plant taxa were documented in the plots (Tables 5 and 6). (Plant names are from USDA Natural Resources Conservation Service 2002.) Of these taxa, 105 (76%) were identified at least to species, 14 (10%) were identified only to genus, and 19 (14%) remained unknown. Only seven species were found in more than half of the plots (i.e., at least 26 plots), and 42 taxa (30% of the total) were found in only one plot (Figure 3). Two species were especially common: *Arenaria hookeri* was recorded in 52 plots and *Poa secunda* in 47. None of the taxa in the plots are known to be exotics.

The plots located along rims and the plots back from rims, taken as groups, differed little from one another in the types of plants present. Twenty-seven of the forb species recorded in the sample plots were considered cushion-plants (Tables 5 and 6) and virtually none occurred exclusively in plots along rims or plots back from rims; rather, all of the cushion-plant species found in more than trace numbers occurred in plots at both topographic positions (Figure 4). For each of the five plant growth-forms (shrubs, subshrubs, graminoids, forbs, and cushion-plants) and for all species together, there was no difference between the plots along rims and the plots back from rims in the average number of species per plot (Figure 5).

The difference between the two types of plots was in the proportions of the plant cover contributed by different plant growth-forms: cushion-plants contributed nearly twice as much of the canopy cover to plots along rims as they did to plots back from rims, while plots back from rims had nearly three times the proportion of shrub cover and twice the proportion of graminoid cover as did plot along rims (Figure 6). Relative cover of sub-shrubs and forbs did not differ between the types of plots.

Ground-cover data suggest that the soil environments differ between the rim plots and the plots back from the rims: percent cover of gravel was greater in the plots along rims, while percent cover of bare soil was greater in plots away from rims (Figure 7).

CLASSIFICATION OF PLOTS BASED ON CANOPY COVER

In a vegetation classification based on some measure of abundance (such as amount of canopy cover), the groups of plots differ from one another in the amounts of each species that they contain, not just in the species present in the vegetation; the point is to find vegetation types that are repeated combinations of certain amounts of some species. Abundant species typically are given greater weight than are rare species. This approach is widely used in the U.S. and is the basis for the national vegetation classification being developed by the Ecological Society of America’s Vegetation Panel (Jennings *et al.* 2003).

Often, species that occur in only a few plots obscure the relationships between plots in terms of relative amounts of species. Those rare species can be excluded as long as species richness is not being used as a feature for classifying the vegetation (McCune and Grace 2002). Hence the 65 taxa that occurred in only one or two sample plots in this study were excluded from the classification based on canopy cover data, leaving 73 taxa in the analysis. The canopy cover data for the remaining taxa were then changed from absolute cover (the mean cover-class for each taxon in each plot) to relative cover (the cover-class for each taxon in a plot divided by the total cover in the plot). This “relativization by plot total” (McCune and Grace 2002) focuses the analysis on the proportions of taxa in each plot (rather than absolute amounts of each taxon) and decreases the influence of differences between plots in the amounts of vegetation present.

Several statistics reveal the effect of excluding those rare taxa and relativizing the cover-class values (Table 9). In the full, unrelativized data set, the heterogeneity among plots in number of taxa (the beta diversity)[2] was 7.01, an indication that the data set might be difficult to analyze successfully (McCune and Grace 2002). The average number of taxa per sample plot (average species richness, or alpha diversity) also was high, at 17.2 species. In contrast, the coefficient of variation among plots in total cover was not particularly high, at 34.42%. Excluding the rarest species reduced the heterogeneity between plots (beta diversity) to 3.71 and the average number of species per plot (alpha diversity) to 15.5, and the number of empty cells in the species-by-plot matrix from 87.6% to 78.8%. Relativizing the data by plot total reduced the coefficient of variation in cover to 0.

The cluster analysis classification based on relative species cover was split at a level giving six plot groups (Figure 8), based on the results of indicator species analyses showing that the maximum number of statistically-significant indicator species and the lowest average probability for indicator values were obtained at that level (Figure 9). Of the information originally present in the matrix of plot-to-plot distances, the 6-group classification left ca. 32% in the data and extracted ca. 78%.

Several MRPP tests were conducted to evaluate the splitting of the plots into six groups. Test A showed a statistically-significant difference in species composition (based on relative cover) between groups 1 and 28 ($p = 0.0048$; Table 10) and test B showed a statistically-significant difference between groups 8 and 21 ($p = 0.000000$; Table 11), suggesting that these groups should be recognized as separate and the dendrogram not be split into a classification with fewer plot groups. Test C suggested that plot group 8 contains two smaller groups that differ from one another ($p = 0.0157$; Table 12), while test D suggested that sub-groups within group 28 do not differ significantly ($p = 0.137$; Table 13). According to these latter tests, the dendrogram might be split into a classification with 7 groups of plots. Group 8 was retained as a single group, though, because one of its sub-groups contains only two plots, and both sub-groups are dominated by graminoids (as discussed below).

The six plot groups are described below. Each is shown on the classification dendrogram in Figure 8 and is summarized in Table 24.

Group 7 (n=13)

This group is composed of plots in which cushion-plants contributed more canopy cover than did plants of other growth-forms (Table 15). These plots had significantly more canopy cover of cushion-plant species, and less canopy cover of non-cushion forbs, than did plots in other groups (Figure 10). They did not contain more cushion-plant species per plot, but they did contain fewer species of non-cushion forbs (Figure 11). Average number of species per plot (alpha diversity) was low relative to other plot groups and beta diversity was high (Figure 14), the latter indicating that plots in this group were heterogeneous in the number of species that they contained.

Plots in this group occurred predominantly along rims (Table 4) in the northern and eastern parts of the study area (Figure 15). Percent gravel cover and percent bare soil ranged widely between plots and did not differ from those in other plot groups. The amount of cobble also ranged widely and was higher in this plot group than in most other groups (Figure 16). Plots were found primarily on sandstone and oil shale substrates (Figure 17) and on a range of soil textural classes (Figure 18).

Two cushion-plants, *Phlox muscoides* and *Eriogonum acaule*, are indicator species for this plot group (Table 14). *Phlox muscoides* dominated or co-dominated in every plot (Table 15). *Arenaria hookeri* also was present in every plot and contributed substantial cover to some. *Eriogonum acaule*

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[2] The measure of beta diversity used here is $B_w = (S_c / S) - 1$, where S_c = the number of species found in all plots of a group and S = the average number of species per plot. B_w expresses the degree to which individual plots contain all of the species found in the group of plots. If $B_w = 0$, the minimum value possible, then every plot contains all of the species found in the group of plots. The maximum possible value of B_w is Sc-1, and is obtained when each plot contains only one species and, hence, no species are shared among plots. See discussion in McCune and Grace 2002, pp. 30 - 31.

and *Astragalus spatulatus* were present in many of the plots and also contributed substantial cover to some plots. *Poa secunda* was widespread but usually contributed little cover.

Group 1 (n=8)

This is a second plot group in which cushion-plants contributed substantial cover to the vegetation, but in this group the cushion-plant cover was equalled or slightly exceeded by that of non-cushion forbs (Table 16). This group had high median forb cover and cushion-plant cover (Figure 10), and a higher median number of forb species per plot than some other groups (Figure 13). Alpha diversity (average number of species per plot) was high relative to the other plot groups and beta diversity (indicating heterogeneity among plots in number of species) was intermediate (Figure 14).

Plots in this group were nearly all located immediately along rims. All but one of the plots was located in the two sampling locations from the southwestern part of the study area (Figure 15) and, consequently, they lay on either tuffaceous sandstone bedrock or landslide deposits (Figure 17). Soils were all some form of loam (Figure 18). Gravel cover ranged widely but was high in many plots, and percent bare soil was low (Figure 16).

Eight plant species -- three cushion-plants, three non-cushion forbs, and two subshrubs -- were identified as indicators of this plot group but none had particularly high indicator values (Table 14). There was no strongly dominant plant species in the plots of this group. Four species -- *Arenaria nutallii*, *Tetraneuris torreyana*, *Artemisia frigida* (all three indicators), and *Arenaria hookeri* -- were present in all plots and dominated or co-dominated many. *Trifolium andinum* (an indicator) and *Poa secunda* were widespread and also contributed substantial cover to several plots. Only one plot contained *Phlox muscoides*.

Group 21 (n=4)

Arenaria hookeri contributed substantial cover to each of the four plots in this small group (Table 17), although cushion-plants as a group contributed less cover than did non-cushion forbs (Figure 10), and the vegetation contained more non-cushion forb species than cushion-plant species (Figure 11). Alpha diversity for this group (average number of species per plot) was intermediate, and beta diversity (reflecting the heterogeneity between plots in number of species) was low (Figure 14).

The plots in this group were located immediately along Joe Hay, Steamboat, or Kinney Rims (Table 4, Figure 15), on oil shale (Kinney Rim) or sandstone (Tables 3 and 4). Gravel cover was high in these plots, and bare soil and cobble cover were low (Figure 16).

Indicator species analysis identified 8 statistically-significant indicator species for this group, but only two of them had indicator values greater than 50 out of a possible 100 (Table 14). Four species were present in all plots (Table 17): the cushion-plants *Arenaria hookeri* (an indicator) and *Astragalus spatulatus*, the subshrub *Krascheninnikovia lanata* (an indicator), and the forb *Stanleya viridiflora* (also an indicator). Of these species, *Arenaria hookeri* and *Krascheninnikovia lanata* contributed substantial cover to at least two plots; *Astragalus spatulatus* and *Stanleya viridiflora* were present in smaller amounts. Several other species also contributed substantial cover to at least one plot.

Group 28 (n=13)

This large group contains plots with a range in vegetation features and species composition (Table 18). It is intermediate among groups in canopy cover and number of species per plot of different growth-forms (Figures 10 and 11). Alpha diversity also is intermediate (although the range in number of species per plot is large), but beta diversity was highest among all plot groups (Figure 14).

Cover of gravel and cobble generally were low in these plots, and percentage of bare soil was high (Figure 16). About half of the plots were found immediately along rims, and the other half back from rims (Table 4). These plots were located at the sampling areas in the northern half of the study area (Figure 15), on oil shale, sandstone, and tuffaceous sandstone parent materials (Tables 3 and 4).

Four plant species that occurred only in plots of this group were identified as significant indicator species (Table 14). All had low indicator values, though, because each was found in less than half of the plots. Only *Artemisia tridentata* ssp. *wyomingensis* was found in all 13 plots (Table 15); it co-dominated some plots and contributed only a trace of cover in others. *Arenaria hookeri*, *Arenaria nuttallii*, and *Poa secunda* were slightly less widespread among the plots and each contributed substantial cover to some plots.

Patterns of species composition among plots in this group makes more sense if the group is divided (for the sake of discussion) into three sub-groups (Table 18). Sub-group 280 includes 5 plots from Steamboat Rim and Packsaddle Canyon, four of them back from the rims, in which cushion-plants contributed substantially to the vegetation: *Arenaria hookeri* and *Astragalus spatulatus* were present in all plots and *Phlox muscoides* was present in four, and all species co-dominated several plots; *Poa secunda* and *Artemisia tridentata* ssp. *wyomingensis* also were present and contributed substantial cover. A second sub-group (282 on Table 18) consists of 5 plots from Round Mountain in which cushion-plants and non-cushion forbs were the major species. *Arenaria hookeri* and *Arenaria nuttallii* (a non-cushion forb) were present in all plots and co-dominated most, *Trifolium andinum* (a cushion-plant) was present in trace amounts in all plots, and *Artemisia tridentata* ssp. *wyomingensis* and *Achnatherum contractum* also were present in all plots but in most they contributed little cover. The third sub-group (number 281 on Table 18) comprises three plots, two from Ross Butte and one from Round Mountain, in which several species were present (*Artemisia tridentata* ssp. *wyomingensis*, *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, *Arenaria nuttallii*, *Eriogonum ovalifolium*) but none were consistently dominant.

Group 8 (n=7)

The plots in this group were strongly dominated by grasses (Table 19). Graminoid canopy cover was substantially higher in this group, and the number of graminoid species per plot slightly higher, than in other plot groups (Figures 10 and 11). Alpha diversity (average number of species per plot) was low relative to other groups, and beta diversity (heterogeneity in number of species per plot) intermediate.

This group includes only plots located back from rims (Table 4), at Delaney, Kinney, and Steamboat Rims (Figure 15). Percent gravel cover and percent bare soil were intermediate among the plot groups, and no cobbles were recorded (Figure 16).

Three grass species and two forbs were identified as indicator species for this group (Table 14). *Elymus lanceolatus* var. *lanceolatus* and *Poa secunda* were found in all plots and dominated or co-dominated 4 of them, and *Pseudoroegneria spicata* dominated three of the four plots in which it occurred (Table 19). *Phlox hoodii*, the fourth indicator species, contributed substantial cover to three plots and was found in three more. The last indicator, *Allium textile*, was present in trace amounts in only three plots and was identified as an indicator species because it was found in only one plot outside this group. *Arenaria hookeri* and *Krascheninnikovia lanata* were present in all or most of the plots and contributed more than a trace of cover to a few.

Group 2 (n=8)

This is a group of shrub plots. In only one plot, shrubs shared dominance with forbs, and shrubs clearly dominated the other 7 plots (Table 20). Shrub canopy cover was substantially higher, and the number of shrub species per plot slightly higher, in this group than in others (Figures 10 and 11). The number of forb species per plot also was relatively high. Alpha diversity and beta diversity both were high in this group (Figure 14).

All of the plots in this group were located back from rims (Table 4) and were widespread through the study area, occurring at Ross Butte, Ross Ridge, Joe Hay Rim, and Cedar Mountain (Figure 15). Bare soil cover was high in these plots, and percent gravel cover ranged widely (Figure 16).

Two shrubs and one grass were identified as indicator species for this group (Table 14). *Artemisia tridentata* ssp. *wyomingensis* was present in other groups as well, but only in this group did it dominate all plots (Table 20). *Chrysothamnus viscidiflorus*, the other indicator shrub, was present in only three plots, but if the other taxon of rabbitbrush, *C. viscidiflorus* ssp. *viscidiflorus*, is combined with it, then it was present in 6 of 8 plots. *Koeleria macrantha* was present in only 3 plots and was identified as an indicator because it was absent from plots in other groups.

No other plant contributed nearly the cover that *A. tridentata* ssp. *wyomingensis* did (Table 20). *Poa secunda* and *Arenaria hookeri* were present in all plots and contributed more than trace amounts of cover to several. *Arenaria nuttallii* was almost as widespread and also contributed substantial cover to several plots.

VEGETATION AND ENVIRONMENTAL FACTORS

No clear relationship between variation in cushion-plant vegetation (as expressed in the classification of plots into 6 groups) and environmental factors emerges from the data. Geological substrate does not differ consistently between plot groups. In Figure 17, the type of substrate underlying each plot is shown on the classification dendrogram, and no group is found exclusively on one substrate type. Similarly, the plots from each group are found on soils of at least two textural classes (Figure 18), suggesting no close relationship between soil texture and composition of the vegetation.

No difference among plot groups was detected in the aspect on which plots were located (Figure 19). For this comparison, the compass bearing of 270^{o} was selected as a reference direction (because of the prevalence of westerly winds in southern Wyoming) and a transformed aspect was calculated to measure the deviation from the reference direction, using the formula (from Beers *et al.* 1966): Aspect (transformed) = cosine (270 - measured aspect) + 1. Measured aspect was converted to radians before the calculation, and transformed aspect was converted from radians back to degrees before the comparison between plot groups was made.

Finally, none of the four plots groups with substantial amounts of cushion-plant cover (groups 7, 1, 21, and 28) were found at just one of the sampling locations (Table 26), and none were restricted to parts of the study area (Figure 15). The data, then, suggest no differences in the geographic distributions of the cushion-plant groups within this limited study area.

SIGNS OF DISTURBANCE IN CUSHION-PLANT VEGETATION

Evidence of at least one type of disturbance was recorded inside or within several meters of 24 of the 27 plots along rims (Table 27). Vehicles were the most common cause of disturbance. Drivers probably are attracted by the views afforded by rims and by the lack of shrubs and other obstructions. In contrast, only half of the plots back from rims contained evidence of disturbance, and the most common cause was small mammals (especially pocket gophers). Signs of anthropogenic disturbance were rare in those plots.

DISCUSSION

COMPOSITION OF CUSHION-PLANT VEGETATION

This study focused on the vegetation of windblown rims and rock outcrops where cushion-form forbs appear to dominate, and one of the questions posed is whether those rims and outcrops provide habitat for cushion-plant species that are absent from the environments occupied by the nearby grasslands and shrub steppe. To the extent that the data actually compare different vegetation types, they suggest that this is not the case: these visually distinct vegetation types are floristically similar, in that the cushion-plant species so apparent along the rims are also present in the nearby vegetation at some distance from the rims (Figure 4). There is no evidence in the data that the cushion-plant vegetation is either richer or poorer in species of the five growth-forms or in total numbers of species (Figure 5). The difference between cushion-plant vegetation and other vegetation is in the relative amounts of different types of plants: cushion-plants contribute a markedly higher proportion of the canopy cover to the vegetation along the rims, while shrubs and graminoids contribute markedly greater proportions of the cover to the shrub and grass vegetation types (Figure 6).

It is possible that, had the back-from-the-rim plots been placed farther from the rims, the data would show that the cushion-plant vegetation along rims differs from the surrounding grassland and shrub-steppe in species composition as well as amounts of species -- that is, that the rims do provide habitat for cushion-plants that are virtually absent from the surrounding vegetation. The field crews minimized the time spent at each location so that they could visit as many locations as possible, and hence the back-from-the-rim plot was, in nearly all cases, placed within several hundred meters of the rim plot. Apparently this was a great enough distance to produce a difference in the soil environment between the plot types (Figure 7). But the back-from-the-rim plot at many locations may still have been so close to the rim that it was sampling an ecotone between the rims and the matrix vegetation farther away. We hope to examine this possibility by comparing the rims plots with vegetation samples collected elsewhere in different environments in southwestern Wyoming.

A second point of this project was to characterize the variability in cushion-plant vegetation in southwestern Wyoming. Throughout the area, the cushion-plant *Arenaria hookeri* is ubiquitous, and it often dominates in terms of canopy cover, especially on the rims atop the long escarpments found throughout much of the area. *Poa secunda* is widespread and common as well. These two species are essentially constant constituents of the vegetation, which varies from place to place in the amounts of several additional species.

In the southeastern, central, and northern parts of the study area, along rims that contain little shrub or forb cover, *Phlox muscoides* dominates or co-dominates, and *Arenaria hookeri*, *Astragalus spatulatus* and *Eriognonum acaule* contribute substantial cover. *Poa secunda* usually is present. This vegetation is represented by the plots in group 7. At some distance from rims (as represented by the plots in sub-group 280 of group 28), the dominance of *Phlox muscoides*, *Arenaria hookeri*, and *Astragalus spatulatus* is diluted by greater amounts of *Poa secunda* and *Artemisia tridentata* ssp. *wyomingensis*.

Also in the central part of the study area, *Arenaria hookeri* was found to dominate vegetation with more forb and subshrub cover. *Astragalus spatulatus* is present in this vegetation (represented by plot group 21), usually in small amounts. No other species appears to be consistently common, but *Artemisia frigida*, *Krascheninnikovia lanata*, and *Eriogonum brevicaule* usually are present and may contribute substantial cover.

Common in the southwestern part of the study area (but present also in the north) is vegetation dominated by *Arenaria hookeri*, *Tetraneuris torreyana*, *Trifolium andinum*, *Arenaria nuttallii*, and *Poa secunda*. This vegetation, represented by the plots in group 1, also contains *Artemisia frigida* and (often) *Astragalus spatulatus*. At Round Mountain in the western part of the study area, on bedrock outcrops surrounded by areas of deeper soil (as contrasted with long bedrock rims), *Arenaria hookeri* is present in vegetation generally dominated by *Arenaria nuttallii*. *Trifolium andinum* and *Achnatherum contractum* are present in small amounts. *Artemisia tridentata* ssp. *wyomingensis* is present but usually only in small amounts. This vegetation is represented by the plots in subgroup 282 of group 28.

GEOGRAPHIC AND GEOLOGIC FACTORS

Geological substrate seems to exert little influence on the composition of the cushion-plant vegetation in the study area. It may be that any resistant substrate capable of forming rims or outcrops provides equally suitable habitat for the common cushion-plant species. But the absence of an apparent relationship between vegetation and substrate also may be due to the manner in which the plots were assigned to geologic substrates. The substrate on which each plot lay was not determined in the field. Rather, each plot was assigned to a stratigraphic unit by comparing its location to a computerized data layer of geologic map units that had been digitized from a 1:500,000-scale map (U.S. Geological Survey 1994). Both the accuracy of the plot locations and the accuracy of the digital geology layer determine whether a plot was correctly assigned to a stratigraphic unit. UTM coordinates for each plot were ascertained with a Trimble GeoExplorer 2 global positioning system receiver (without selective availability), which typically gives horizontal accuracy to within 10 meters (K. Driese, University of Wyoming Geographic Information Science Center, personal communication). This degree of accuracy is unlikely to produce large errors. The amount of horizontal inaccuracy in the boundaries of the stratigraphic units is unknown, though, (the U.S. Geological Survey has no national mapping accuracy standards for data produced at the 1:500,000 scale; Berendsen 1998), and Reiners and Thurston (1995) suggest that it could be hundreds of meters. That amount of inaccuracy might cause plots to be assigned to the wrong stratigraphic units.

Moreover, the generality of the descriptions of stratigraphic units could be obscuring relationships between vegetation and geologic substrate. For example, landslide deposits are mapped and described as a single stratigraphic unit, but the composition of a particular landslide deposit depends on the composition of the rock where it originated, the composition of the rock over which it slid, and the degree of mixing of the two. Rocks in other stratigraphic units may differ from place to place in some features important to the vegetation, but this variation cannot be known from small-scale maps of the type used here. Perhaps relationships between cushion-plant vegetation and geology could be elucidated if the substrate were identified (and characterized to some extent) in the field, not from small-scale maps.

The lack of clear relationships between vegetation composition and environmental factors may be due to the size of the vegetation samples. Ten meter x 25 meter plots were used for sampling because of advantages in their length-to-width ratio and the arrangement of subplots within them (Stohlgren *et al.* 1995), and because they fit easily into the narrow bands of vegetation along rims. The differences between these 250 m^2 areas may be local variation resulting from historical factors that caused, for example, *Phlox muscoides* to become established at one place and *Arenaria hookeri* at another nearby place. This possibility is suggested by the co-occurrence at various sampling locations of plots from different groups (Table 26). Data from a broader geographic area may show that the plot groups identified here are minor variants of a general *Arenaria hookeri*-rich cushion-plant vegetation common throughout southwestern Wyoming, and that this vegetation differs substantially from that in other areas with a wider range of environments.

RELATIONSHIP OF PLOT GROUPS TO THE NATIONAL VEGETATION CLASSIFICATION

The U.S. National Vegetation Classification provides a framework for interpreting vegetation types around the country. The Ecological Society of America's Vegetation Panel recently adopted guidelines for using plot data to identify the plant associations that will constitute the most-detailed level of the national classification (Jennings *et al.* 2003). In the meantime, the national classification already includes a list of plant associations and plant alliances (slightly broader vegetation units that subsume related plant associations; NatureServe 2004) taken primarily from the literature. Many of these have not been described at all or are only poorly described, and the existing list of plant associations is incomplete. Still, a comparison of local classifications, such as this one of southwestern Wyoming cushion-plant vegetation, to the existing national classification can help resource managers understand the context for vegetation in their areas.

The list of plant associations and alliances in the national classification at present contains one type that resembles the cushion-plant vegetation from southwestern Wyoming (Table 28). The *Arenaria hookeri* Barrens Herbaceous Alliance has been described from slopes and ravines developed in siltstones in the shortgrass steppe of northeastern Nebraska (NatureServe 2004). *Astragalus spatulatus* is mentioned as a characteristic species (among others). This vegetation type is poorly enough known that the single association within it, the *Arenaria hookeri* Barrens Herbaceous Vegetation Association, has been assigned no conservation status rank. Plot groups 7, 1, 21, and 28 from southwestern Wyoming probably can be assigned to the *Arenaria hookeri* Alliance, but the description of that alliance must be substantially changed.

The remaining plot groups also can be assigned to types from the national classification (Table 28). Plot group 8, composed of grass-dominated plots, may represent two alliances from the national classification. The sagebrush-rich plots of group 2 might be assigned to the *Artemisia tridentata* ssp. *wyomingensis* / *Poa secunda* Association from the national classification. Unfortunately that association is undescribed, so the composition of the vegetation is unknown.

Disturbance in Cushion-Plant Vegetation

Vehicle trails or tire tracks were observed in or near half of the cushion-plant plots sampled in this study, but the point must be made that the method of selecting sampling sites may have produced the high frequency of vehicle disturbance. Potential sampling sites were initially identified by BLM or WYNDD staff familiar with parts of southwestern Wyoming, and that familiarity had been gained in part by driving. Sites without roads were less likely to be known and sampled.

Little can be concluded from the plot data about the impact of vehicles on the cushion-plant vegetation. The presence of unvegetated vehicle tracks demonstrates beyond a doubt that some level of vehicle traffic kills the plants. In many cases, the tracks lay in ruts noticeably lower than the undisturbed ground surface, due to compaction of the soil, or to wind deflation of the bare surface, or both. No estimates were made of the proportion of the ground surface at the sampling sites disturbed by vehicle tracks. The presence of tire tracks without ruts is more worrisome; if vehicles begin to travel these new tracks often enough, then unvegetated ruts probably will form and a substantial part of the vegetation be killed.

The absence of weed species in the sample sites, despite the frequent signs of disturbance, is encouraging. So far, vehicles and the tracks they make have not introduced weeds into the cushion-plant vegetation. Either the weed species now in the region cannot survive in environments sampled here, or they just have not yet reached the sample sites.

Conclusion

Vegetation dominated by cushion-plants differs substantially from place to place in the relative amounts of the various species, although the same group of species (especially *Arenaria hookeri, Astragalus spatulatus,* and *Poa secunda*) usually is present and *Arenaria hookeri* often is common. The differences in vegetation from site to site may indicate underlying differences in habitat factors, although no vegetation / habitat relationship has been demonstrated from the data. A comparison of these data from southwestern Wyoming to data from a wider geographic area may show that the site-to-site differences described here are best considered local variation within a general cushion-plant vegetation. The cushion-plant species so obvious in the vegetation on resistant bedrock rims and outcrops in windblown sites also can be found in smaller amounts in the shrub- or grass-dominated vegetation up to several hundred meters away. This sharing of cushion-plant species may simply indicate that our back-from-the-rim plots were in an ecotone between the vegetation clearly dominated by cushion-plants and the surrounding shrub-steppe vegetation.

References

Beers, T.W., P.E. Dress, and L.C. Wensel. 1966. Aspect transformation in site productivity research. Journal of Forestry 4:691-692.

Berendsen, Margo. 1998. Metadata for Bedrock Geology of Wyoming. University of Wyoming Geographic Information Science Center, Laramie WY. Retrieved March 11, 2004 from http://www.wygisc.uwyo.edu/clearinghouse/metadata/bedgeol.faq.html.

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

Fertig, Walter, Laura Welp, and Stuart Markow. 1998. The status of rare plants in southwestern Wyoming. Report prepared for the Bureau of Land Management, Wyoming State Office by the Wyoming Natural Diversity Database, University of Wyoming, Laramie WY. Agreement #K910-A4-0011, Task Order TO-14. Unpublished. 141 pp.

Jennings, Michael, Orie Loucks, Robert Peet, Don Faber-Langendoen, David Glenn-Lewin, Dennis Grossman, Antoni Damman, Michael Barbour, Robert Pfister, Marilyn Walker, Stephen Talbot, Joan Walker, Gary Hartshorn, Gary Waggoner, Marc Abrams, Alison Hill, David Roberts, David Tart, and Marcel Rejmanek. 2003. Guidelines for Describing Associations and Alliances of the U.S. National Vegetation Classification. Version 3.0. November 25, 2003. Retrieved February 2004 from http://www.esa.org/vegweb/.

Love, J.D. and Ann Coe Christiansen (compilers). 1985. Geologic map of Wyoming. U.S. Geological Survey, Reston VA. 1:500,000 scale.

McCune, B. and J.B. Grace. 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach OR. 300 pp.

McCune, B., and M.J. Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach OR. 237 pp.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.0. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer. (Accessed October 12, 2004).

Reiners, William A. and Robert C. Thurston. 1995. Delineations of landtype associations within the Great Plains physiographic province of Wyoming. Final report, Bureau of Land Management / University of Wyoming Contract K-910-P40261. 65 pp.

Stohlgren, T. J., M. B. Faulkner, and L. D. Schell. 1995. A modified-Whittaker nested vegetation sampling method. Vegetatio 117: 113-121.

U.S. Geological Survey. 1994. Bedrock Geology of Wyoming. U.S. Geological Survey, Denver CO. Retrieved May 21, 2002 from http://www.sdvc.uwyo.edu/24K/bedgeol.html>geology

USDA Natural Resources Conservation Service. 2002. The PLANTS Database, Version 3.5. National Plant Data Center, Baton Rouge LA, USA. Available at http://plants.usda.gov.

Zar, J. H. 1984. Biostatistical Analysis. Second edition. Prentice-Hall, Engelwood Cliffs NJ, USA. 718 pp.

TABLES

Table 1. Canopy cover ranges and mid-points.

% cover	>1	1-5	5-15	15-25	25-35	35-45	45-55	55-65	65-75	75-85	85-95	95-99	>99
Mid-point (value recorded)	1	3	10	20	30	40	50	60	70	80	90	98	100

Table 2. Categories of ground cover recorded in the sampling plots

Category	Description
Bare Soil	Particles < 2 mm across
Gravel	Particles 2 mm - 75 mm across
Cobble	Rocks 75 mm - 250 mm across
Boulder	Rocks > 250 mm across
Bedrock	Consolidated rock
Litter	Loose organic matter < 6 mm across
Wood	Loose organic matter > 6 mm across
Lichen	Fruticose lichens on soil surface
Moss	--
Clubmoss	--
Cushion-plant	Recorded as ground cover; approximately equal to canopy cover
Dead Rooted Plant (DRP)	Rooted in soil. Loose dead plants are recorded as litter or wood.

Table 3. Substrate types on which sample plots were presumed to lie.
Names and descriptions of stratigraphic units are from Love and Christiansen (1985).

Stratigraphic Unit Name	Stratigraphic Unit Description	Substrate Type
Green River Formation, Laney Member	Oil shale and marlstone	Oil Shale
Green River Formation, Tipton Shale Member or Tongue	Oil shale and marlstone	Oil Shale
Green River Formation, Wilkins Peak Member	Green, brown, and gray tuffaceous sandstone, shale, and marlstone	Tuffaceous Sandstone
Wasatch Formation, New Fork Tongue ("Green River and Wasatch Formations, New Fork Tongue of Wasatch Formation" on U.S. Geological Survey 1995)	Dull-red and green mudstone, brown sandstone, and thin limestone beds	Sandstone
Wasatch Formation, Cathedral Bluffs Tongue	Variegated claystone and lenticular sandstone	Sandstone
Wasatch Formation, Main Body	Drab sandstone, drab to variegated claystone and siltstone; locally derived conglomerate…	Sandstone
Bishop Conglomerate	Clasts of red quartzite, gray chert, and limestone in a grey to white tuffaceous sandstone matrix	Tuffaceous Sandstone
Bridger Formation	Greenish-gray, olive drab, and white tuffaceous sandstone and claystone; lenticular marlstone and conglomerate	Tuffaceous Sandstone
(Quaternary) Landslide Deposits	Locally includes intermixed landslide and glacial deposits, talus, and rock-glacier deposits.	Landslide

Table 4. Locations and environmental features of sample plots.
UTM Coordinates are NAD17, Zone 12 North.

PlotName	Area	Plot Group	Description	T	R	Sec.	1/4 sec.	UTM Northing*	UTM Easting*	Elev (ft.)	Aspect (deg.)	Slope (deg)	Soil Texture	Stratigraphic Unit
01CM16.01	Cedar Mountain	1	On rim	13N	112N	10	NE	4553437	582219	8400	300	4	Silt Loam	Bishop
01CM58.01	Cedar Mountain	1	On rim	13N	112N	24	SE	4549431	584695	8300	170	1	Sandy Loam	Bishop
01CM71.01	Cedar Mountain	1	On rim	13N	112N	22	SE	4549285	582680	8500	200	2	Clay Loam	Bishop
01HM26.01	Hickey Mountain	1	On rim	13N	114N	13	SE	4550434	566583	8660	160	4	Sandy Clay Loam	Landslide deposits
01HM26.02	Hickey Mountain	1	Back from rim	13N	114N	13	NW	4550449	566535	8670	170	2	Sandy Clay Loam	Landslide deposits
01HM32.01	Hickey Mountain	1	On rim	13N	114N	24	SW	4548578	565592	8700	50	3	Sandy Clay Loam	Landslide deposits
01HM32.02	Hickey Mountain	1	Back from rim	12N	114N	24	SE	4548590	565561	8720	40	1	Sandy Clay Loam	Landslide deposits
01RR73.01	Ross Butte / Ridge	1	On rim	30N	110N	25	SE	4710631	590417	7400	270	2	Loam	Green River, Wilkins Pk.
01CM16.02	Cedar Mountain	2	Back from rim	13N	112N	10	NE	4553383	582184	8440	240	2	Silt Loam	Bishop
01CM58.02	Cedar Mountain	2	Back from rim	13N	112N	24	NW	4549448	584673	8300	170	0	Silt Loam	Bishop
01CM71.02	Cedar Mountain	2	Back from rim	13N	112N	22	NE	4549287	582689	8500	170	1	Sandy Clay Loam	Bishop
01JH01.02	Joe Hay / Bush Rims	2	Back from rim	24N	101N	7	NW	4659623	674428	7700	85	1	Sandy Clay Loam	Wasatch, Cathedral Bluffs
01JH02.02	Joe Hay / Bush Rims	2	Back from rim	25N	101N	31	SW	4662060	671836	7640	100	2	Sandy Clay Loam	Wasatch, Cathedral Bluffs
01RB05.02	Ross Butte / Ridge	2	Back from rim	30N	110N	24	NE	4713040	589990	7460	320	0	Silty Clay Loam	Wasatch, New Fork
01RB79.02	Ross Butte / Ridge	2	Back from rim	30N	110N	13	SW	4713560	589963	7460	40	3	Clay Loam	Wasatch, New Fork
01RR73.02	Ross Butte / Ridge	2	Back from rim	30N	110N	25	NW	4710601	590444	7400	276	1	Silty Clay	Green River, Wilkins Pk.
01DR05.01	Delaney Rim	7	On rim	19N	96N	34	SE	4606193	732396	7400	127	2	Silty Clay Loam	Wasatch, Cathedral Bluffs
01DR06.01	Delaney Rim	7	On rim	19N	96N	34	NE	4606332	732677	7380	140	4	Sandy Clay Loam	Wasatch, Cathedral Bluffs
01DR11.01	Delaney Rim	7	On rim	19N	95N	32	NE	4607364	739837	7380	180	2	Clay Loam	Wasatch, Cathedral Bluffs
01DR12.01	Delaney Rim	7	On rim	18N	95N	10	NW	4604978	741571	7250	120	2	Silty Clay Loam	Wasatch, Cathedral Bluffs
01DR15.01	Delaney Rim	7	On rim	18N	97N	20	SE	4599742	720862	7474	48	2	Silty Clay Loam	Wasatch, Cathedral Bluffs
01JH03.01	Joe Hay / Bush Rims	7	On rim	25N	101N	9	NE	4669437	675363	7760	260	1	Sandy Loam	Bridger
01PS48.01	Packsaddle Canyon	7	On rim	25N	103N	15	NE	4667029	658084	7540	230	2	Sandy Loam	Green River, Tipton
01PS48.02	Packsaddle Canyon	7	Back from rim	25N	103N	15	NE	4667065	658080	7520	250	4	Sandy Loam	Green River, Tipton
01RR21.01	Ross Butte / Ridge	7	Back from rim	30N	110N	35	NW	4709852	588278	7400	184	1	Silty Clay	Wasatch, New Fork
01RR21.02	Ross Butte / Ridge	7	On rim	30N	110N	36	NE	4709867	588302	7400	160	0	Silty Clay Loam	Wasatch, New Fork
01SM06.01	Steamboat Mtn. / Rim	7	On rim	24N	103N	35	SW	4652564	661370	8040	330	1	Sandy Loam	Green River, Tipton
01SM12.01	Steamboat Mtn. / Rim	7	On rim	24N	103N	22	SW	4655661	660218	7980	225	2	Sandy Loam	Wasatch, main body
01SM14.01	Steamboat Mtn. / Rim	7	On rim	23N	103N	7	NW	4649568	664612	8000	110	45	Loamy Sand	Green River, Tipton

Table 4 (continued).

PlotName	Area	Plot Group	Description	T	R	Sec.	1/4 sec.	UTM Northing*	UTM Easting*	Elev (ft.)	Aspect (deg.)	Slope (deg)	Soil Texture	Stratigraphic Unit
01DR05.02	Delaney Rim	8	Back from rim	19N	96N	34	SW	4606095	732448	7400	140	1	Clay Loam	Wasatch, Cathedral Bluffs
01DR06.02	Delaney Rim	8	Back from rim	19N	96N	34	SE	4606221	732668	7400	135	3	Clay Loam	Wasatch, Cathedral Bluffs
01DR11.02	Delaney Rim	8	Back from rim	19N	95N	32	NE	4607307	739808	7349	190	1	Sandy Clay Loam	Wasatch, Cathedral Bluffs
01DR12.02	Delaney Rim	8	Back from rim	18N	95N	10	NW	4604993	741545	7240	244	1	Silt Loam	Wasatch, Cathedral Bluffs
01DR15.02	Delaney Rim	8	Back from rim	18N	97N	20	SE	4599699	720889	7520	140	2	Clay Loam	Wasatch, Cathedral Bluffs
01KR01.02	Kinney Rim	8	Back from rim	15N	100N	16	SE	4570992	695568	8366	116	3	Sandy Clay Loam	Green River, Laney
01SM04.02	Steamboat Mtn. / Rim	8	Back from rim	23N	102N	6	NE	4650324	667470	8040	50	1	Silty Clay Loam	Green River, Laney
01JH01.01	Joe Hay / Bush Rims	21	On rim	24N	101N	7	NW	4659446	674524	7700	50	0	Clay Loam	Wasatch, Cathedral Bluffs
01JH02.01	Joe Hay / Bush Rims	21	On rim	25N	101N	31	SW	4662019	671623	7630	265	5	Clay Loam	Green River, Tipton
01KR01.01	Kinney Rim	21	On rim	15N	100N	16	SE	4570989	695539	8440	100	4	Sandy Loam	Green River, Laney
01SM04.01	Steamboat Mtn. / Rim	21	On rim	23N	102N	8	NE	4650324	667442	8040	200	1	Sandy Loam	Wasatch, main body
01PS37.01	Packsaddle Canyon	28	On rim	25N	103N	14	NW	4667338	658961	7560	102	3	Sandy Loam	Green River, Laney
01SM06.02	Steamboat Mtn. / Rim	28	Back from rim	24N	103N	35	SW	4652589	661386	8040	340	2	Sandy Loam	Green River, Tipton
01PS37.02	Packsaddle Canyon	28	Back from rim	25N	103N	14	NW	4667329	658933	7540	140	1	Sandy Loam	Green River, Laney
01SM12.02	Steamboat Mtn. / Rim	28	Back from rim	24N	103N	22	SW	4655674	660213	7980	54	1	Sandy Loam	Wasatch, main body
01SM14.02	Steamboat Mtn. / Rim	28	Back from rim	23N	103N	7	NW	4649587	664621	8000	142	1	Loamy Sand	Green River, Tipton
01RB05.01	Ross Butte / Ridge	28	On rim	30N	110N	24	NE	4713013	589985	7460	200	2	Silty Clay	Wasatch, New Fork
01RB79.01	Ross Butte / Ridge	28	On rim	30N	110N	13	SE	4713602	589982	7440	48	3	Sandy Clay Loam	Wasatch, New Fork
01RM02.02	Round Mountain	28	Back from rim	22N	115N	23	SW	4635473	546510	7380	86	1	Silty Clay Loam	Green River, Wilkins Pk.
01RM01.01	Round Mountain	28	On rim	22N	115N	23	SW	4635729	546371	7380	246	9	Silty Clay Loam	Green River, Wilkins Pk.
01RM01.02	Round Mountain	28	Back from rim	22N	115N	23	NW	4635742	546398	7380	340	2	Silty Clay Loam	Green River, Wilkins Pk.
01RM02.01	Round Mountain	28	On rim	22N	115N	23	NW	4635469	546483	7380	20	0	Silty Clay Loam	Green River, Wilkins Pk.
01RM04.01	Round Mountain	28	On rim	22N	115N	13	NE	4637280	549203	7500	160	5	Silty Clay Loam	Green River, Wilkins Pk.
01RM04.02	Round Mountain	28	Back from rim	22N	115N	13	SE	4637245	549249	7620	324	12	Silty Clay Loam	Wasatch, New Fork

Table 5. The 138 vascular plant species documented in the 53 sample plots, sorted by species name. Cushion-plants are shown in italic typeface. For each species, the number of plots of occurrence and the average canopy cover in those plots is shown for all sample plots, for plots along rims, and for plots back from rims.

		All Plots		Plots Along Rims		Plots Back From Rims	
Species		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
		53	--	27	--	26	--
achnatherum contractum, contracted indian ricegrass	acco22	7	1.29	3	1.67	4	1.00
achnatherum hymenoides, indian ricegrass	achy	25	1.48	12	1.67	13	1.31
allium textile, textile onion	alte	4	1.00	1	1.00	3	1.00
allium, wild onion	alliu	2	1.00	0		2	1.00
amelanchier utahensis, utah serviceberry	amut	2	1.00	1	1.00	1	1.00
antennaria microphylla, littleleaf pussytoes	anmi3	4	1.50	1	3.00	3	1.00
arabis holboellii, holboell's rockcress	arho2	1	1.00	0		1	1.00
arabis pendulina, rabbitear rockcress	arpe	1	1.00	0		1	1.00
arabis pendulocarpa, dropseed rockcress	arpe10	1	1.00	0		1	1.00
arabis, rockcress	arabi2	2	1.00	0		2	1.00
arenaria hookeri, hooker's sandwort	arho4	52	2.69	26	2.50	26	2.88
arenaria nuttallii, nuttall's sandwort	arnu5	26	3.96	13	4.46	13	3.46
artemisia frigida, fringed sagewort	arfr4	23	1.78	12	1.83	11	1.73
artemisia pedatifida, birdfoot sagebrush	arpe6	14	3.14	7	4.71	7	1.57
artemisia tridentata ssp. tridentata, basin big sagebrush	artrt	1	1.00	1	1.00	0	
artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	artrw	31	6.39	11	1.18	20	9.25
aster, aster	aster	1	1.00	0		1	1.00
astragalus agrestis, purple milkvetch	asag2	1	1.00	0		1	1.00
astragalus convallarius, timber milkvetch	asco12	1	1.00	0		1	1.00
astragalus diversifolius, meadow milkvetch	asdi5	1	1.00	0		1	1.00
astragalus drabelliformis, bastard draba milkvetch	asdr2	5	1.40	3	1.67	2	1.00
astragalus jejunus, starveling milkvetch	asje2	4	1.50	2	2.00	2	1.00
astragalus lentiginosus, specklepod milkvetch	asle8	1	1.00	0		1	1.00
astragalus purshii, woollypod milkvetch	aspu9	3	1.00	0		3	1.00
astragalus spatulatus, tufted milkvetch	assp6	32	2.22	18	2.72	14	1.57
astragalus, milkvetch	astra	1	1.00	1	1.00	0	
atriplex confertifolia, shadscale saltbush	atco	16	1.25	7	1.29	9	1.22
atriplex gardneri, gardner's saltbush	atga	9	1.22	4	1.00	5	1.40
atriplex sp., saltbush	atrip	1	1.00	1	1.00	0	
castilleja angustifolia, northwestern indian paintbrush	caan7	1	1.00	0		1	1.00
castilleja exilis, lesser indian paintbrush	caex6	1	1.00	0		1	1.00
castilleja flava, yellow indian paintbrush	cafl7	4	1.00	1	1.00	3	1.00
castilleja linariifolia, wyoming indian paintbrush	cali4	2	1.00	0		2	1.00
castilleja pilosa, parrothead indian paintbrush	capi3	2	1.00	0		2	1.00
castilleja, indian paintbrush	casti2	2	1.00	1	1.00	1	1.00
chaenactis douglasii, douglas' dustymaiden	chdo	3	1.00	0		3	1.00

Table 5 (continued).

		All Plots		Plots Along Rims		Plots Back From Rims	
Species		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
chrysothamnus sp., rabbitbrush	chrys9	10	1.20	5	1.00	5	1.40
chrysothamnus viscidiflorus ssp. lanceolatus, yellow rabbitbrush	chvil4	1	1.00	1	1.00	0	
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	19	1.21	9	1.00	10	1.40
chrysothamnus viscidiflorus, green rabbitbrush	chvi8	3	1.67	0		3	1.67
comandra umbellata, bastard toadflax	coum	1	1.00	0		1	1.00
cordylanthus ramosus, bushy bird's beak	cora5	1	1.00	0		1	1.00
crepis, hawksbeard	crepi	1	1.00	0		1	1.00
cryptantha caespitosa, tufted catseye	crca7	9	1.00	7	1.00	2	1.00
cryptantha cinerea, james's catseye	crci3	7	1.00	3	1.00	4	1.00
cryptantha, cryptantha	crypt	5	1.00	4	1.00	1	1.00
cymopterus nivalis, snowline springparsley	cyni3	4	1.50	2	2.00	2	1.00
cymopterus terebinthinus, spring parsley	cyte8	1	1.00	0		1	1.00
draba oligosperma, fewseed whitlowgrass	drol	7	1.29	3	1.00	4	1.50
elymus elymoides ssp. elymoides, squirreltail	elele	23	1.35	13	1.31	10	1.40
elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	ellal	19	5.21	7	1.57	12	7.33
elymus, wildrye	elymu	15	2.27	9	1.44	6	3.50
erigeron compositus, cutleaf daisy	erco4	4	1.00	2	1.00	2	1.00
erigeron nanus, dwarf fleabane	erna5	6	1.00	3	1.00	3	1.00
erigeron pumilus, shaggy fleabane	erpu2	4	1.00	1	1.00	3	1.00
eriogonum acaule, singlestem buckwheat	erac3	16	2.19	11	2.55	5	1.40
eriogonum brevicaule, shortstem buckwheat	erbr5	6	1.33	5	1.40	1	1.00
eriogonum caespitosum, matted buckwheat	erca8	2	1.00	1	1.00	1	1.00
eriogonum flavum, yellow eriogonum	erfl4	2	1.00	1	1.00	1	1.00
eriogonum microthecum var. laxiflorum, slender buckwheat	ermil2	10	1.60	3	1.67	7	1.57
eriogonum ovalifolium var. purpureum, cushion buckwheat	erovp2	8	1.25	2	1.00	6	1.33
eriogonum umbellatum, sulphur wildbuckwheat	erum	2	1.00	1	1.00	1	1.00
eriogonum, eriogonum	eriog	6	1.00	4	1.00	2	1.00
escobaria vivipara var. vivipara, spinystar cactus	esviv	3	1.00	2	1.00	1	1.00
fabaceae unknown cp01-1	fab101	1	1.00	0		1	1.00
fabaceae unknown cp01-3	fab103	1	1.00	0		1	1.00
fabaceae unknown cp01-2	fab102	1	3.00	1	3.00	0	
forb, unknown	forbunk	19	1.00	7	1.00	12	1.00
forb, unknown cp01-1	forb1001	2	1.00	1	1.00	1	1.00
forb, unknown cp01-10	forb1010	3	1.00	2	1.00	1	1.00
forb, unknown cp01-11	forb1011	3	1.00	0		3	1.00
forb, unknown cp01-12	forb1012	2	1.00	1	1.00	1	1.00
forb, unknown cp01-13	forb1013	3	1.67	1	3.00	2	1.00
forb, unknown cp01-2	forb1002	2	1.00	1	1.00	1	1.00
forb, unknown cp01-3	forb1003	2	1.00	2	1.00	0	
forb, unknown cp01-4	forb1004	2	1.00	1	1.00	1	1.00
forb, unknown cp01-5	forb1005	5	1.00	2	1.00	3	1.00
forb, unknown cp01-6	forb1006	3	1.67	2	2.00	1	1.00

Table 5 (continued).

Species		All Plots		Plots Along Rims		Plots Back From Rims	
		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
forb, unknown cp01-7	forb1007	2	1.00	2	1.00	0	
forb, unknown cp01-8	forb1008	2	2.00	2	2.00	0	
forb, unknown cp01-9	forb1009	3	1.67	1	1.00	2	2.00
grass, unknown	grassunk	4	1.00	1	1.00	3	1.00
hesperostipa comata, needle and thread	heco26	8	1.75	5	1.80	3	1.67
heterotheca villosa, hairy goldenaster	hevi4	1	1.00	0		1	1.00
hymenoxys richardsonii, pingue hymenoxys	hyri	1	1.00	0		1	1.00
ipomopsis aggregata, skyrocket gilia	ipag	1	1.00	1	1.00	0	
ipomopsis congesta, ballhead gilia	ipco5	7	1.00	3	1.00	4	1.00
kochia americana, greenmolly	koam	2	1.00	1	1.00	1	1.00
koeleria macrantha, prairie junegrass	koma	3	1.67	0		3	1.67
krascheninnikovia lanata, winterfat	krla2	34	1.24	16	1.25	18	1.22
lappula redowskii, western stickseed	lare	1	1.00	0		1	1.00
leptodactylon pungens, granite pricklygilia	lepu	1	1.00	0		1	1.00
lesquerella alpina, alpine bladderpod	leal	12	1.00	8	1.00	4	1.00
lesquerella condensata, dense bladderpod	leco2	1	1.00	1	1.00	0	
linum lewisii, prairie flax	lile3	8	1.00	4	1.00	4	1.00
machaeranthera grindelioides, rayless aster	magr2	30	1.20	18	1.22	12	1.17
malacothrix torreyi, torrey's desertdandelion	mato2	1	1.00	0		1	1.00
mertensia humilis, rocky mountain bluebells	mehu2	1	1.00	0		1	1.00
opuntia polyacantha, plains pricklypear	oppo	1	1.00	0		1	1.00
oxytropis nana, wyoming locoweed	oxna	2	1.00	2	1.00	0	
oxytropis sericea, silvery oxytrope	oxse	2	1.00	1	1.00	1	1.00
oxytropis sp., crazyweed	oxytr	6	1.00	4	1.00	2	1.00
packera cana, woolly groundsel	paca15	1	1.00	1	1.00	0	
packera multilobata, lobeleaf groundsel	pamu11	1	1.00	0		1	1.00
penstemon acaulis, stemless beardtongue	peac3	2	1.00	0		2	1.00
penstemon fremontii, fremont's beardtongue	pefr	3	1.00	0		3	1.00
penstemon humilis, low penstemon	pehu	1	1.00	0		1	1.00
penstemon laricifolius, larchleaf beardtongue	pela9	9	1.00	5	1.00	4	1.00
penstemon, penstemon	penst	10	1.00	5	1.00	5	1.00
phlox hoodii, hoods phlox	phho	11	2.73	3	1.67	8	3.13
phlox longifolia, longleaf phlox	phlo2	1	1.00	0		1	1.00
phlox multiflora, flowery phlox	phmu3	1	10.00	1	10.00	0	
phlox muscoides, musk phlox	phmu4	23	7.17	15	8.00	8	5.63
phlox opalensis, opal phlox	phop2	2	1.00	0		2	1.00
poa secunda, sandberg bluegrass	pose	47	2.91	22	1.55	25	4.12
potentilla ovina, sheep cinquefoil	poov2	3	1.00	1	1.00	2	1.00
potentilla plattensis, platte river cinquefoil	popl	1	1.00	1	1.00	0	
pseudoroegneria spicata, bluebunch wheatgrass	pssp6	19	3.79	11	1.36	8	7.13
sedum lanceolatum, spearleaf stonecrop	sela	1	1.00	0		1	1.00
shrub, unknown	shrubunk	2	1.00	1	1.00	1	1.00

Table 5 (continued).

Species		All Plots		Plots Along Rims		Plots Back From Rims	
		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
sphaeralcea coccinea, scarlet globemallow	spco	6	1.00	4	1.00	2	1.00
sphaeromeria argentea, silver chickensage	spar2	5	1.00	3	1.00	2	1.00
stanleya pinnata, desert princesplume	stpi	1	1.00	1	1.00	0	
stanleya viridiflora, green princesplume	stvi	9	1.00	8	1.00	1	1.00
stanleya, princesplume	stanl	2	1.00	1	1.00	1	1.00
stenotus acaulis, stemless mock goldenweed	stac	15	2.13	7	1.00	8	3.13
stenotus armerioides, thrift mock goldenweed	star10	3	1.00	1	1.00	2	1.00
stephanomeria runcinata, desert wirelettuce	stru3	1	1.00	0		1	1.00
symphoricarpos oreophilus, whortleleaf snowberry	syor2	3	1.00	0		3	1.00
tetradymia canescens, spineless horsebrush	teca2	6	1.00	2	1.00	4	1.00
tetradymia spinosa, shortspine horsebrush	tesp2	1	1.00	0		1	1.00
tetraneuris acaulis, stemless hymenoxys	teac	1	1.00	0		1	1.00
tetraneuris torreyana, torrey's hymenoxys	teto	25	2.16	13	2.77	12	1.50
townsendia nuttallii, nuttall's townsend daisy	tonu	1	1.00	0		1	1.00
townsendia spathulata, sword townsendia	tosp	12	1.17	9	1.22	3	1.00
trifolium andinum, andes clover	tran2	13	2.15	7	2.57	6	1.67
trifolium gymnocarpon, hollyleaf clover	trgy	3	1.00	0		3	1.00
trifolium, clover	trifo	3	1.67	2	2.00	1	1.00

Table 6. The 138 vascular plant species documented in the 53 sample plots, sorted by frequency of occurrence.
Cushion-plants are shown in italic typeface. For each species, the number of plots of occurrence and the average canopy cover in those plots is shown for all sample plots, for plots along rims, and for plots back from rims.

Species	NRCS Code	All Plots		Plots Along Rims		Plots Back From Rims	
		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
		53	--	27	--	26	--
arenaria hookeri, hooker's sandwort	arho4	52	2.69	26	2.50	26	2.88
poa secunda, sandberg bluegrass	pose	47	2.91	22	1.55	25	4.12
krascheninnikovia lanata, winterfat	krla2	34	1.24	16	1.25	18	1.22
astragalus spatulatus, tufted milkvetch	assp6	32	2.22	18	2.72	14	1.57
artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	artrw	31	6.39	11	1.18	20	9.25
machaeranthera grindelioides, rayless aster	magr2	30	1.20	18	1.22	12	1.17
arenaria nuttallii, nuttall's sandwort	arnu5	26	3.96	13	4.46	13	3.46
achnatherum hymenoides, indian ricegrass	achy	25	1.48	12	1.67	13	1.31
tetraneuris torreyana, torrey's hymenoxys	teto	25	2.16	13	2.77	12	1.50
artemisia frigida, fringed sagewort	arfr4	23	1.78	12	1.83	11	1.73
elymus elymoides ssp. elymoides, squirreltail	elele	23	1.35	13	1.31	10	1.40
phlox muscoides, musk phlox	phmu4	23	7.17	15	8.00	8	5.63
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	19	1.21	9	1.00	10	1.40
elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	ellal	19	5.21	7	1.57	12	7.33
forb, unknown	forbunk	19	1.00	7	1.00	12	1.00
pseudoroegneria spicata, bluebunch wheatgrass	pssp6	19	3.79	11	1.36	8	7.13
atriplex confertifolia, shadscale saltbush	atco	16	1.25	7	1.29	9	1.22
eriogonum acaule, singlestem buckwheat	erac3	16	2.19	11	2.55	5	1.40
elymus, wildrye	elymu	15	2.27	9	1.44	6	3.50
stenotus acaulis, stemless mock goldenweed	stac	15	2.13	7	1.00	8	3.13
artemisia pedatifida, birdfoot sagebrush	arpe6	14	3.14	7	4.71	7	1.57
trifolium andinum, andes clover	tran2	13	2.15	7	2.57	6	1.67
lesquerella alpina, alpine bladderpod	leal	12	1.00	8	1.00	4	1.00
townsendia spathulata, sword townsendia	tosp	12	1.17	9	1.22	3	1.00
phlox hoodii, hoods phlox	phho	11	2.73	3	1.67	8	3.13
chrysothamnus sp., rabbitbrush	chrys9	10	1.20	5	1.00	5	1.40
eriogonum microthecum var. laxiflorum, slender buckwheat	ermil2	10	1.60	3	1.67	7	1.57
penstemon, penstemon	penst	10	1.00	5	1.00	5	1.00
atriplex gardneri, gardner's saltbush	atga	9	1.22	4	1.00	5	1.40
cryptantha caespitosa, tufted catseye	crca7	9	1.00	7	1.00	2	1.00
penstemon laricifolius, larchleaf beardtongue	pela9	9	1.00	5	1.00	4	1.00
stanleya viridiflora, green princesplume	stvi	9	1.00	8	1.00	1	1.00
eriogonum ovalifolium var. purpureum, cushion buckwheat	erovp2	8	1.25	2	1.00	6	1.33
hesperostipa comata, needle and thread	heco26	8	1.75	5	1.80	3	1.67
linum lewisii, prairie flax	lile3	8	1.00	4	1.00	4	1.00
achnatherum contractum, contracted indian ricegrass	acco22	7	1.29	3	1.67	4	1.00
cryptantha cinerea, james' catseye	crci3	7	1.00	3	1.00	4	1.00

Table 6 (continued).

Species	NRCS Code	All Plots		Plots Along Rims		Plots Back From Rims	
		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
draba oligosperma, fewseed whitlowgrass	drol	7	1.29	3	1.00	4	1.50
ipomopsis congesta, ballhead gilia	ipco5	7	1.00	3	1.00	4	1.00
erigeron nanus, dwarf fleabane	erna5	6	1.00	3	1.00	3	1.00
eriogonum brevicaule, shortstem buckwheat	erbr5	6	1.33	5	1.40	1	1.00
eriogonum, eriogonum	eriog	6	1.00	4	1.00	2	1.00
oxytropis sp., crazyweed	oxytr	6	1.00	4	1.00	2	1.00
sphaeralcea coccinea, scarlet globemallow	spco	6	1.00	4	1.00	2	1.00
tetradymia canescens, spineless horsebrush	teca2	6	1.00	2	1.00	4	1.00
astragalus drabelliformis, bastard draba milkvetch	asdr2	5	1.40	3	1.67	2	1.00
cryptantha, cryptantha	crypt	5	1.00	4	1.00	1	1.00
forb, unknown cp01-5	forb1005	5	1.00	2	1.00	3	1.00
sphaeromeria argentea, silver chickensage	spar2	5	1.00	3	1.00	2	1.00
allium textile, textile onion	alte	4	1.00	1	1.00	3	1.00
antennaria microphylla, littleleaf pussytoes	anmi3	4	1.50	1	3.00	3	1.00
astragalus jejunus, starveling milkvetch	asje2	4	1.50	2	2.00	2	1.00
castilleja flava, yellow indian paintbrush	cafl7	4	1.00	1	1.00	3	1.00
cymopterus nivalis, snowline springparsley	cyni3	4	1.50	2	2.00	2	1.00
erigeron compositus, cutleaf daisy	erco4	4	1.00	2	1.00	2	1.00
erigeron pumilus, shaggy fleabane	erpu2	4	1.00	1	1.00	3	1.00
grass, unknown	grassunk	4	1.00	1	1.00	3	1.00
astragalus purshii, woollypod milkvetch	aspu9	3	1.00	0		3	1.00
chaenactis douglasii, douglas' dustymaiden	chdo	3	1.00	0		3	1.00
chrysothamnus viscidiflorus, green rabbitbrush	chvi8	3	1.67	0		3	1.67
escobaria vivipara var. vivipara, spinystar cactus	esviv	3	1.00	2	1.00	1	1.00
forb, unknown cp01-10	forb1010	3	1.00	2	1.00	1	1.00
forb, unknown cp01-11	forb1011	3	1.00	0		3	1.00
forb, unknown cp01-13	forb1013	3	1.67	1	3.00	2	1.00
forb, unknown cp01-6	forb1006	3	1.67	2	2.00	1	1.00
forb, unknown cp01-9	forb1009	3	1.67	1	1.00	2	2.00
koeleria macrantha, prairie junegrass	koma	3	1.67	0		3	1.67
penstemon fremontii, fremont's beardtongue	pefr	3	1.00	0		3	1.00
potentilla ovina, sheep cinquefoil	poov2	3	1.00	1	1.00	2	1.00
stenotus armerioides, thrift mock goldenweed	star10	3	1.00	1	1.00	2	1.00
symphoricarpos oreophilus, whortleleaf snowberry	syor2	3	1.00	0		3	1.00
trifolium gymnocarpon, hollyleaf clover	trgy	3	1.00	0		3	1.00
trifolium, clover	trifo	3	1.67	2	2.00	1	1.00
allium, wild onion	alliu	2	1.00	0		2	1.00
amelanchier utahensis, utah serviceberry	amut	2	1.00	1	1.00	1	1.00
arabis, rockcress	arabi2	2	1.00	0		2	1.00
castilleja linariifolia, wyoming indian paintbrush	cali4	2	1.00	0		2	1.00
castilleja pilosa, parrothead indian paintbrush	capi3	2	1.00	0		2	1.00
castilleja, indian paintbrush	casti2	2	1.00	1	1.00	1	1.00

Table 6 (continued).

Species	NRCS Code	All Plots		Plots Along Rims		Plots Back From Rims	
		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
eriogonum caespitosum, matted buckwheat	erca8	2	1.00	1	1.00	1	1.00
eriogonum flavum, yellow eriogonum	erfl4	2	1.00	1	1.00	1	1.00
eriogonum umbellatum, sulphur wildbuckwheat	erum	2	1.00	1	1.00	1	1.00
forb, unknown cp01-1	forb1001	2	1.00	1	1.00	1	1.00
forb, unknown cp01-12	forb1012	2	1.00	1	1.00	1	1.00
forb, unknown cp01-2	forb1002	2	1.00	1	1.00	1	1.00
forb, unknown cp01-3	forb1003	2	1.00	2	1.00	0	
forb, unknown cp01-4	forb1004	2	1.00	1	1.00	1	1.00
forb, unknown cp01-7	forb1007	2	1.00	2	1.00	0	
forb, unknown cp01-8	forb1008	2	2.00	2	2.00	0	
kochia americana, greenmolly	koam	2	1.00	1	1.00	1	1.00
oxytropis nana, wyoming locoweed	oxna	2	1.00	2	1.00	0	
oxytropis sericea, silvery oxytrope	oxse	2	1.00	1	1.00	1	1.00
penstemon acaulis, stemless beardtongue	peac3	2	1.00	0		2	1.00
phlox opalensis, opal phlox	phop2	2	1.00	0		2	1.00
shrub, unknown	shrubunk	2	1.00	1	1.00	1	1.00
stanleya, princesplume	stanl	2	1.00	1	1.00	1	1.00
arabis holboellii, holboell's rockcress	arho2	1	1.00	0		1	1.00
arabis pendulina, rabbitear rockcress	arpe	1	1.00	0		1	1.00
arabis pendulocarpa, dropseed rockcress	arpe10	1	1.00	0		1	1.00
artemisia tridentata ssp. tridentata, basin big sagebrush	artrt	1	1.00	1	1.00	0	
aster, aster	aster	1	1.00	0		1	1.00
astragalus agrestis, purple milkvetch	asag2	1	1.00	0		1	1.00
astragalus convallarius, timber milkvetch	asco12	1	1.00	0		1	1.00
astragalus diversifolius, meadow milkvetch	asdi5	1	1.00	0		1	1.00
astragalus lentiginosus, specklepod milkvetch	asle8	1	1.00	0		1	1.00
astragalus, milkvetch	astra	1	1.00	1	1.00	0	
atriplex sp., saltbush	atrip	1	1.00	1	1.00	0	
castilleja angustifolia, northwestern indian paintbrush	caan7	1	1.00	0		1	1.00
castilleja exilis, lesser indian paintbrush	caex6	1	1.00	0		1	1.00
chrysothamnus viscidiflorus ssp. lanceolatus, yellow rabbitbrush	chvil4	1	1.00	1	1.00	0	
comandra umbellata, bastard toadflax	coum	1	1.00	0		1	1.00
cordylanthus ramosus, bushy bird's beak	cora5	1	1.00	0		1	1.00
crepis, hawksbeard	crepi	1	1.00	0		1	1.00
cymopterus terebinthinus, spring parsley	cyte8	1	1.00	0		1	1.00
fabaceae unknown cp01-1	fab101	1	1.00	0		1	1.00
fabaceae unknown cp01-3	fab103	1	1.00	0		1	1.00
fabaeceae unknown cp01-2	fab102	1	3.00	1	3.00	0	
heterotheca villosa, hairy goldenaster	hevi4	1	1.00	0		1	1.00
hymenoxys richardsonii, pingue hymenoxys	hyri	1	1.00	0		1	1.00
ipomopsis aggregata, skyrocket gilia	ipag	1	1.00	1	1.00	0	
lappula redowskii, western stickseed	lare	1	1.00	0		1	1.00

Table 6 (continued).

Species	NRCS Code	All Plots		Plots Along Rims		Plots Back From Rims	
		No. of Plots	Ave. Cover	No. of Plots	Ave. Cover	No. of Plots	Ave. Cover
leptodactylon pungens, granite pricklygilia	lepu	1	1.00	0		1	1.00
lesquerella condensata, dense bladderpod	leco2	1	1.00	1	1.00	0	
malacothrix torreyi, torrey's desertdandelion	mato2	1	1.00	0		1	1.00
mertensia humilis, rocky mountain bluebells	mehu2	1	1.00	0		1	1.00
opuntia polyacantha, plains pricklypear	oppo	1	1.00	0		1	1.00
packera cana, woolly groundsel	paca15	1	1.00	1	1.00	0	
packera multilobata, lobeleaf groundsel	pamu11	1	1.00	0		1	1.00
penstemon humilis, low penstemon	pehu	1	1.00	0		1	1.00
phlox longifolia, longleaf phlox	phlo2	1	1.00	0		1	1.00
phlox multiflora, flowery phlox	phmu3	1	10.00	1	10.00	0	
potentilla plattensis, platte river cinquefoil	popl	1	1.00	1	1.00	0	
sedum lanceolatum, spearleaf stonecrop	sela	1	1.00	0		1	1.00
stanleya pinnata, desert princesplume	stpi	1	1.00	1	1.00	0	
stephanomeria runcinata, desert wirelettuce	stru3	1	1.00	0		1	1.00
tetradymia spinosa, shortspine horsebrush	tesp2	1	1.00	0		1	1.00
tetraneuris acaulis, stemless hymenoxys	teac	1	1.00	0		1	1.00
townsendia nuttallii, nuttall's townsend daisy	tonu	1	1.00	0		1	1.00

Table 7. Results of two-way analysis of variance for differences in relative cover per plot of each growth form in plots along rims vs. plots back from rims.

a. Analysis of Variance for Relative Cover, using Adjusted Sums of Squares for Tests:

H_0: Average per-plot relative cover of plant growth-forms does not differ between plots along rims and plots back from rims.

Source	Type of Factor	Levels	DF	Seq SS	Adj SS	Adj MS	F	P
Location	Fixed	2	1	0.00000	0.00000	0.00000	0.00	1.000
Growth-Form	Fixed	5	4	2.23223	2.19550	0.54888	27.51	0.000
Location x Growth-Form			4	1.08356	1.08356	0.27089	13.58	0.000
Error			255	5.08744	5.08744	0.01995		
Total			264	8.40324				

Conclusion: Average per-plot cover of plant growth forms differs between plots along rims and plots back from rims.

b. Bonferroni Simultaneous Tests for Differences Within Each Growth-Form

Growth-Form/ Location	N	Mean	StdDev	Difference of Means	SE of Difference	T-Value	P Value
Shrub							
Along Rims	27	0.06054	0.02718	0.15026	0.03881	3.8741	0.0061
Back From Rims	26	0.21090	0.02770				
Sub-shrub							
Along Rims	27	0.09397	0.02718	0.02331	0.03881	-0.6007	1.0000
Back From Rims	26	0.07066	0.02770				
Graminoid							
Along Rims	27	0.15248	0.02718	0.12789	0.03881	3.295	0.0505
Back From Rims	26	0.28037	0.02770				
Forb							
Along Rims	27	0.24262	0.02718	0.0574	0.03881	-1.480	1.0000
Back From Rims	26	0.18518	0.02770				
Cushion-plant							
Along Rims	27	0.45038	0.02718	0.01975	0.03881	-5.089	0.0000
Back From Rims	26	0.25289	0.02770				

Table 8. Results of two-sample t-tests for difference between plots along rims and plots back from rims in percentage of gravel and bare soil.

Gravel (particles 2 mm to 75 mm)

H_0: Average percent gravel in plots along rims equals average percent gravel in plots back from rims.

Location	N	Mean	StDev	SE Mean
Along rims	27	48.4	28.9	5.6
Back from rims	26	30.5	25.9	5.1

T-Test mu (1) = mu (2) (vs not =): T = 2.38 P = 0.021 DF = 50

Conclusion: Plots along rims have more gravel than plots back from rims.

Bare Soil (particles < 2 mm)

H_0: Average percent soil in plots along rims equals average percent soil in plots back from rims.

Location	N	Mean	StDev	SE Mean
Along rims	27	35.0	32.4	6.2
Back from rims	26	54.9	28.9	5.7

T-Test mu (1) = mu (2) (vs not =): T = -2.36 P = 0.022 DF = 50

Conclusion: Plots along rims have less bare soil than plots back from rims.

Table 9. Effect of removing rare species and of relativizing cover measurements on heterogeneity of the data set.

Statistic	Full data set, unrelativized cover class	Reduced data set, relativized cover class
Number of species	138	73
Average number of species / plot (alpha diversity)	17.2	15.5
Heterogeneity among plots (beta diversity)	7.01	3.71
Percent of empty cells in species-by-plot matrix	87.558%	78.754%
Coefficient of variation among plots in total number of species	34.42%	0

Table 10. Results of MRPP test A for difference between plot groups 1 and 28.

Comparison	Observed Delta	Expected Delta	T	p	A
Group 1 vs. Group 28*	0.0.438	0.50	-3.824	0.0048	0.125

* Group 1 contains 8 plots and group 28 contains 13 plots. See Figure 8.

Delta = weighted average distance between plots within a group

$= \sum_{\text{all groups}} (n_i / \Sigma n_i)$(ave. within group distance between plots)

T = (observed delta - expected delta) / (standard deviation of expected delta)

p = probability of delta this small or smaller

A = chance-corrected, within-group agreement = 1 - (observed delta / expected delta).

A = 1 when all items are identical within groups (i.e., with complete homogeneity within groups) and delta = 0; A = 0 when heterogeneity within groups equals expectation by chance; A < 0 when heterogeneity within groups than is greater than that expected by chance

Analysis was performed with PC-ORD Version 4.27. Weighting option: C(I) = n(I)/sum(n(I)); Distance measure = Sorensen; distance matrix rank transformed.

Conclusion: group 1 differs from group 28 based on relative cover

Table 11. Results of MRPP test B for difference between plot groups 8 and 21.

Comparison	Observed Delta	Expected Delta	T	p	A
Group 8 vs. Group 21*	0.224	0.50	-17.73	0.000000	0.553

*Group 8 contains 7 plots and group 21 contains 4 plots See Figure 8.

See Table 10 for explanations of terms.

Conclusion: group 8 differs from group 21 based on relative cover.

Table 12. Results of MRPP test C for difference between two groups with plot group 8.

Comparison	Observed Delta	Expected Delta	T	p	A
Two groups within group 8*	0.314	0.50	-2.612	0.0157	0.372

*First group contains 2 plots and the second contains 5 plots. See Figure 8.

See Table 10 for explanations of terms.

Conclusion: the two groups differ from each other based on relative canopy cover.

Table 13. Results of MRPP test D for difference between two groups within plot groups 28.

Comparison	Observed Delta	Expected Delta	T	p	A
Two groups within group 28*	0.471	0.50	-1.098	0.137	0.057

*First group contains 8 plots and the second contains 5 plots. See Figure 8.

See Table 10 for explanations of terms.

Conclusion: the two groups do not differ from each other based on relative canopy cover.

Table 14. Significant indicator species (p ≤ 0.05) for the 6 plot groups based on relative canopy cover. Composition of the groups is shown in Figure R3. Bold typeface indicates maximum values. Italic typeface indicates a cushion-plant.

		Abundance						Frequency						Indicator Value (max. = 100)						
	Groups (N)	1	2	7	8	21	28	1 (8)	2 (8)	7 (13)	8 (7)	21 (4)	28 (13)	1	2	7	8	21	28	Prob-ability
grp 1	*trifolium andinum, andes clover*	**81**	6	-	-	-	13	**75**	25	-	-	-	38	**61**	2	-	-	-	5	0.001
	tetraneuris torreyana, torrey's hymenoxys	**59**	11	14	-	-	16	**100**	50	46	-	-	54	**59**	6	6	-	-	9	0.001
	draba oligosperma, fewseed whitlowgrass	**81**	19	-	-	-	-	**63**	25	-	-	-	-	**51**	5	-	-	-	-	0.005
	artemisia frigida, fringed sagewort	**49**	9	11	11	-	20	**100**	38	31	29	-	31	**49**	3	4	3	-	6	0.002
	forb unknown cp01-5	**76**	-	-	24	-	-	**50**	-	-	14	-	-	**38**	-	-	3	-	-	0.003
	arenaria nuttallii, nuttall's sandwort	**35**	17	1	-	4	43	**100**	75	8	-	25	77	**35**	13	-	-	1	33	0.046
	machaeranthera grindelioides, rayless aster	**39**	14	18	-	12	17	**88**	63	62	-	50	62	**34**	9	11	-	6	10	0.025
	eriogonum microthecum var. laxiflorum, slender buckwheat	**54**	31	3	-	-	12	**50**	38	8	-	-	15	**27**	12	-	-	-	2	0.047
grp 2	artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	2	**74**	2	2	-	19	38	**100**	31	43	-	100	1	**74**	1	1	-	19	0.001
	chrysothamnus viscidiflorus, green rabbitbrush	-	**100**	-	-	-	-	-	**38**	-	-	-	-	-	**38**	-	-	-	-	0.016
	koeleria macrantha, prairie junegrass	-	**100**	-	-	-	-	-	**38**	-	-	-	-	-	**38**	-	-	-	-	0.016
grp 7	*phlox muscoides, musk phlox*	1	-	**79**	10	-	10	13	-	**100**	43	-	46	-	-	**79**	4	-	5	0.001
	eriogonum acaule, singlestem buckwheat	-	-	**53**	-	-	47	-	-	**77**	-	-	46	-	-	**41**	-	-	22	0.029
grp 8	elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	-	2	2	**68**	20	8	-	13	23	**100**	50	46	-	-	1	**68**	10	4	0.001
	phlox hoodii, hoods phlox	-	15	4	**57**	24	-	-	25	15	**86**	25	-	-	4	1	**49**	6	-	0.002
	pseudoroegneria spicata, bluebunch wheatgrass	11	1	9	**71**	8	-	75	13	46	**57**	50	-	8	-	4	**41**	4	-	0.028
	poa secunda, sandberg bluegrass	19	15	9	**38**	4	14	100	100	85	**100**	50	85	19	15	8	**38**	2	11	0.004
	allium textile, textile onion	-	-	11	**89**	-	-	-	-	8	**43**	-	-	-	-	1	**38**	-	-	0.009
grp 21	stanleya viridiflora, green princesplume	6	4	12	-	**78**	-	13	13	23	-	**100**	-	1	1	3	-	**78**	-	0.001
	eriogonum brevicaule, shortstem buckwheat	-	-	-	-	**84**	16	-	-	-	-	**75**	23	-	-	-	-	**63**	4	0.002
	krascheninnikovia lanata, winterfat	10	8	7	18	**43**	13	63	63	54	86	**100**	54	6	5	4	15	**43**	7	0.004
	townsendia spathulata, sword townsendia	-	-	39	-	**47**	14	-	-	46	-	**75**	23	-	-	18	-	**35**	3	0.021
	arenaria hookeri, hooker's sandwort	14	7	16	8	**33**	21	100	100	100	100	**100**	92	14	7	16	8	**33**	19	0.004
	sphaeralcea coccinea, scarlet globemallow	23	-	-	-	**63**	14	25	-	-	-	**50**	15	6	-	-	-	**32**	2	0.018
	cryptantha sp., cryptantha	34	-	8	-	**59**	-	25	-	8	-	**50**	-	8	-	1	-	**29**	-	0.04
	ipomopsis congesta, ballhead gilia	-	13	8	21	**59**	-	-	25	8	29	**50**	-	-	3	1	6	**29**	-	0.038
grp 28	achnatherum contractum, contracted indian ricegrass	-	-	-	-	-	**100**	-	-	-	-	-	**46**	-	-	-	-	-	**46**	0.005
	astragalus jejunus, starveling milkvetch	-	-	-	-	-	**100**	-	-	-	-	-	**31**	-	-	-	-	-	**31**	0.032
	cymopterus nivalis, snowline springparsley	-	-	-	-	-	**100**	-	-	-	-	-	**31**	-	-	-	-	-	**31**	0.034
	grass, unknown	-	-	-	-	-	**100**	-	-	-	-	-	**31**	-	-	-	-	-	**31**	0.037

Table 15. Plot table for plot group 7 from the classification based on relative canopy cover.
The table shows, for each species, the number of plots occupied, the average canopy cover (expressed as the canopy cover class) for the plots occupied, and the cover class in each plot. Cover of each growth-form in each plot also is shown. Indicator species are shown in bold typeface.

Species (with NRCS codes)		No. of Plots (n=13)	Ave. Cover	DR05.01	DR15.01	DR06.01	JH03.01	PS48.01	PS48.02	SM06.01	SM12.01	SM14.01	DR11.01	RR21.02	RR21.01	DR12.01
2. Shrub				*0*	*1*	*1*	*1*	*3*	*7*	*2*	*0*	*2*	*1*	*4*	*1*	*0*
artemisia tridentata ssp. tridentata, basin big sagebrush	artrt	1	1.0				1									
artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	artrw	4	1.5					1	3	1		1				
atriplex confertifolia, shadscale saltbush	atco	6	1.3					1	3	1			1	1	1	
atriplex sp., saltbush	atrip	1	1.0		1											
chrysothamnus sp., rabbitbrush	chrys9	3	1.7					1	1					3		
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	2	1.0			1						1				
3. Subshrub				*12*	*3*	*4*	*3*	*1*	*2*	*3*	*0*	*1*	*4*	*1*	*0*	*2*
artemisia frigida, fringed sagewort	arfr4	4	1.5					1	1	3						1
artemisia pedatifida, birdfoot sagebrush	arpe6	5	4.0	10	3	3	1						3			
atriplex gardneri, gardner's saltbush	atga	2	1.0	1												1
eriogonum microthecum var. laxiflorum, slender buckwheat	ermil2	1	1.0				1									
krascheninnikovia lanata, winterfat	krla2	7	1.0	1		1	1		1			1	1	1		
5. Graminoid				*7*	*4*	*10*	*7*	*6*	*4*	*4*	*2*	*4*	*6*	*6*	*2*	*5*
achnatherum hymenoides, indian ricegrass	achy	7	1.9	3	3	3	1	1	1				1			
elymus elymoides ssp. elymoides, squirreltail	elele	7	1.6	1			1	1	1	3	1	3				
elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	ellal	3	1.0		1	1		1								
elymus, wildrye	elymu	6	2.0	1		3							1	3	1	3
hesperostipa comata, needle and thread	heco26	1	3.0				3									
poa secunda, sandberg bluegrass	pose	11	1.4	1			1	3	1	1	1	1	1	3	1	1
pseudoroegneria spicata, bluebunch wheatgrass	pssp6	6	1.7	1		3	1		1				3			1
6. Forb				*5*	*3*	*3*	*2*	*3*	*2*	*3*	*5*	*3*	*0*	*0*	*2*	*4*
allium textile, textile onion	alte	1	1.0	1												
arenaria nuttallii, nuttall's sandwort	arnu5	1	1.0						1							
cryptantha, cryptantha	crypt	1	1.0						1							
eriogonum, eriogonum	eriog	1	1.0			1										
forb, unknown cp01-6	forb1006	1	1.0					1								
forb, unknown cp01-8	forb1008	1	1.0								1					

Table 15 (continued).

Species (with NRCS codes)		No. of Plots (n=13)	Ave. Cover	DR05.01	DR15.01	DR06.01	JH03.01	PS48.01	PS48.02	SM06.01	SM12.01	SM14.01	DR11.01	RR21.02	RR21.01	DR12.01
forb, unknown cp01-9	forb1009	1	1.0												1	
forb, unknown cp01-10	forb1010	1	1.0		1											
forb, unknown	forbunk	1	1.0							1						
ipomopsis congesta, ballhead gilia	ipco5	1	1.0		1											
kochia americana, greenmolly	koam	1	1.0							1						
linum lewisii, prairie flax	lile3	2	1.0					1			1					
machaeranthera grindelioides, rayless aster	magr2	8	1.0	1	1			1		1	1	1			1	1
oxytropis nana, wyoming locoweed	oxna	1	1.0				1									
oxytropis sp., crazyweed	oxytr	1	1.0								1					
penstemon, penstemon	penst	2	1.0	1		1										
phlox hoodii, hoods phlox	phho	2	1.0	1			1									
sphaeromeria argentea, silver chickensage	spar2	1	1.0									1				
stanleya pinnata, desert princesplume	stpi	1	1.0			1										
stanleya viridiflora, green princesplume	stvi	3	1.0	1							1	1				
trifolium, clover	trifo	1	3.0													3
7. Cushion-plant				*28*	*17*	*19*	*29*	*21*	*20*	*27*	*24*	*21*	*19*	*12*	*7*	*14*
arenaria hookeri, hooker's sandwort	arho4	13	2.2	1	1	1	3	3	3	3	3	3	3	1	1	3
astragalus drabelliformis, bastard draba milkvetch	asdr2	1	1.0												1	
astragalus spatulatus, tufted milkvetch	assp6	9	3.6	3	3	3	3	3	1	10	3	3				
cryptantha caespitosa, tufted catseye	crca7	5	1.0	1	1			1					1			1
eriogonum acaule, singlestem buckwheat	erac3	10	1.8	1	1	1				3	3	1	3	1	1	3
erigeron compositus, cutleaf daisy	erco4	1	1.0									1				
eriogonum flavum, yellow eriogonum	erfl4	1	1.0			1										
eriogonum ovalifolium var. purpureum, cushion buckwheat	erovp2	1	1.0						1							
erigeron pumilus, shaggy fleabane	erpu2	1	1.0									1				
lesquerella alpina, alpine bladderpod	leal	5	1.0	1		1							1		1	1
penstemon laricifolius, larchleaf beardtongue	pela9	4	1.0		1	1	1				1					
phlox muscoides, musk phlox	phmu4	13	10.5	20	10	10	20	10	10	10	10	10	10	10	3	3
stenotus acaulis, stemless mock goldenweed	stac	4	1.5	1		1	1		3							
tetraneuris torreyana, torrey's hymenoxys	teto	6	1.7					3	1		1	1	1			3
townsendia spathulata, sword townsendia	tosp	6	1.3				1	1	1	1	3	1				

Table 16. Plot table for plot group 1 from the classification based on relative canopy cover.
The table shows, for each species, the number of plots occupied, the average canopy cover (expressed as the canopy cover class) for the plots occupied, and the cover class in each plot. Cover of each growth-form in each plot also is shown. Indicator species are shown in bold typeface.

Species (with NRCS codes)		No. of Plots (n=8)	Ave. Cover	CM16.01	CM58.01	RR73.01	CM71.01	HM26.02	HM32.02	HM32.01	HM26.01
2. Shrub				*0*	*1*	*7*	*2*	*1*	*1*	*1*	*2*
amelanchier utahensis, utah serviceberry	amut	1	1.0		1						
artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	artrw	3	1.0			1	1	1			
atriplex confertifolia, shadscale saltbush	atco	1	3.0			3					
chrysothamnus sp., rabbitbrush	chrys9	3	1.0						1	1	1
chrysothamnus viscidiflorus ssp. lanceolatus, yellow rabbitbrush	chvil4	1	1.0			1					
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	3	1.0			1	1				1
shrub, unknown	shrubunk	1	1.0			1					
3. Subshrub				***2***	***4***	***4***	***1***	***5***	***3***	***3***	***4***
artemisia frigida, fringed sagewort	arfr4	8	1.8	1	3	3	1	3	1	1	1
eriogonum microthecum var. laxiflorum, slender buckwheat	ermil2	4	1.5					1	1	1	3
krascheninnikovia lanata, winterfat	krla2	5	1.0	1	1	1			1	1	
opuntia polyacantha, plains pricklypear	oppo	1	1.0					1			
5. Graminoid				***5***	***6***	***4***	***6***	***5***	***6***	***3***	***7***
achnatherum hymenoides, indian ricegrass	achy	3	1.7	1	3						1
elymus elymoides ssp. elymoides, squirreltail	elele	1	1.0								1
elymus, wildrye	elymu	2	1.0			1	1				
hesperostipa comata, needle and thread	heco26	4	1.5				1	1		1	3
poa secunda, sandberg bluegrass	pose	8	2.5	3	3	3	3	3	3	1	1
pseudoroegneria spicata, bluebunch wheatgrass	pssp6	6	1.3	1			1	1	3	1	1
6. Forb				***8***	***8***	***6***	***18***	***12***	***13***	***13***	***12***
allium, wild onion	alliu	1	1.0					1			
antennaria microphylla, littleleaf pussytoes	anmi3	2	2.0						1	3	
arenaria nuttallii, nuttall's sandwort	arnu5	8	3.6	1	3	3	10	3	3	3	3
astragalus diversifolius, meadow milkvetch	asdi5	1	1.0					1			
castilleja flava, yellow indian paintbrush	cafl7	1	1.0				1				
cryptantha cinerea, james' catseye	crci3	4	1.0				1	1	1	1	

Table 16 (continued).

Species (with NRCS codes)		No. of Plots (n=8)	Ave. Cover	CM16.01	CM58.01	RR73.01	CM71.01	HM26.02	HM32.02	HM32.01	HM26.01
cryptantha, cryptantha	crypt	2	1.0		1	1					
eriogonum, eriogonum	eriog	1	1.0	1							
escobaria vivipara var. vivipara, spinystar cactus	esviv	2	1.0				1				1
forb, unknown	forbunk	4	1.0	1			1	1	1		
forb, unknown cp01-1	forb1001	2	1.0					1			1
forb, unknown cp01-12	forb1012	1	1.0				1				
forb, unknown cp01-13	forb1013	2	2.0						1	3	
forb, unknown cp01-4	forb1004	1	1.0	1							
forb, unknown cp01-5	forb1005	4	1.0					1	1	1	1
forb, unknown cp01-7	forb1007	2	1.0							1	1
linum lewisii, prairie flax	lile3	1	1.0	1							
machaeranthera grindelioides, rayless aster	magr2	7	1.9	1	3	1	3	1	3		1
oxytropis sp., crazyweed	oxytr	2	1.0			1					1
packera cana, woolly groundsel	paca15	1	1.0	1							
penstemon, penstemon	penst	4	1.0	1				1	1		1
potentilla ovina, sheep cinquefoil	poov2	2	1.0						1	1	
sphaeralcea coccinea, scarlet globemallow	spco	2	1.0					1			1
stanleya viridiflora, green princesplume	stvi	1	1.0								1
trifolium, clover	trifo	1	1.0		1						
7. Cushion-plant				***12***	***11***	***8***	***16***	***10***	***13***	***7***	***18***
arenaria hookeri, hooker's sandwort	arho4	8	2.3	3	3	3	1	3	3	1	1
astragalus drabelliformis, bastard draba milkvetch	asdr2	1	3.0			3					
astragalus spatulatus, tufted milkvetch	assp6	6	1.7		3		1	1	1	1	3
draba oligosperma, fewseed whitlowgrass	drol	5	1.4				1	1	3	1	1
erigeron compositus, cutleaf daisy	erco4	1	1.0	1							
erigeron nanus, dwarf fleabane	erna5	3	1.0	1	1		1				
lesquerella alpina, alpine bladderpod	leal	1	1.0							1	
phlox muscoides, musk phlox	phmu4	1	1.0	1							
stenotus acaulis, stemless mock goldenweed	stac	2	1.0			1	1				
tetraneuris torreyana, torrey's hymenoxys	teto	8	3.4	3	3	1	10	1	3	3	3
townsendia nuttallii, nuttall's townsend daisy	tonu	1	1.0					1			
trifolium andinum, andes clover	tran2	6	3.5	3	1		1	3	3		10

Table 17. Plot table for plot group 21 from the classification based on relative canopy cover.
The table shows, for each species, the number of plots occupied, the average canopy cover (expressed as the canopy cover class) for the plots occupied, and the cover class in each plot. Cover of each growth-form in each plot also is shown. Indicator species are shown in bold typeface.

Species (with NRCS codes)		No. of Plots (n=4)	Ave. Cover	JH01.01	JH02.01	KR01.01	SM04.01
2. Shrub				*0*	*0*	*1*	*0*
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	1	1.0			1	
3. Subshrub				*5*	*12*	*3*	*3*
artemisia pedatifida, birdfoot sagebrush	arpe6	2	6.5	3	10		
atriplex gardneri, gardner's saltbush	atga	2	1.0	1	1		
krascheninnikovia lanata, winterfat	krla2	4	2.0	1	1	3	3
5. Graminoid				*4*	*4*	*3*	*5*
achnatherum hymenoides, indian ricegrass	achy	3	1.0	1	1	1	
elymus elymoides ssp. elymoides, squirreltail	elele	3	1.0		1	1	1
elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	ellal	2	3.0	3			3
poa secunda, sandberg bluegrass	pose	2	1.0		1		1
pseudoroegneria spicata, bluebunch wheatgrass	pssp6	2	1.0		1	1	
6. Forb				*7*	*15*	*6*	*20*
arenaria nuttallii, nuttall's sandwort	arnu5	1	1.0			1	
castilleja, indian paintbrush	casti2	1	1.0		1		
cryptantha cinerea, james' catseye	crci3	1	1.0				1
cryptantha, cryptantha	crypt	2	1.0	1	1		
eriogonum brevicaule, shortstem buckwheat	erbr5	3	1.7	3	1	1	
eriogonum umbellatum, sulphur wildbuckwheat	erum	1	1.0				1
fabaeceae unknown cp01-2	fab102	1	3.0		3		
forb, unknown cp01-2	forb1002	1	1.0		1		
forb, unknown cp01-8	forb1008	1	3.0				3
forb, unknown cp01-10	forb1010	1	1.0			1	
forb, unknown	forbunk	2	1.0		1		1
ipomopsis congesta, ballhead gilia	ipco5	2	1.0	1		1	
linum lewisii, prairie flax	lile3	1	1.0				1
machaeranthera grindelioides, rayless aster	magr2	2	1.0	1	1		
oxytropis sericea, silvery oxytrope	oxse	1	1.0			1	
oxytropis sp., crazyweed	oxytr	1	1.0				1
phlox hoodii, hoods phlox	phho	1	3.0		3		
phlox multiflora, flowery phlox	phmu3	1	10.0				10
sphaeromeria argentea, silver chickensage	spar2	1	1.0		1		
sphaeralcea coccinea, scarlet globemallow	spco	2	1.0		1		1
stanleya viridiflora, green princesplume	stvi	4	1.0	1	1	1	1
7. Cushion-plant				*15*	*8*	*5*	*7*
arenaria hookeri, hooker's sandwort	arho4	4	4.8	10	3	3	3
astragalus spatulatus, tufted milkvetch	assp6	4	1.5	3	1	1	1
cryptantha caespitosa, tufted catseye	crca7	2	1.0		1	1	
eriogonum caespitosum, matted buckwheat	erca8	1	1.0		1		
lesquerella alpina, alpine bladderpod	leal	2	1.0	1			1
penstemon laricifolius, larchleaf beardtongue	pela9	1	1.0				1
stenotus armerioides, thrift mock goldenweed	star10	1	1.0		1		
townsendia spathulata, sword townsendia	tosp	3	1.0	1	1		1

Table 18. Plot table for plot group 28 from the classification based on relative canopy cover.
The table shows, for each species, the number of plots occupied, the average canopy cover (expressed as the canopy cover class) for the plots occupied, and the cover class in each plot. Cover of each growth-form in each plot also is shown. For ease of discussion, the plots are divided into sub-groups 280, 281, and 282. Indicator species are shown in bold typeface.

Species (with NRCS codes)		No. of Plots (n=13)	Ave. Cover	280					281			282				
				PS37.01	SM06.02	PS37.02	SM12.02	SM14.02	RB05.01	RB79.01	RM02.02	RM01.01	RM01.02	RM04.01	RM04.02	RM02.01
2. Shrub				*2*	*3*	*4*	*12*	*13*	*4*	*5*	*7*	*2*	*12*	*2*	*1*	*2*
artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	artrw	13	3.5	1	1	3	10	10	1	3	3	1	10	1	1	1
atriplex confertifolia, shadscale saltbush	atco	4	1.0	1	1	1			1							
chrysothamnus sp., rabbitbrush	chrys9	2	1.0						1			1				
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	8	1.5		1		1	3	1	1	3		1			1
symphoricarpos oreophilus, whortleleaf snowberry	syor2	1	1.0								1					
tetradymia canescens, spineless horsebrush	teca2	4	1.0				1			1			1	1		
3. Subshrub				*1*	*3*	*3*	*0*	*1*	*1*	*4*	*2*	*0*	*1*	*4*	*3*	*0*
artemisia frigida, fringed sagewort	arfr4	5	2.6	1	3					3				3	3	
artemisia pedatifida, birdfoot sagebrush	arpe6	1	1.0			1										
eriogonum microthecum var. laxiflorum, slender buckwheat	ermil2	2	1.0			1					1					
krascheninnikovia lanata, winterfat	krla2	7	1.0			1		1	1	1	1		1	1		
5. Graminoid				*4*	*4*	*6*	*4*	*14*	*3*	*2*	*6*	*2*	*6*	*6*	*5*	*4*
achnatherum contractum, contracted indian ricegrass	acco22	6	1.3								1	1	1	3	1	1
achnatherum hymenoides, indian ricegrass	achy	2	1.0			1		1								
elymus elymoides ssp. elymoides, squirreltail	elele	9	1.4	1	3	1	1	1					1	1	3	1
elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	ellal	6	1.7			1		1			3	1	3			1
elymus, wildrye	elymu	2	1.0						1	1						
grass, unknown	grassunk	4	1.0					1			1		1	1		
hesperostipa comata, needle and thread	heco26	1	1.0						1							
poa secunda, sandberg bluegrass	pose	11	2.4	3	1	3	3	10	1	1	1			1	1	1
6. Forb				*5*	*3*	*2*	*6*	*14*	*5*	*5*	*5*	*14*	*11*	*25*	*18*	*2*
allium, wild onion	alliu	1	1.0					1								
arenaria nuttallii, nuttall's sandwort	arnu5	10	5.6	1		1			1	1	1	10	10	20	10	1
astragalus convallarius, timber milkvetch	asco12	1	1.0					1								
astragalus lentiginosus, specklepod milkvetch	asle8	1	1.0								1					
astragalus, milkvetch	astra	1	1.0						1							

Table 18 (continued).

Species (with NRCS codes)		No. of Plots (n=13)	Ave. Cover	280					281			282				
				PS37.01	SM06.02	PS37.02	SM12.02	SM14.02	RB05.01	RB79.01	RM02.02	RM01.01	RM01.02	RM04.01	RM04.02	RM02.01
castilleja angustifolia, northwestern indian paintbrush	caan7	1	1.0					1								
castilleja flava, yellow indian paintbrush	cafl7	1	1.0			1										
chaenactis douglasii, douglas' dustymaiden	chdo	1	1.0					1								
comandra umbellata, bastard toadflax	coum	1	1.0					1								
cryptantha cinerea, james' catseye	crci3	1	1.0					1								
cymopterus terebinthinus, spring parsley	cyte8	1	1.0					1								
eriogonum brevicaule, shortstem buckwheat	erbr5	3	1.0							1				1	1	
eriogonum, eriogonum	eriog	3	1.0							1		1			1	
fabaceae unknown cp01-1	fab101	1	1.0												1	
forb, unknown cp01-3	forb1003	2	1.0									1				1
forb, unknown cp01-6	forb1006	2	2.0	3				1								
forb, unknown cp01-9	forb1009	2	2.0				3	1								
forb, unknown cp01-11	forb1011	2	1.0				1	1								
forb, unknown	forbunk	3	1.0						1		1	1				
ipomopsis aggregata, skyrocket gilia	ipag	1	1.0						1							
kochia americana, greenmolly	koam	1	1.0		1											
leptodactylon pungens, granite pricklygilia	lepu	1	1.0					1								
linum lewisii, prairie flax	lile3	2	1.0				1	1								
machaeranthera grindelioides, rayless aster	magr2	8	1.0		1		1	1	1	1			1	1	1	
oxytropis nana, wyoming locoweed	oxna	1	1.0											1		
oxytropis sp., crazyweed	oxytr	1	1.0												1	
penstemon, penstemon	penst	1	1.0									1				
phlox longifolia, longleaf phlox	phlo2	1	1.0								1					
potentilla plattensis, platte river cinquefoil	popl	1	1.0							1						
sphaeromeria argentea, silver chickensage	spar2	3	1.0	1	1			1								
sphaeralcea coccinea, scarlet globemallow	spco	2	1.0											1	1	
stanleya, princesplume	stanl	2	1.0											1	1	
stephanomeria runcinata, desert wirelettuce	stru3	1	1.0												1	
trifolium gymnocarpon, hollyleaf clover	trgy	1	1.0								1					

Table 18 (continued).

Species (with NRCS codes)		No. of Plots (n=13)	Ave. Cover	280					281			282				
				PS37.01	SM06.02	PS37.02	SM12.02	SM14.02	RB05.01	RB79.01	RM02.02	RM01.01	RM01.02	RM04.01	RM04.02	RM02.01
7. Cushion-plant				*6*	*19*	*10*	*31*	*13*	*4*	*7*	*5*	*7*	*20*	*6*	*6*	*19*
arenaria hookeri, hooker's sandwort	arho4	12	4.1	1	10	3	10	3	1		1	1	10	3	3	3
astragalus drabelliformis, bastard draba milkvetch	asdr2	1	1.0							1						
astragalus jejunus, starveling milkvetch	asje2	4	1.5								1	1	1			3
astragalus spatulatus, tufted milkvetch	assp6	7	2.4	3	3	3	3	3					1	1		
cymopterus nivalis, snowline springparsley	cyni3	4	1.5								1	3	1			1
eriogonum acaule, singlestem buckwheat	erac3	6	2.8		1		3	1				1	1			10
erigeron compositus, cutleaf daisy	erco4	1	1.0					1								
eriogonum ovalifolium var. purpureum, cushion buckwheat	erovp2	5	1.0						1	1	1		1		1	
erigeron pumilus, shaggy fleabane	erpu2	2	1.0			1		1								
lesquerella condensata, dense bladderpod	leco2	1	1.0						1							
penstemon acaulis, stemless beardtongue	peac3	1	1.0										1			
penstemon laricifolius, larchleaf beardtongue	pela9	1	1.0				1									
phlox muscoides, musk phlox	phmu4	6	3.2	1	3		10	3	1	1						
stenotus acaulis, stemless mock goldenweed	stac	4	2.0			3							3	1		1
tetraneuris torreyana, torrey's hymenoxys	teto	7	1.6	1	1		3	1		3	1				1	
townsendia spathulata, sword townsendia	tosp	3	1.0		1		1			1						
trifolium andinum, andes clover	tran2	5	1.0									1	1	1	1	1

Table 19. Plot table for plot group 8 from the classification based on relative canopy cover.
The table shows, for each species, the number of plots occupied, the average canopy cover (expressed as the canopy cover class) for the plots occupied, and the cover class in each plot. Cover of each growth-form in each plot also is shown. Indicator species are shown in bold typeface.

Species (with NRCS codes)		No. of Plots (n=7)	Ave. Cover	DR05.02	DR06.02	DR11.02	DR12.02	KR01.02	DR15.02	SM04.02
2. Shrub				*7*	*3*	*3*	*7*	*6*	*7*	*4*
artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	artrw	3	1.0			1	1		1	
atriplex confertifolia, shadscale saltbush	atco	3	1.0			1	1		1	
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	2	1.0					1		1
3. Subshrub				*7*	*3*	*1*	*5*	*5*	*5*	*3*
artemisia frigida, fringed sagewort	arfr4	2	2.0				3	1		
artemisia pedatifida, birdfoot sagebrush	arpe6	5	1.8	3	1	1	1		3	
atriplex gardneri, gardner's saltbush	atga	4	1.5	3	1			1	1	
krascheninnikovia lanata, winterfat	krla2	6	1.7	1	1		1	3	1	3
5. Graminoid				*61*	*25*	*15*	*28*	*31*	*15*	*15*
achnatherum hymenoides, indian ricegrass	achy	5	1.0	1	1		1		1	1
elymus elymoides ssp. elymoides, squirreltail	elele	1	1.0		1					
elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	ellal	7	11.3	50	20	1	1	1	3	3
elymus, wildrye	elymu	1	1.0						1	
hesperostipa comata, needle and thread	heco26	2	2.0			1	3			
poa secunda, sandberg bluegrass	pose	7	7.0	10	3	3	3	10	10	10
pseudoroegneria spicata, bluebunch wheatgrass	pssp6	4	12.8			10	20	20		1
6. Forb				*12*	*6*	*2*	*4*	*5*	*10*	*5*
allium textile, textile onion	alte	3	1.0		1		1		1	
aster, aster	aster	1	1.0						1	
astragalus agrestis, purple milkvetch	asag2	1	1.0					1		
castilleja exilis, lesser indian paintbrush	caex6	1	1.0							1
eriogonum umbellatum, sulphur wildbuckwheat	erum	1	1.0							1
forb, unknown	forbunk	5	1.0	1	1		1	1	1	
forb, unknown cp01-10	forb1010	1	1.0						1	
forb, unknown cp01-11	forb1011	1	1.0							1
forb, unknown cp01-5	forb1005	1	1.0							1
heterotheca villosa, hairy goldenaster	hevi4	1	1.0				1			
hymenoxys richardsonii, pingue hymenoxys	hyri	1	1.0						1	

Table 19 (continued).

Species (with NRCS codes)		No. of Plots (n=7)	Ave. Cover	DR05.02	DR06.02	DR11.02	DR12.02	KR01.02	DR15.02	SM04.02
ipomopsis congesta, ballhead gilia	ipco5	2	1.0					1	1	
lappula redowskii, western stickseed	lare	1	1.0		1					
oxytropis sericea, silvery oxytrope	oxse	1	1.0					1		
penstemon fremontii, fremont's beardtongue	pefr	1	1.0							1
penstemon, penstemon	penst	3	1.0	1		1			1	
phlox hoodii, hoods phlox	phho	6	3.2	10	3	1	1	1	3	
7. Cushion-plant				*2*	*1*	*9*	*8*	*2*	*5*	*9*
arenaria hookeri, hooker's sandwort	arho4	7	1.6	1	1	3	1	1	1	3
astragalus purshii, woollypod milkvetch	aspu9	1	1.0				1			
astragalus spatulatus, tufted milkvetch	assp6	3	1.0					1	1	1
cryptantha caespitosa, tufted catseye	crca7	2	1.0			1			1	
eriogonum flavum, yellow eriogonum	erfl4	1	1.0				1			
lesquerella alpina, alpine bladderpod	leal	3	1.0	1		1	1			
penstemon laricifolius, larchleaf beardtongue	pela9	2	1.0						1	1
phlox muscoides, musk phlox	phmu4	3	3.0			3	3			3
stenotus acaulis, stemless mock goldenweed	stac	1	1.0						1	
stenotus armerioides, thrift mock goldenweed	star10	2	1.0			1	1			
tetraneuris acaulis, stemless hymenoxys	teac	1	1.0							1

Table 20. Plot table for plot group 2 from the classification based on relative canopy cover.
The table shows, for each species, the number of plots occupied, the average canopy cover (expressed as the canopy cover class) for the plots occupied, and the cover class in each plot. Cover of each growth-form in each plot also is shown. Indicator species are shown in bold typeface.

Species (with NRCS codes)		No. of Plots (n=8)	Ave. Cover	CM16.02	CM58.02	CM71.02	RB05.02	RB79.02	RR73.02	JH01.02	JH02.02
2. Shrub				*14*	*20*	*21*	*23*	*21*	*13*	*24*	*23*
amelanchier utahensis, utah serviceberry	amut	1	1.0	1							
artemisia tridentata ssp. wyomingensis, wyoming big sagebrush	artrw	8	17.5	10	20	20	20	20	10	20	20
atriplex confertifolia, shadscale saltbush	atco	2	1.0				1		1		
chrysothamnus sp., rabbitbrush	chrys9	2	1.0			1	1				
chrysothamnus viscidiflorus ssp. visicidiflorus, yellow rabbitbrush	chviv2	3	1.0				1	1	1		
chrysothamnus viscidiflorus, green rabbitbrush	chvi8	3	1.7	3						1	1
shrub, unknown	shrubunk	1	1.0						1		
symphoricarpos oreophilus, whortleleaf snowberry	syor2	2	1.0							1	1
tetradymia canescens, spineless horsebrush	teca2	2	1.0							1	1
tetradymia spinosa, shortspine horsebrush	tesp2	1	1.0							1	
3. Subshrub				*2*	*2*	*1*	*1*	*1*	*2*	*6*	*3*
artemisia frigida, fringed sagewort	arfr4	4	1.0	1	1			1	1		
artemisia pedatifida, birdfoot sagebrush	arpe6	1	1.0							1	
atriplex gardneri, gardner's saltbush	atga	1	1.0							1	
eriogonum microthecum var. laxiflorum, slender buckwheat	ermil2	3	2.3			1				3	3
krascheninnikovia lanata, winterfat	krla2	5	1.0	1	1		1		1	1	
5. Graminoid				*6*	*7*	*13*	*4*	*7*	*4*	*5*	*15*
achnatherum contractum, contracted indian ricegrass	acco22	1	1.0					1			
achnatherum hymenoides, indian ricegrass	achy	5	1.8	1	3				1	3	1
elymus elymoides ssp. elymoides, squirreltail	elele	2	1.0							1	1
elymus lanceolatus ssp. lanceolatus, thickspike wheatgrass	ellal	1	1.0						1		
elymus, wildrye	elymu	4	4.3				3	3	1		10
koeleria macrantha, prairie junegrass	koma	3	1.7	1	1	3					
poa secunda, sandberg bluegrass	pose	8	3.1	3	3	10	1	3	1	1	3
pseudoroegneria spicata, bluebunch wheatgrass	pssp6	1	1.0	1							

Table 20 (continued).

Species (with NRCS codes)		No. of Plots (n=8)	Ave. Cover	CM16.02	CM58.02	CM71.02	RB05.02	RB79.02	RR73.02	JH01.02	JH02.02
6. Forb				*14*	*11*	*13*	*4*	*5*	*5*	*10*	*14*
antennaria microphylla, littleleaf pussytoes	anmi3	2	1.0	1						1	
arabis, rockcress	arabi2	2	1.0					1	1		
arabis holboellii, holboell's rockcress	arho2	1	1.0								1
arenaria nuttallii, nuttall's sandwort	arnu5	6	2.7	3	3	3	3	3	1		
arabis pendulina, rabbitear rockcress	arpe	1	1.0		1						
arabis pendulocarpa, dropseed rockcress	arpe10	1	1.0							1	
castilleja flava, yellow indian paintbrush	cafl7	2	1.0	1	1						
castilleja linariifolia, wyoming indian paintbrush	cali4	2	1.0	1	1						
castilleja pilosa, parrothead indian paintbrush	capi3	2	1.0							1	1
castilleja, indian paintbrush	casti2	1	1.0			1					
chaenactis douglasii, douglas' dustymaiden	chdo	2	1.0	1							1
cordylanthus ramosus, bushy bird's beak	cora5	1	1.0								1
cryptantha cinerea, james' catseye	crci3	1	1.0			1					
crepis, hawksbeard	crepi	1	1.0		1						
eriogonum, eriogonum	eriog	1	1.0			1					
escobaria vivipara var. vivipara, spinystar cactus	esviv	1	1.0		1						
fabaceae unknown cp01-3	fab103	1	1.0								1
forb, unknown cp01-2	forb1002	1	1.0								1
forb, unknown cp01-4	forb1004	1	1.0	1							
forb, unknown cp01-12	forb1012	1	1.0			1					
forb, unknown cp01-13	forb1013	1	1.0	1							
forb, unknown	forbunk	4	1.0	1	1					1	1
ipomopsis congesta, ballhead gilia	ipco5	2	1.0							1	1
linum lewisii, prairie flax	lile3	2	1.0	1					1		
machaeranthera grindelioides, rayless aster	magr2	5	1.0	1	1		1	1	1		
malacothrix torreyi, torrey's desertdandelion	mato2	1	1.0			1					
mertensia humilis, rocky mountain bluebells	mehu2	1	1.0			1					
oxytropis sp., crazyweed	oxytr	1	1.0						1		
packera multilobata, lobeleaf groundsel	pamu11	1	1.0	1							
penstemon fremontii, fremont's beardtongue	pefr	2	1.0							1	1
penstemon humilis, low penstemon	pehu	1	1.0			1					

Table 20 (continued).

Species (with NRCS codes)		No. of Plots (n=8)	Ave. Cover	CM16.02	CM58.02	CM71.02	RB05.02	RB79.02	RR73.02	JH01.02	JH02.02
phlox hoodii, hoods phlox	phho	2	3.0							3	3
phlox opalensis, opal phlox	phop2	2	1.0							1	1
potentilla ovina, sheep cinquefoil	poov2	1	1.0			1					
sedum lanceolatum, spearleaf stonecrop	sela	1	1.0			1					
stanleya viridiflora, green princesplume	stvi	1	1.0								1
trifolium gymnocarpon, hollyleaf clover	trgy	2	1.0	1		1					
trifolium, clover	trifo	1	1.0		1						
7. Cushion-plant				*10*	*9*	*13*	*1*	*4*	*5*	*8*	*9*
arenaria hookeri, hooker's sandwort	arho4	8	1.8	3	1	1	1	1	1	3	3
astragalus drabelliformis, bastard draba milkvetch	asdr2	2	1.0					1	1		
astragalus purshii, woollypod milkvetch	aspu9	2	1.0							1	1
astragalus spatulatus, tufted milkvetch	assp6	3	1.0	1	1					1	
draba oligosperma, fewseed whitlowgrass	drol	2	1.0	1	1						
eriogonum caespitosum, matted buckwheat	erca8	1	1.0			1					
erigeron compositus, cutleaf daisy	erco4	1	1.0							1	
erigeron nanus, dwarf fleabane	erna5	3	1.0	1	1	1					
eriogonum ovalifolium var. purpureum, cushion buckwheat	erovp2	2	2.0							1	3
erigeron pumilus, shaggy fleabane	erpu2	1	1.0					1			
lesquerella alpina, alpine bladderpod	leal	1	1.0						1		
penstemon acaulis, stemless beardtongue	peac3	1	1.0						1		
penstemon laricifolius, larchleaf beardtongue	pela9	1	1.0								1
stenotus acaulis, stemless mock goldenweed	stac	4	3.8		3	10				1	1
tetraneuris torreyana, torrey's hymenoxys	teto	4	1.5	3	1			1	1		
trifolium andinum, andes clover	tran2	2	1.0	1	1						

Table 21. Results of non-parametric tests for differences among plot groups in plant canopy cover.

a. Shrub Canopy Cover

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	1.000	20.75	-1.24
2	8	21.000	49.44	4.46
7	13	1.000	20.27	-1.81
8	7	1.000	18.00	-1.66
21	4	0.000	7.75	-2.59
28	13	4.000	34.54	2.03
Overall	53		27.0	

H = 33.32, DF = 5, P = 0.000 (adjusted for ties). NOTE : One or more small samples

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in amount of shrub canopy cover per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 2 vs. Group 21	41.69	9.319	4.47	2.936	*Reject H_o -- groups differ*
Group 2 vs. Group 8	31.44	8.702	2.613	2.936	*Reject H_o -- groups differ*
Group 2 vs. Group 7	29.17	6.839	4.265	2.936	*Reject H_o -- groups differ*
Group 2 vs. Group 1	28.69	7.609	3.77	2.936	*Reject H_o -- groups differ*
Group 2 vs. Group 28	14.9	6.839	2.179	2.936	Do not reject H_o -- groups do not differ
Group 28 vs. Group 21	26.79	8.702	3.079	2.936	*Reject H_o -- groups differ*
Group 28 vs. Group 8	16.54	7.135	2.381	2.936	Do not reject H_o -- groups do not differ
Group 1 vs. Group 21	13	9.319	1.395	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	21	8	7	1	28	2
Rank Sum	31	127	263.5	166	449	395.5
N	4	7	13	8	13	8
Mean Rank	7.75	18.00	20.27	20.75	34.54	49.44

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7.75    18.00   20.27   20.75   34.54   49.44
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Table 21 (continued).

b. Subshrub Canopy Cover.

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	3.500	33.06	1.20
2	8	2.000	22.31	-0.93
7	13	2.000	23.85	-0.85
8	7	5.000	37.93	2.01
21	4	4.000	40.38	1.80
28	13	1.000	19.31	-2.07
Overall	53		27.0	

H = 12.65, DF = 5, P = 0.027 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in amount of subshrub canopy cover per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 21 vs Group 28	21.07	8.686	2.426	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	28	2	7	1	8	21
Rank Sum	251	178.5	310	264.5	265.5	161.5
N	19	8	13	8	7	4
Mean Rank	19.31	22.31	23.85	33.06	37.93	40.38
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Table 21 (continued).

c. Graminoid Canopy Cover

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	5.500	25.38	-0.32
2	8	6.500	31.88	0.97
7	13	5.000	23.35	-0.98
8	7	25.000	49.79	4.19
21	4	4.000	14.38	-1.70
28	13	4.000	20.27	-1.81
Overall	53		27.0	

H = 22.60, DF = 5, P = 0.000 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in amount of graminoid canopy cover per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 8 vs. Group 21	35.41	9.55	3.709	2.936	*Reject H_o -- groups differ*
Group 8 vs. Group 28	29.52	7.14	4.133	2.936	*Reject H_o -- groups differ*
Group 8 vs. Group 7	26.44	7.143	3.702	2.936	*Reject H_o -- groups differ*
Group 8 vs. Group 1	24.41	7.89	3.094	2.936	*Reject H_o -- groups differ*
Group 8 vs. Group 2	17.91	7.89	2.67	2.936	Do not reject H_o -- groups do not differ
Group 2 vs. Group 21	17.5	9.33	1.876	2.936	Do not reject H_o -- groups do not differ
Group 2 vs. Group 28	11.61	6.846	1.696	2.936	Do not reject H_o -- groups do not differ

*This result is ambiguous, given the significant difference between groups 8 and 28. It results from the small size of group 21 (n=4).

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	21	28	7	1	2	8
Rank Sum	57.5	263	303	203	255	349.5
N	4	13	13	8	8	7
Mean Rank	14.38	20.27	23.35	25.38	31.88	49.79
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Table 21 (continued).

d. Forb Canopy Cover

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	12.00	39.1	2.41
2	8	10.500	33.7	1.34
7	13	3.000	10.6	-4.40
8	7	5.000	24.5	-0.46
21	4	11.000	40.6	1.84
28	13	5.000	28.9	0.52
Overall	53		27.0	

H = 24.86, DF = 5, P = 0.000 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in amount of forb canopy cover per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 21 vs. Group 7	30.01	8.662	3.465	2.936	*Reject H_o -- groups differ*
Group 21 vs. Group 8	16.125	9.496	1.698	2.936	Do not reject H_o -- groups do not differ
Group 1 vs. Group 7	28.51	6.808	4.188	2.936	*Reject H_o -- groups differ*
Group 1 vs. Group 8	14.625	7.841	1.865	2.936	Do not reject H_o -- groups do not differ
Group 2 vs. Group 7	23.135	6.808	3.398	2.936	Do not reject H_o -- groups do not differ
Group 2 vs. Group 8	9.24	7.84	1.18	2.936	Do not reject H_o -- groups do not differ
Group 28 vs. Group 7	18.3	5.94	3.08	2.936	*Reject H_o -- groups differ*
Group 8 vs. Group 7	13.88	7.10	1.95	2.936	Do not reject H_o -- groups do not differ

*This result is ambiguous, given the significant difference between groups 1 and 7. It results from the small size of group 21 (n=4).

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	7	8	28	2	1	21
Rank Sum	138	171.5	376	270	313	162.5
N	13	7	13	8	8	4
Mean Rank	10.615	28.923	28.923	33.75	39.125	40.625
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Table 21 (continued).

e. Cushion Plant Canopy Cover

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	11.500	29.75	0.55
2	8	8.500	18.38	-1.71
7	13	20.000	42.31	4.11
8	7	5.000	12.36	-2.69
21	4	7.500	20.5	-0.88
28	13	7.000	25.19	-0.49
Overall	53		27.00	

H = 22.77, DF = 5, P = 0.000 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in amount of cushion-plant canopy cover per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 7 vs Group 8	29.95	7.223	4.146	2.936	*Reject H_o -- groups differ*
Group 7 vs Group 2	23.93	6.924	3.456	2.936	Do not reject H_o -- groups do not differ
Group 7 vs Group 21	21.81	8.81	2.48	2.936	Do not reject H_o -- groups do not differ
Group 1 vs Group 8	17.39	7.974	2.181	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	8	2	21	28	1	7
Rank Sum	86.5	147	82	327.5	238	550
N	7	8	4	13	8	13
Mean Rank	12.36	18.38	20.5	25.19	29.75	42.31

Table 21 (continued).

f. Canopy Cover of All Plants

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	31.50	24.5	-0.50
2	8	47.50	39.5	2.48
7	13	31.00	23.27	-1.00
8	7	37.00	34.86	1.44
21	4	33.00	22.75	-0.57
28	13	27.00	21.65	-1.44
Overall	53		27.0	

H = 9.90, DF = 5, P = 0.078 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Do not reject null hypothesis of no difference among groups; plot groups do not differ in amount of canopy cover per plot of all plants.

Table 22. Results of non-parametric tests for differences among plot groups in numbers of species.

a. Number of Shrub Species

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	1.000	23.31	-0.73
2	8	3.500	40.5	2.68
7	13	1.000	21.46	-1.49
8	7	1.000	19.64	-1.35
21	4	0.000	7.88	-2.58
28	13	2.000	36.35	2.51
Overall	53		27.0	

H = 21.92, DF = 5, P = 0.001 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in number of shrub species per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 2 vs. Group 21	32.62	9.196	3.982	2.926	*Reject H_o -- groups differ*
Group 2 vs. Group 8	20.86	7.772	2.684	2.936	Do not reject H_o -- groups do not differ
Group 28 vs. Group 21	28.47	8.587	3.316	2.936	*Reject H_o -- groups differ*

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	21	8	7	1	28	2
Rank Sum	31.5	137.5	279	186.5	472.5	324
N	4	7	13	8	13	8
Mean Rank	7.88	19.64	21.46	23.31	36.35	40.5
		--				

Table 22 (continued).

b. Number of Subshrub Species

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	2.000	35.4	1.68
2	8	1.500	26.6	-0.09
7	13	1.000	23.5	-0.94
8	7	3.000	37.3	1.89
21	4	2.000	30.8	0.51
28	13	1.000	18.9	-2.18
Overall	53		27.0	

H = 10.95, DF = 5, P = 0.052 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Do not reject null hypothesis of no difference among groups; plot groups do not differ in number of subshrub species per plot.

c. Number of Graminoid Species

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	3.000	23.7	-0.66
2	8	3.000	26.1	-0.19
7	13	3.000	26.0	-0.27
8	7	4.000	36.7	1.79
21	4	3.000	24.1	-0.39
28	13	3.000	26.3	-0.20
Overall	53		27.0	

H = 3.71, DF = 5, P = 0.591 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Do no reject null hypothesis of no difference among groups; plot groups do not differ in number of graminoid species per plot.

Table 22 (continued).

d. Number of Forb Species.

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	7.500	37.94	2.17
2	8	8.500	36.44	1.88
7	13	3.000	13.23	-3.70
8	7	4.000	24.43	-0.47
21	4	7.500	40.25	1.78
28	13	5.000	25.54	-0.39
Overall	53		27.0	

H = 20.97, DF = 5, P = 0.001 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in number of forb species per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 21 vs. Group 7	27.02	8.75	3.09	2.936	*Reject H_o -- groups differ*
Group 21 vs. Group 8	15.82	9.59	1.649	2.936	Do not reject H_o -- groups do not differ
Group 1 vs. Group 7	24.71	6.88	3.59	2.936	*Reject H_o -- groups differ*
Group 2 vs. Group 7	23.21	6.88	3.372	2.936	*Reject H_o -- groups differ*
Group 28 vs. Group 7	12.31	6.003	2.051	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	7	8	28	2	1	21
Rank Sum	172	171	332	291.5	303.5	161
N	13	7	13	8	8	4
Mean Rank	13.23	24.43	25.54	36.44	37.94	40.25
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Table 22 (continued).

e. Number of Cushion-plant Species

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	5.000	28.0	0.20
2	8	5.000	23.8	-0.63
7	13	6.000	37.0	2.68
8	7	5.000	16.4	-1.96
21	4	4.500	19.1	-1.06
28	13	5.000	26.5	-0.12
Overall	53		27.0	

H = 10.63, DF = 5, P = 0.059 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Do not reject null hypothesis of no difference among groups; plot groups do not differ in number of cushion-plant species per plot.

Table 22 (continued).

f. All Plant Species

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	19.50	37.0	1.99
2	8	21.00	36.5	1.89
7	13	14.00	18.23	-2.36
8	7	14.00	21.43	-1.02
21	4	16.00	26.5	0.12
28	13	17.00	27.88	-0.13
Overall	53		27.0	

H = 11.60, DF = 5, P = 0.041 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in number of all plant species per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 1 vs. Group 7	18.77	6.91	2.71	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	7	8	21	28	2	1
Rank Sum	237	150	344.5	111.5	292	296
N	12	7	4	13	8	8
Mean Rank	18.23	21.43	26.5	27.88	36.5	37.0
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Table 23. Results of statistical tests for differences between plot groups in amounts of ground cover.

a. Gravel

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	75.00	37.94	2.17
2	8	16.00	21.75	-1.04
7	13	50.00	28.81	0.49
8	7	35.00	19.93	-1.30
21	4	75.50	43.00	2.15
28	13	20.00	20.58	-1.73
Overall	53		27.0	

H = 13.18, DF = 5, P = 0.022 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in amount of gravel per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 21 vs. Group 8	23.07	9.66	2.388	2.936	Do not reject H_o -- groups do not differ
Group 1 vs. Group 8	19.01	7.98	2.258	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	8	28	2	7	1	21
Rank Sum	139.5	267.5	174	374.5	303.5	172
N	7	13	8	13	8	4
Mean Rank	19.93	20.58	21.75	28.81	37.94	43.00

Table 23 (continued).

b. Bare Soil.

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	15.00	16.63	-2.06
2	8	76.00	31.56	0.91
7	13	31.00	23.54	-0.93
8	7	49.00	30.79	0.70
21	4	13.00	14.5	-1.68
28	13	65.00	35.85	2.38
Overall	53		27.0	

H = 12.30, DF = 5, P = 0.031 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in number of all plant species per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 28 vs. Group 21	21.35	8.81	2.423	2.936	Do not reject H_o -- groups do not differ
Group 28 vs. Group 1	19.22	6.93	2.773	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	21	1	7	8	2	28
Rank Sum	58	133	306	215.5	252.5	466
N	4	8	13	7	8	13
Mean Rank	14.5	16.63	23.54	30.79	31.56	35.85

Table 23 (continued).

c. Cobble

Kruskal-Wallis test for differences between groups.

Plot Group	N	Median	Ave. Rank	Z
1	8	0		-1.42
2	8	0		-2.39
7	13	10.00		3.87
8	7	0		-1.18
21	4	2.750		0.91
28	13	0		-0.33
Overall	53		27.0	

H = 23.88, DF = 5, P = 0.000 (adjusted for ties). NOTE: One or more small samples.

Conclusion: Reject null hypothesis of no difference among groups; plot groups differ in number of all plant species per plot.

Non-parametric pairwise comparisons of differences between groups.

Comparison	Difference in Mean Ranks	Std Error	Q	$Q_{0.05,6}$	Conclusion
Group 7 vs. Group 2	25.58	6.33	4.041	2.936	*Reject H_o -- groups differ*
Group 7 vs. Group 1	20.7	6.33	3.27	2.936	*Reject H_o -- groups differ*
Group 7 vs. Group 8	20.01	6.604	3.03	2.936	*Reject H_o -- groups differ*
Group 7 vs. Group 28	14.77	5.53	2.67	2.936	Do not reject H_o -- groups do not differ
Group 21 vs. Group 2	16.25	8.63	1.88	2.936	Do not reject H_o -- groups do not differ
Group 28 vs. Group 2	10.81	6.33	1.71	2.936	Do not reject H_o -- groups do not differ

Lines beneath mean ranks link groups that do not differ significantly (p=0.05)

Groups (by mean rank)	2	1	8	28	21	7
Rank Sum	120	159	144	335.5	125	527.5
N	8	8	7	13	4	13
Mean Rank	15.00	19.88	20.57	25.81	31.25	40.58

Table 24. Summary of features of 6 plot groups based on relative canopy cover.

Plot Group	Vegetation	Species	Ground-cover	Substrate	Topographic Position	Distribution
7 (n=13)	CUSHION-PLANT: cushion-plant cover greater than other groups and forb cover less. Few non-cushion forb species. Low alpha diversity, high beta diversity.	*Phlox muscoides* dominant, *Arenaria hookeri* sub-dominant, *Poa secunda* common; *Eriogonum acaule* and *Astragalus spatulatus* often present and sometimes common.	Gravel, cobble, and bare soil ranged widely.	Sandstone, oil shale, tuffaceous sandstone	Nearly all plots along rims	North and east: Ross, Joe Hay, Steamboat, and Delaney Rims, Packsaddle Canyon
1 (n=8)	CUSHION-PLANT WITH OTHER FORBS: high cushion-plant and forb cover, very little shrub cover, many forb species. High alpha diversity and intermediate beta diversity .	*Arenaria nuttallii*, *Artemisia frigida* present in all plots and co-dominate many; other common co-dominants were *Arenaria hookeri*, *Tetraneuris torreyana* (both present in all plots), *Trifolium andinum*, and *Poa secunda*.	Gravel cover generally high and bare soil low.	Tuffaceous sandstone, landslide deposits	4 of 6 plots along rims	Southwest (Cedar and Hickey Mountains) and north (Ross Ridge)
21 (n=4)	CUSHION-PLANT WITH OTHER FORBS: Forb cover and number of forbs per plot relatively high. Alpha diversity intermediate and beta diversity low.	*Arenaria hookeri*, *Astragalus spatulatus*, and *Krascheninnikovia lanata* widespread and contributed substantial cover; *Stanleya viridiflora* also widespread but in trace amounts.	Lots of gravel, little bare soil or cobble cover.	Sandstone, oil shale.	All from along rims	Central: Joe Hay, Steamboat, Kinney Rims
28 (n=13)	CUSHION-PLANT WITH SAGEBRUSH OR WITH FORBS. Alpha diversity intermediate and beta diversity high.	Three sub-groups. #280 is 5 plots at Packsaddle & Steamboat with *Arenaria hookeri*, *Astragalus spatulatus*, *Phlox muscoides, Poa secunda* and *Artemisia tridentata* ssp. *wyomingensis* dominant or co-dominant; #282, 5 plots at Round Mtn. with *Arenaria nuttallii* and *Arenaria hookeri* co-dominant, and smaller amounts of *Trifolium andinum*, *Artemisia tridentata* spp. *wyomingensis*, and *Achnatherum contractum*; #281, 3 plots without consistently important species.	Bare soil common, minor cover of gravel and cobble	Tuffaceous sandstone, oil shale, sandstone	6 plots from along rims, 7 back from rims	In the northern sample areas: Ross Butte, Packsaddle Canyon, Steamboat Rim, Round Mtn.
8 (n=7)	GRASS. Alpha diversity low, beta diversity intermediate	*Elymus lanceolatus* ssp. *lanceolatus* and *Poa secunda* present in all plots and dominated four; *Pseudoroegneria spicata* dominated 3 plots. *Arenaria hookeri*, *Phlox hoodii*, and *Krascheninnikovia lanata* widespread and contributed more than a trace of cover to several plots.	Intermediate amounts of gravel and bare soil	Sandstone and oil shale.	All plots back from rims	Most plots at Delaney Rim, one each at Steamboat and Kinney Rims
2 (n=8)	SAGEBRUSH. Alpha diversity and beta diversity both high.	*Artemisia tridentata* spp. *wyomingensis* dominates all plots, and *Poa secunda*, *Arenaria hookeri*, and *Arenaria nuttallii* widespread and each contributed more than a trace of cover to several plots.	Percent bare soil high, percent gravel cover ranged widely	Tuffaceous sandstone, sandstone	All plots back from rims	Widespread: Cedar Mtn., Joe Hay Rim, Ross Butte and Rim

Table 25. Results of non-parametric test for differences among plot groups in aspect.
Aspect as measured in degrees was converted to radians, then transformed using the formula (from Beers *et al.* 1966):

Aspect (transformed) = cosine (270-Aspect) +1.

The resulting transformed aspect was then converted to degrees.

Plot Group	N	Median	Ave. Rank	Z
1	8	47.35	31.6	0.91
2	8	47.35	28.0	0.20
7	13	57.30	28.7	0.45
8	7	20.47	21.9	-0.95
21	4	45.15	25.9	-0.15
28	13	37.70	25.0	-0.54
Overall	53		27.0	

H = 1.91, DF = 5, P = 0.862 (adjusted for ties). NOTE: One or more small samples.

Conclusion: do not reject null hypothesis of no difference among groups; plot groups do not differ in aspect.

Table 26. Co-occurrence of cushion-plant plot groups at the 10 sampling areas.
Cells show the number of plots at each sampling area that were classified into one of the four plot groups with substantial amounts of cushion-plant cover.

	Number of Plots in Plot Group			
Sampling Area	1	7	21	28
Cedar Mtn.	3			
Delaney Rim		5		
Hickey Mtn.	4			
Joe Hay Rim		1	2	
Kinney Rim			1	
Packsaddle		2		2
Ross Butte				2
Ross Ridge	1	2		
Round Mtn.				6
Steamboat		3	1	3

Table 27. Numbers of plots in which signs of disturbance were noted.

Type of Disturbance	Plots Along Rims (n=27)	Plots Back From Rims (n=26)
Unvegetated Vehicle Trail	9	
Vehicle Tire Tracks	5	
Rock Monument	1	
Excavation by Humans	1	
Fence	1	
Trash	4	4
Small Mammal Burrows (mostly pocket gopher)	3	8
Ungulate Trail		1
Plots With at least One Disturbance	24	13
No Disturbance Observed	3	8
No Information	3	7

Table 28. Relationships of plot groups from the classification based on relative canopy cover to vegetation types from the national vegetation classification.

Plot Group	National Classification Unit	Relationship
7	*Arenaria hookeri* Barren Herbaceous Alliance.	Plot group probably can be included in this alliance.
1	*Arenaria hookeri* Barren Herbaceous Alliance.	Plot group probably can be included in this alliance.
21	*Arenaria hookeri* Barren Herbaceous Alliance.	Plot group probably can be included in this alliance.
28	*Arenaria hookeri* Barren Herbaceous Alliance.	Plot group probably can be included in this alliance.
8	*Elymus lanceolatus* Herbaceous Alliance and *Pseudoroegneria spicata* Herbaceous Alliance	Plots dominated by *Elymus* lanceolatus probably fit into the former alliance, and plots dominated by *Pseudoroegneria spicata* into the latter.
2	*Artemisia tridentata* ssp. *wyomingensis* / *Poa secunda* Shrubland Plant Association. National code: CEGL001049. Conservation status rank: G4 (common)	Plot group might be included in association, although the association is undescribed in the national classification and is not listed from Wyoming

FIGURES

Figure 1. Layout of the nested, modified-Whittaker sampling plots.

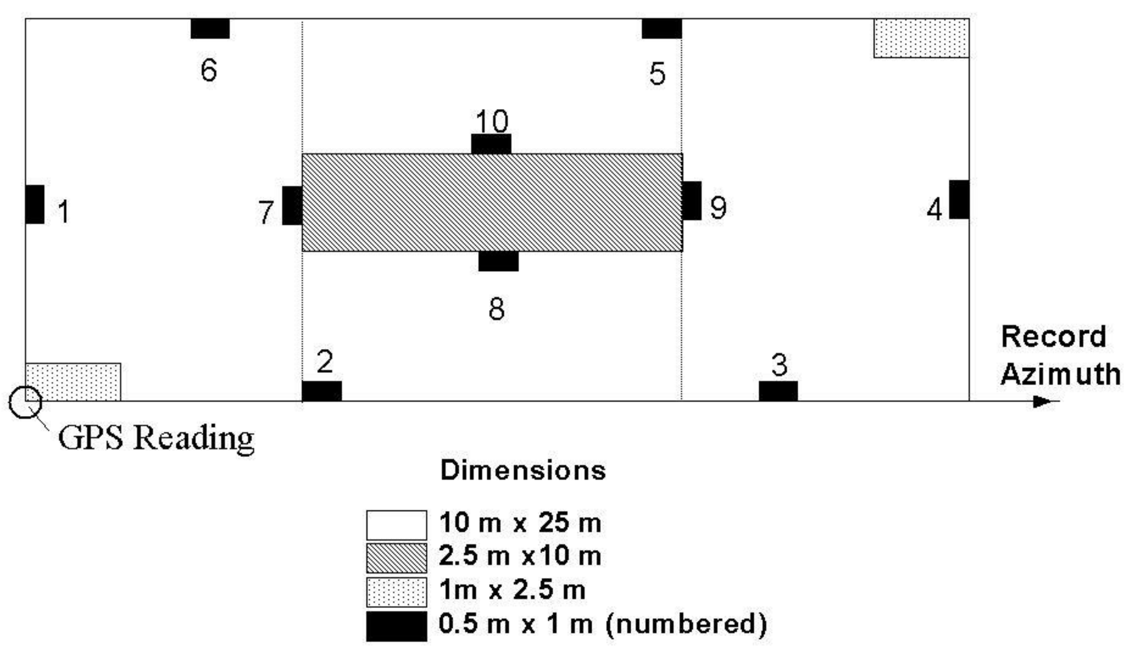
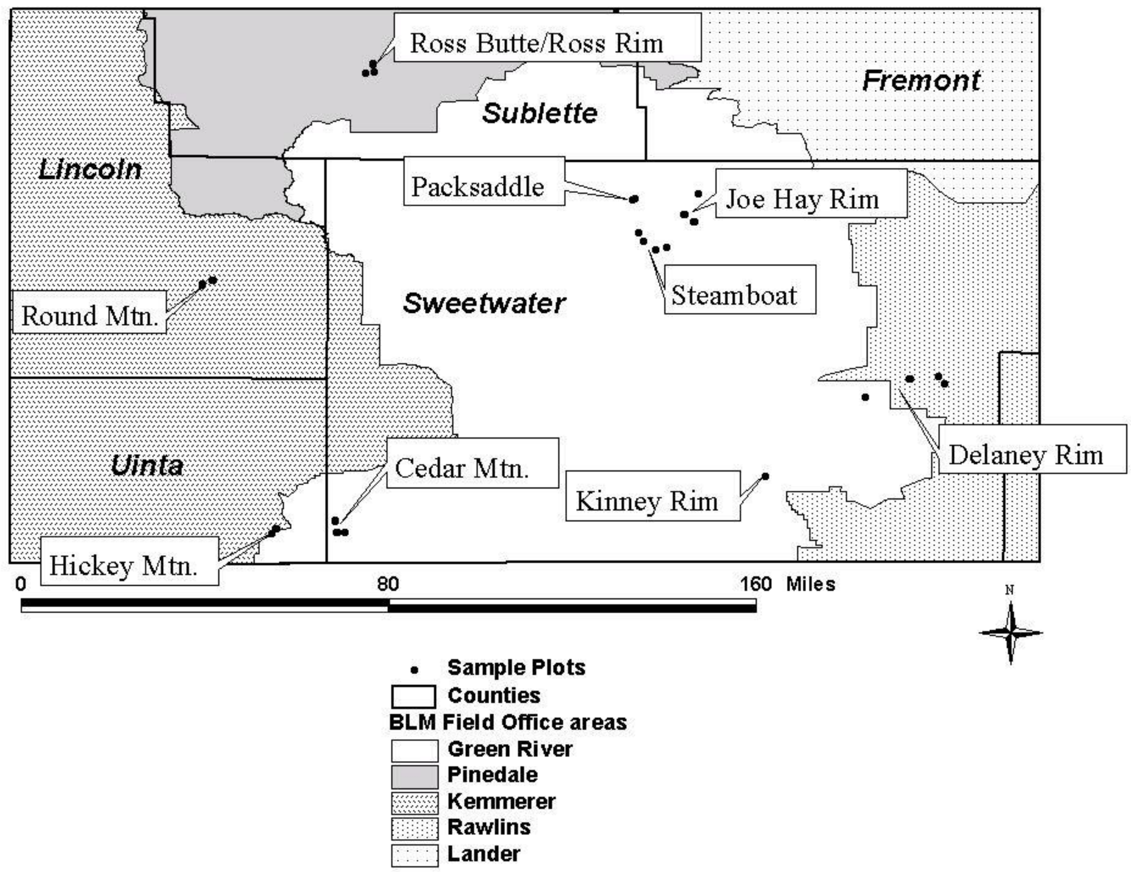


Figure 2. Locations of sample plots at 10 sampling areas in southwestern Wyoming.



Map is unprojected. Datum is GCS North American 1983.

Figure 3. Frequency of occurrence of 138 vascular plant species in the 53 sample plots.

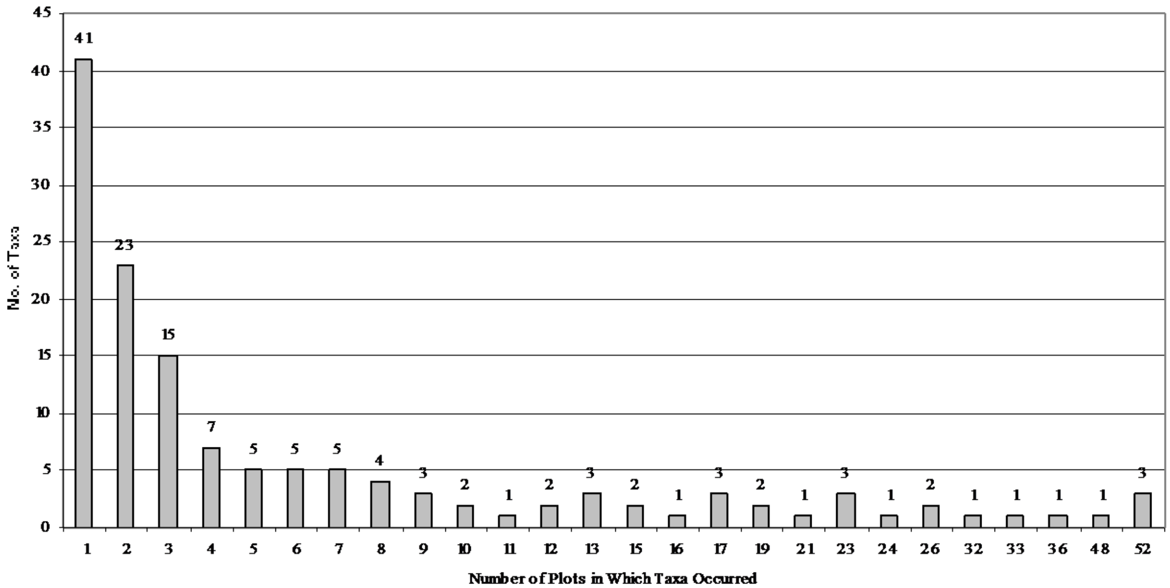


Figure 4. Occurrence of each cushion-plant species in plots along rims and in plots back from rims.
Bars show the numbers of plots in which each cushion-plant species was recorded. Full names for species are shown in Tables 5 and 6.

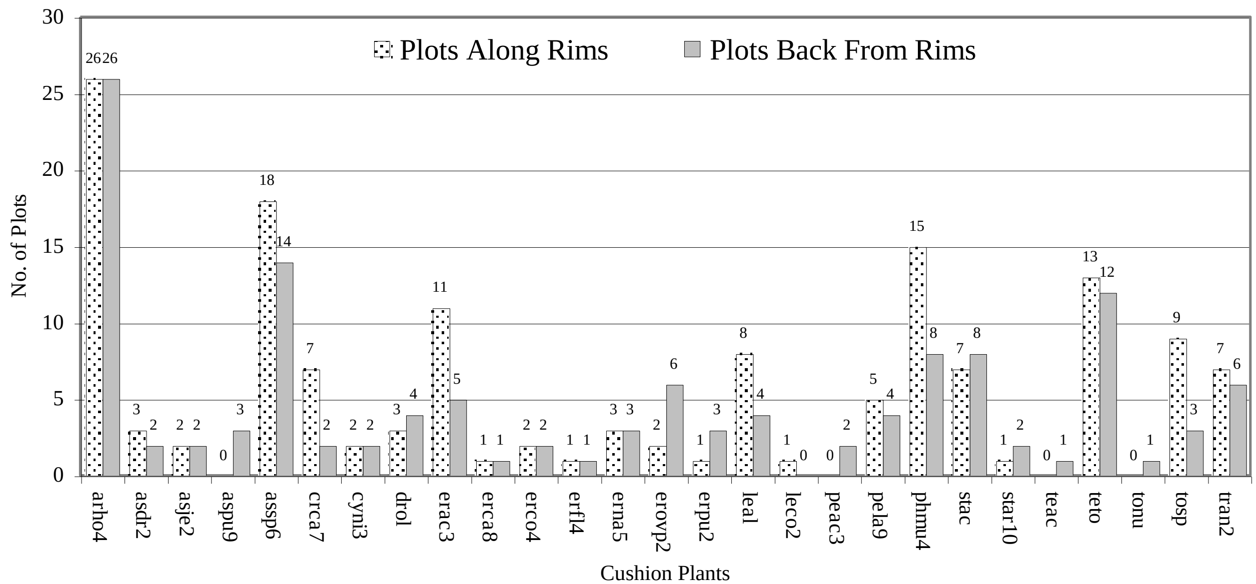


Figure 5. Average number per plot of species of different growth forms, plots along rims vs. plots back from rims.
Columns are average number of species per plot. Lines are 95% confidence intervals. Analysis of variance showed no difference between types of plots for any growth-form.

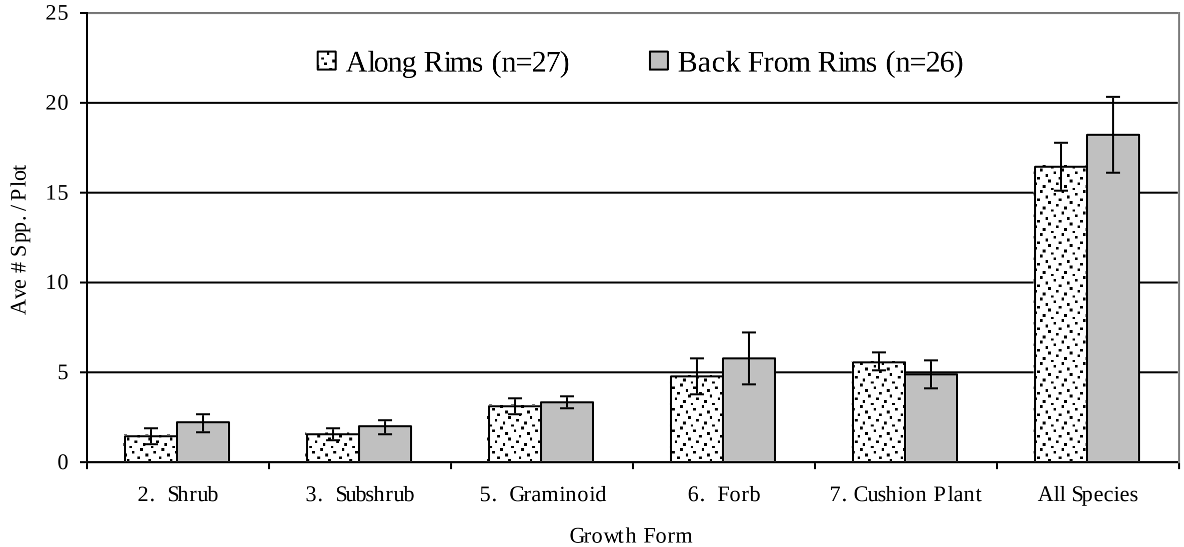


Figure 6. Average relative cover per plot of different growth forms, plots along rims vs. plots back from rims.
Columns are average relative cover-class (i.e., cover-class for all species of that growth-form / total plot cover) per plot. Lines are 95% confidence intervals. P values are from Bonferroni tests for differences. See Table 7 for statistical tests.

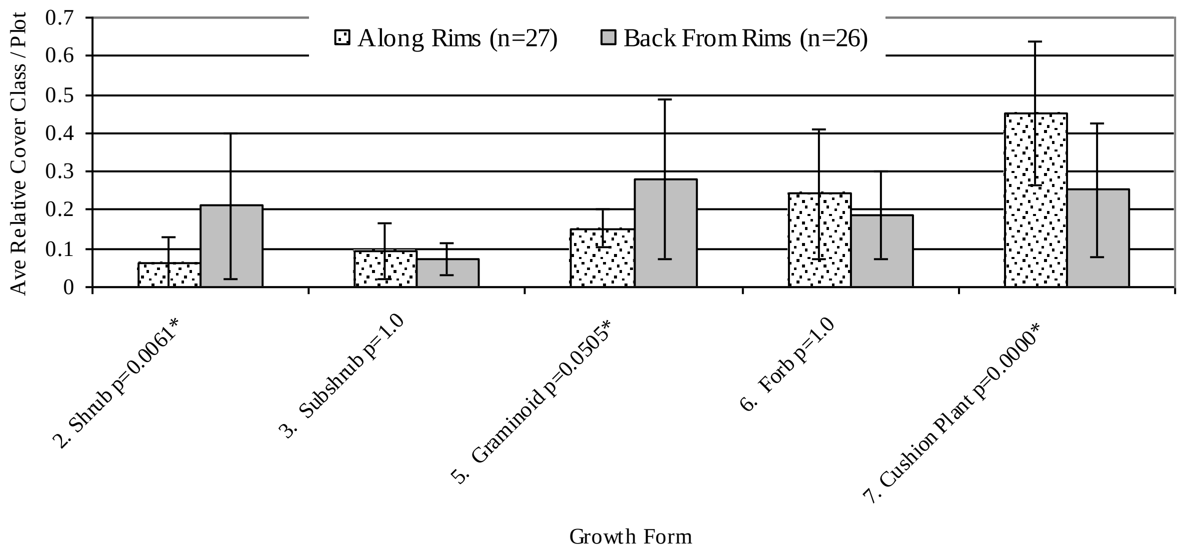


Figure 7. Average percent cover per plot of different ground-cover categories, plots along rims vs. plots away from rims.
Columns are average percentage per plot for each category. Lines are 95% confidence intervals. P values are from t-tests. See Table 8 for statistical tests on gravel and bare soil.

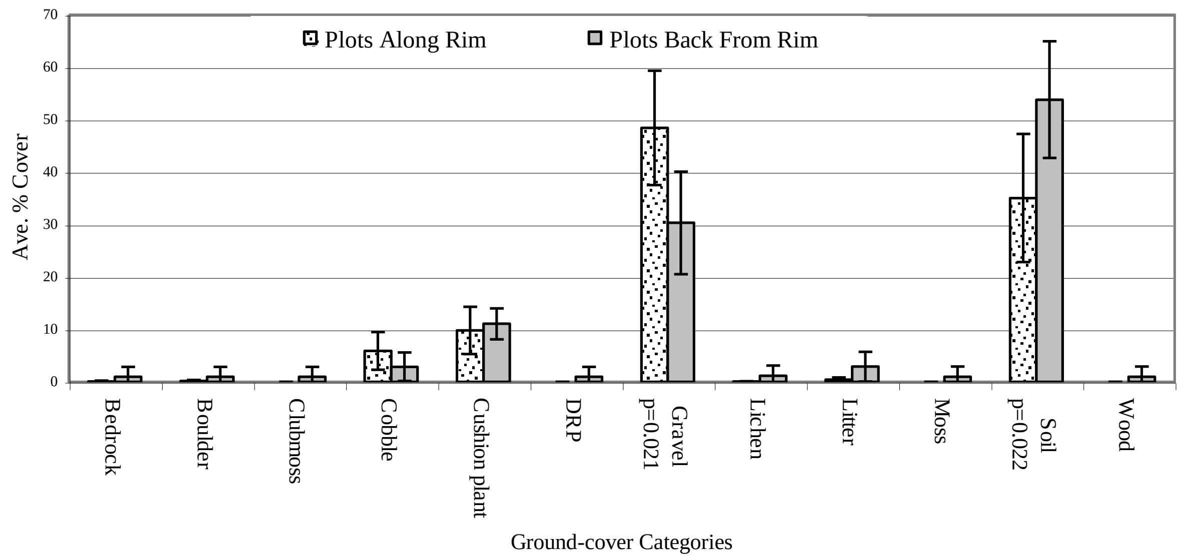


Figure 8. Classification of sample plots based on relative canopy cover, showing sampling areas. Plot group numbers are shown on dendrogram branches. Diagonal lines indicate MRPP tests for differences between groups. (See Tables 10-13 for results.) Symbols denote the 10 sampling areas shown in Figure 2.

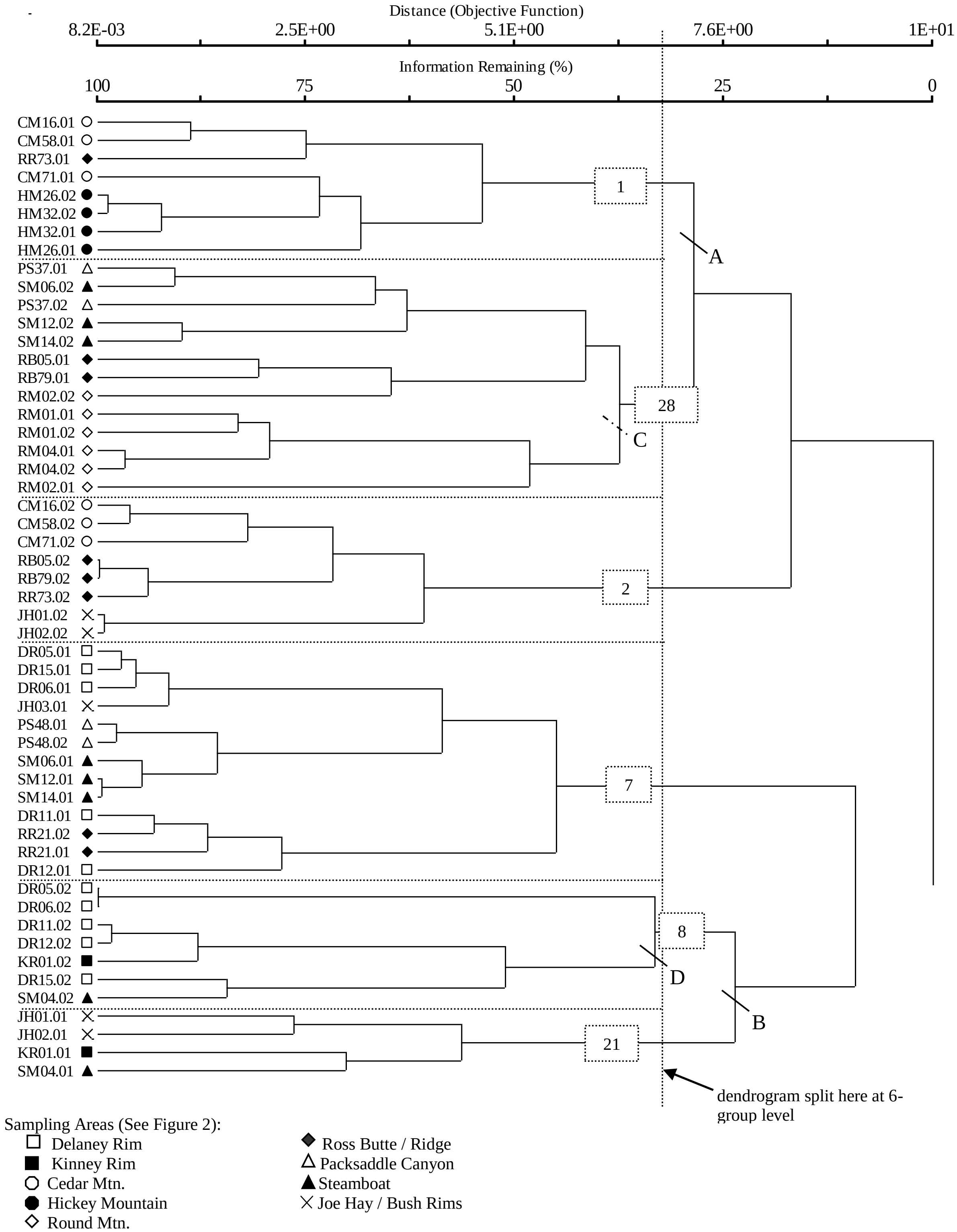


Figure 9. Number of significant ($p \leq 0.05$) indicator species and average probabilities of indicator values for different numbers of plot groups.
The number of plot groups is determined by the level at which the classification dendrogram (Figure 8) is cut.

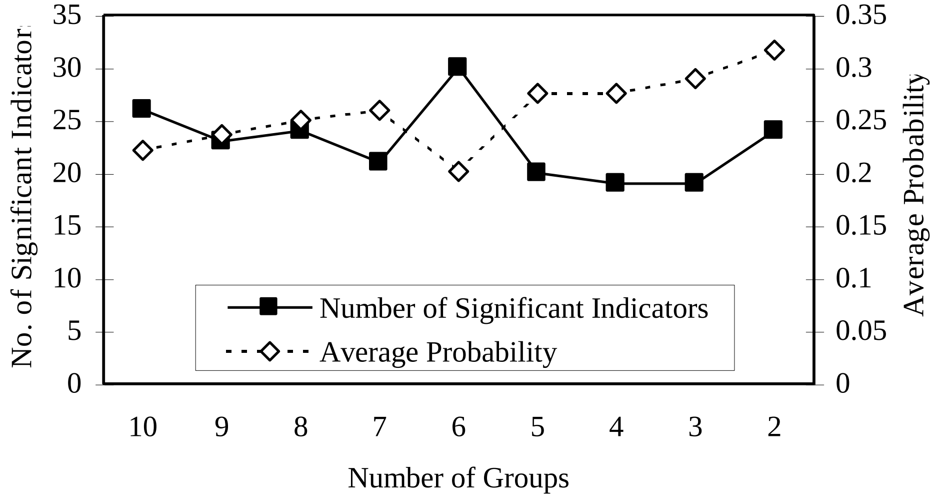


Figure 10. Median per-plot canopy cover of different plant growth-forms in the 6 plot groups. Asterisks indicate significant differences (p=0.05) among plot groups. Details of comparisons between groups are shown in Figure 12.

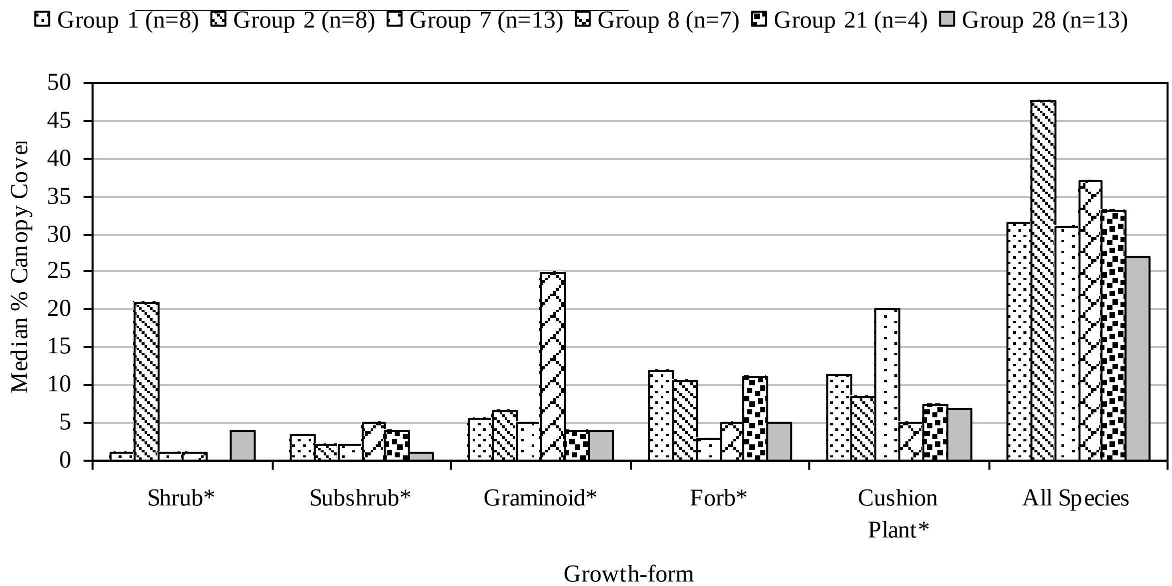


Figure 11. Median number of species per plot of different plant growth-forms in the 6 plot groups. Asterisks indicate significant differences (p=0.05) among plot groups. Details of comparisons between groups are shown in Figure 13.

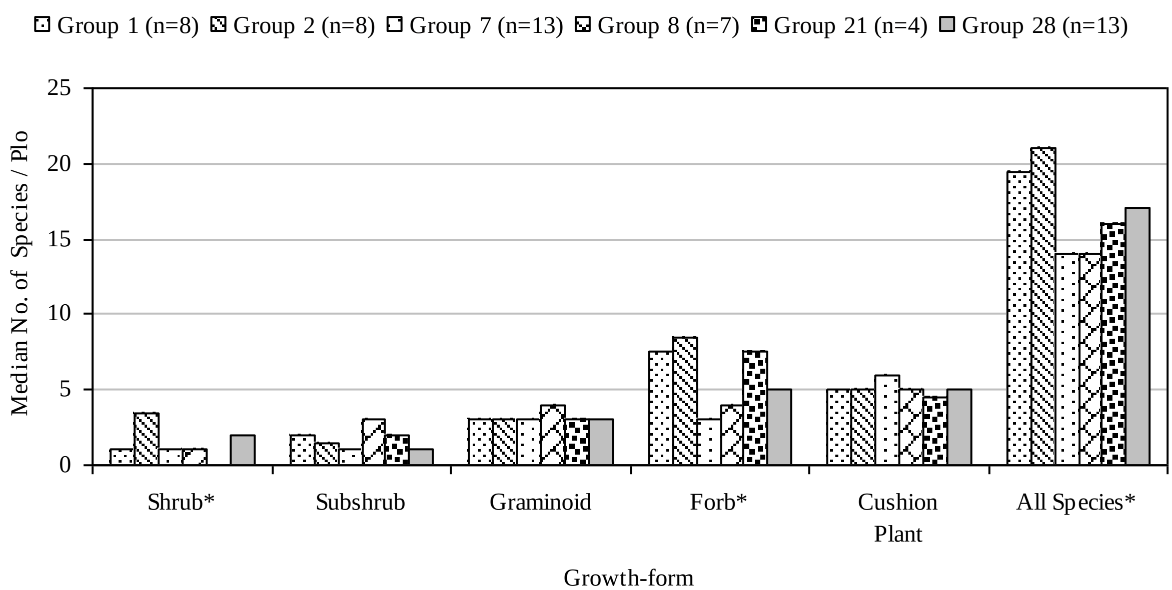
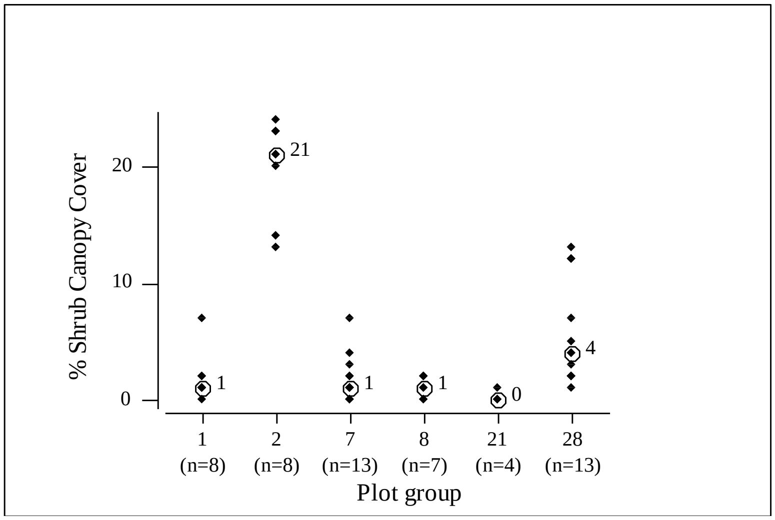


Figure 12. Per-plot canopy cover of plant growth-forms in each of the 6 plot groups.
In all cases, canopy cover is the sum of cover-class values for all plants of the growth-form in the plot.
Diamonds are values for individual plots. Circles and numbers are medians for groups.

a. Shrub Canopy Cover.

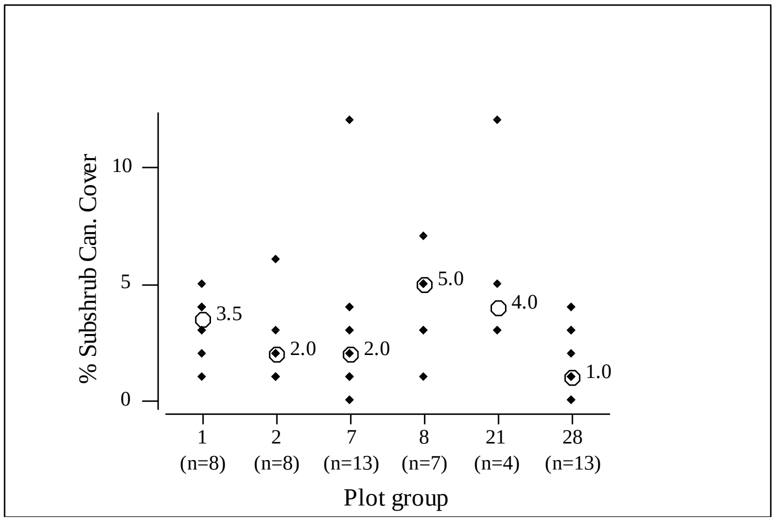


Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups. Pairwise comparisons showed this pattern of significant differences. (Lines beneath mean ranks link groups that do not differ significantly). See Table 21a for details.

Groups (by mean rank)	21	8	7	1	28	2
Rank Sum	31	127	263.5	166	449	395.5
N	4	7	13	8	13	8
Mean Rank	7.75	18.00	20.27	20.75	34.54	49.44

Figure 12 (continued).

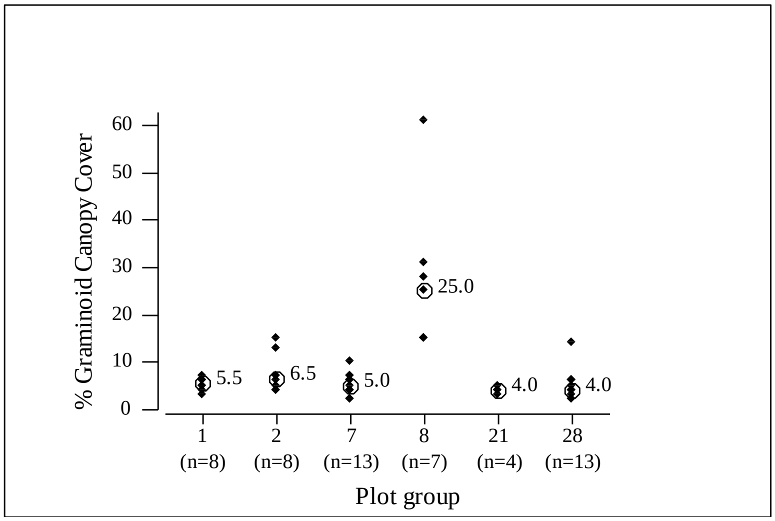
b. Subshrub Canopy Cover



Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups but pairwise comparisons were unable to find significant differences between pairs of groups. See Table 21b for details.

Figure 12 (continued).

c. Graminoid Canopy Cover



Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups. Pairwise comparisons showed this pattern of significant differences. (Lines beneath mean ranks link groups that do not differ significantly). See Table 21c for details.

Groups (by mean rank)	21	28	7	1	2	8
Rank Sum	57.5	263	303	203	255	349.5
N	4	13	13	8	8	7
Mean Rank	14.38	20.27	23.35	25.38	31.88	49.79
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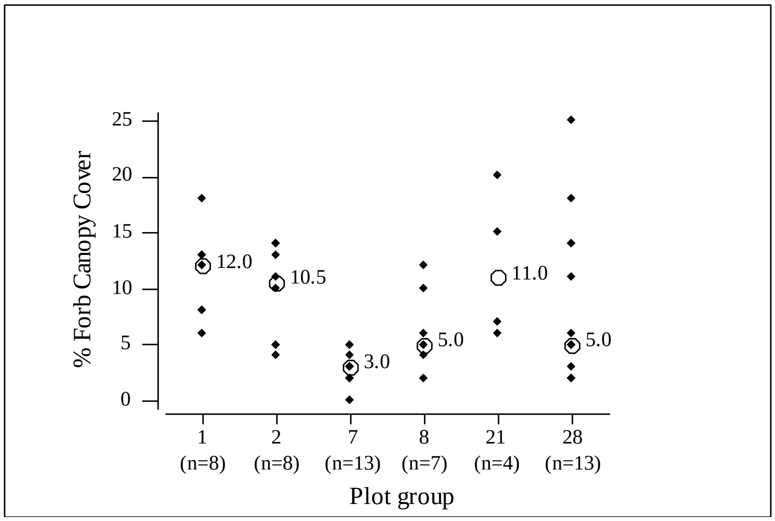
Figure 12 (continued).

d. Forb canopy cover.



Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups. Pairwise comparisons showed this pattern of significant differences. (Lines beneath mean ranks link groups that do not differ significantly). See Table 21d for details.

Groups (by mean rank)	7	8	28	2	1	21
Rank Sum	138	171.5	376	270	313	162.5
N	13	7	13	8	8	4
Mean Rank	10.615	28.923	28.923	33.75	39.125	40.625
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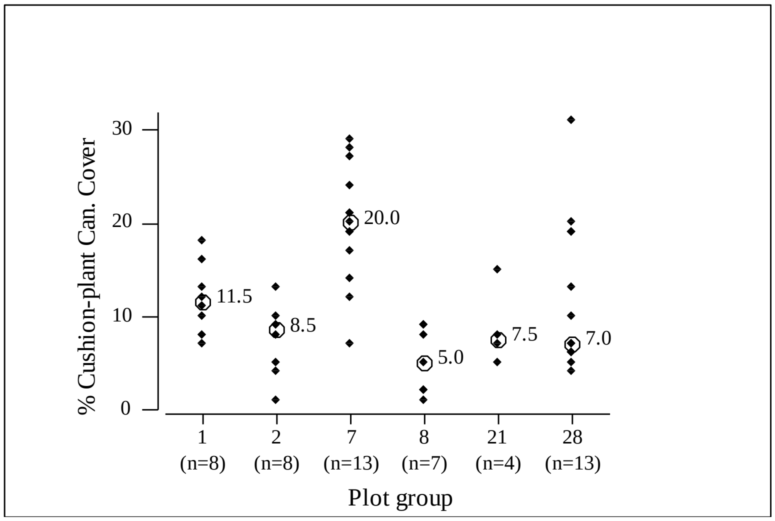
Figure 12 (continued).

e. Cushion-plant canopy cover

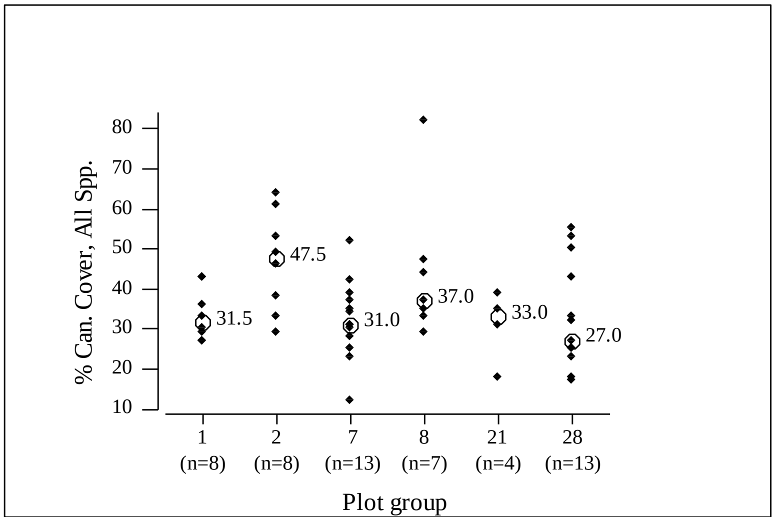


Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups. Pairwise comparisons showed this pattern of significant differences. (Lines beneath mean ranks link groups that do not differ significantly). See Table 21e for details.

Groups (by mean rank)	8	2	21	28	1	7
Rank Sum	86.5	147	82	327.5	238	550
N	7	8	4	13	8	13
Mean Rank	12.36	18.38	20.5	25.19	29.75	42.31

Figure 12 (continued).

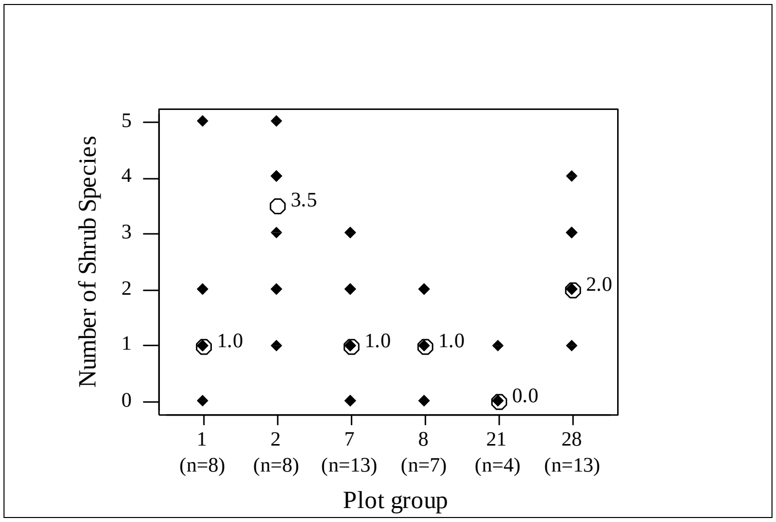
f. Canopy cover of all plants.



Kruskal-Wallis test showed no significant (0.05) differences among groups. See Table 21f for details.

Figure 13. Number of species per plot of each growth-form in each of the 6 plot groups. Diamonds are values for individual plots. Circles and numbers are medians for groups.

a. Number of Shrub Species.

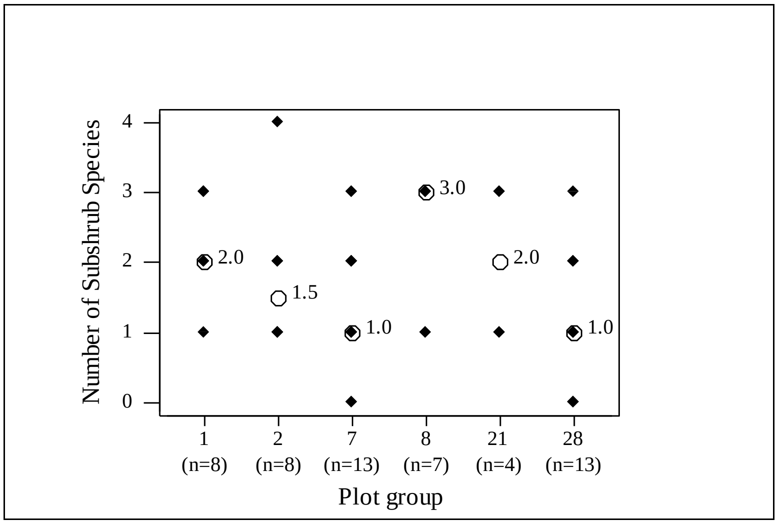


Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups. Pairwise comparisons showed this pattern of significant differences. (Lines beneath mean ranks link groups that do not differ significantly). See Table 22a for details.

Groups (by mean rank)	21	8	7	1	28	2
Rank Sum	31.5	137.5	279	186.5	472.5	324
N	4	7	13	8	13	8
Mean Rank	7.88	19.64	21.46	23.31	36.35	40.5

Figure 13 (continued).

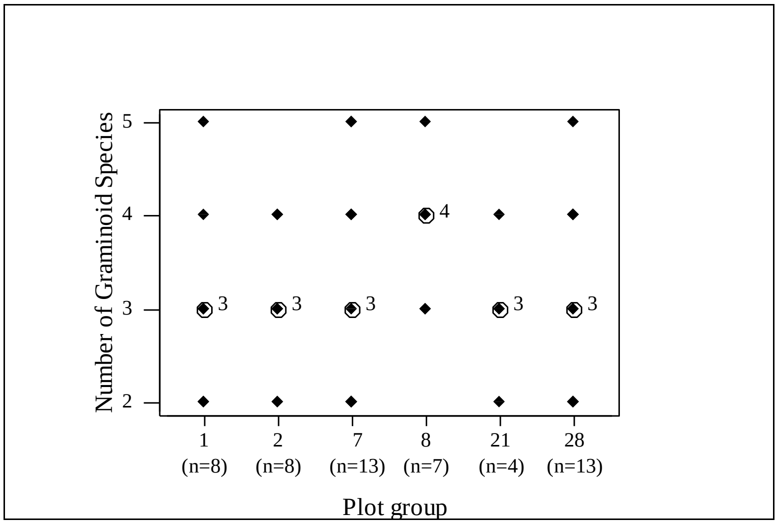
b. Number of Subshrub Species.



Kruskal-Wallis test showed no significant difference (p=0.50) among groups. See Table 22b for details.

Figure 13 (continued).

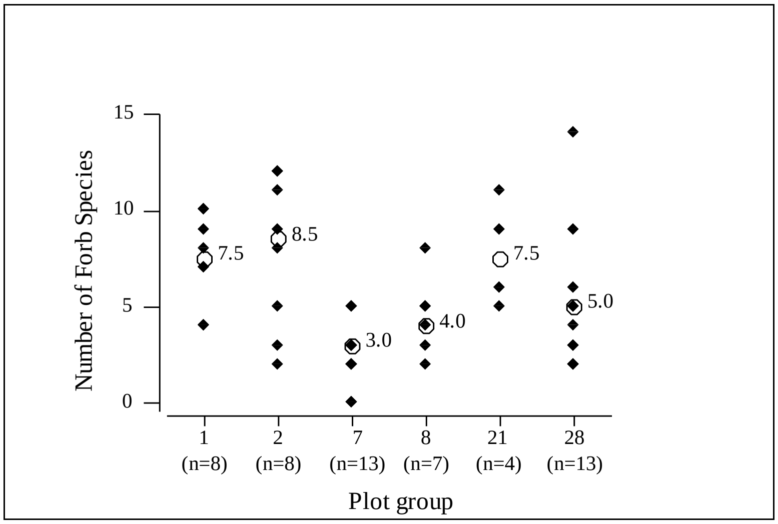
c. Number of graminoid species.



Kruskal-Wallis test showed no significant difference ($p=0.50$) among groups. See Table 22c for details.

Figure 13 (continued).

d. Number of Forb Species.



Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups. Pairwise comparisons showed this pattern of significant differences. (Lines beneath mean ranks link groups that do not differ significantly). See Table 22d for details.

Groups (by mean rank)	7	8	28	2	1	21
Rank Sum	172	171	332	291.5	303.5	161
N	13	7	13	8	8	4
Mean Rank	13.23	24.43	25.54	36.44	37.94	40.25
		--------	--------	--------	--------	--------
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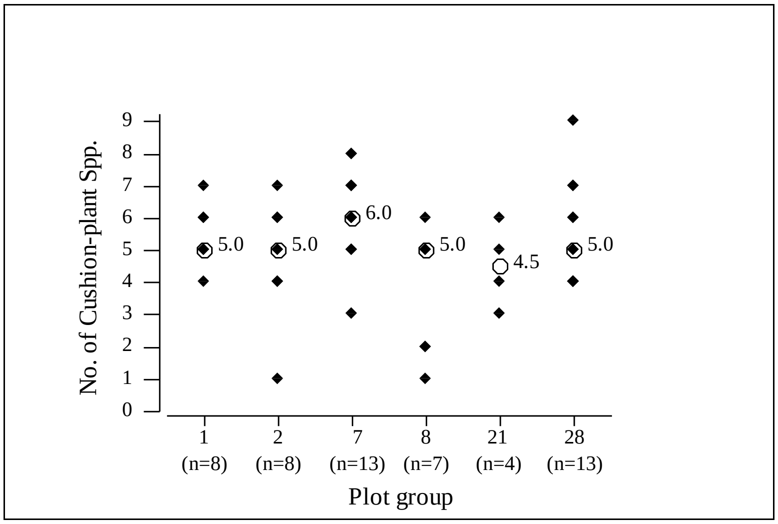
Figure 13 (continued).

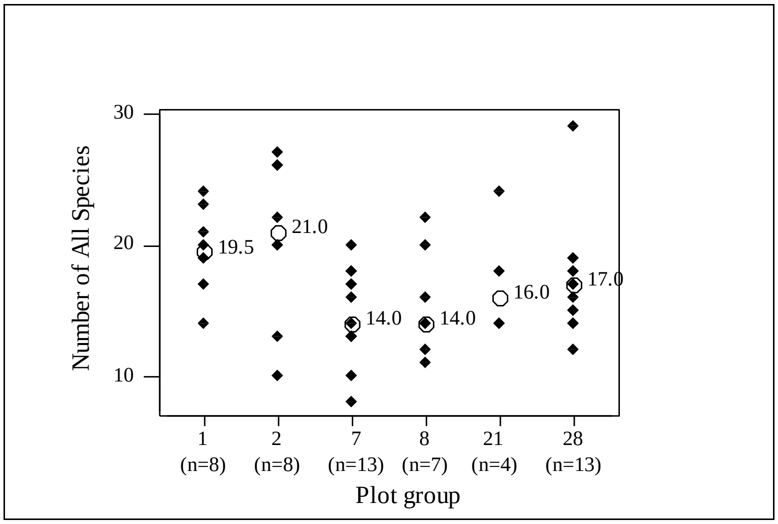
e. Number of Cushion-plant Species.



Kruskal-Wallis test showed no significant difference (p=0.50) among groups. See Table 22e for details.

Figure 13 (continued).

f. Number of All Plant Species.

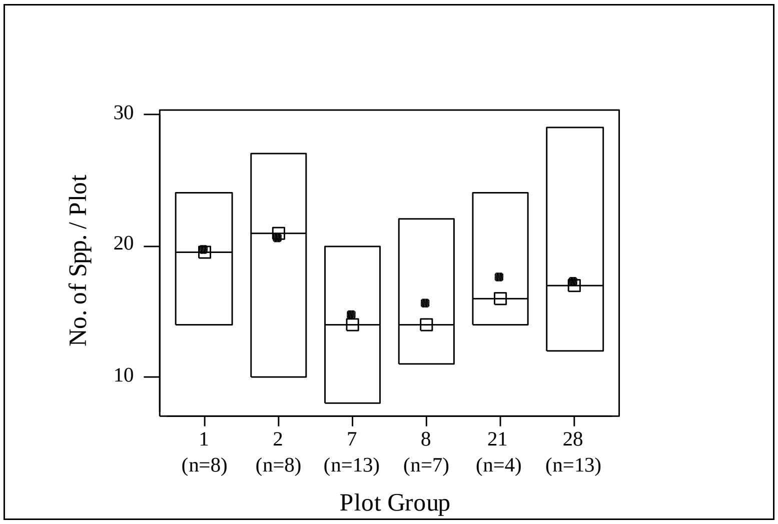


Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups but pairwise comparisons were unable to find significant differences between pairs of groups. See Table 22f for details.

Figure 14. Number of species per plot (alpha diversity) and heterogeneity between plots (beta diversity) within the 6 plot groups.

Alpha Diversity

Boxes show range in number of species / plot for plots in each group. Lines with open squares show median number of species per plot. Solid circles show average number of species per plot (alpha diversity.



Beta Diversity

Bw = (total number of species in all plots of group) / (average number of species per plot)

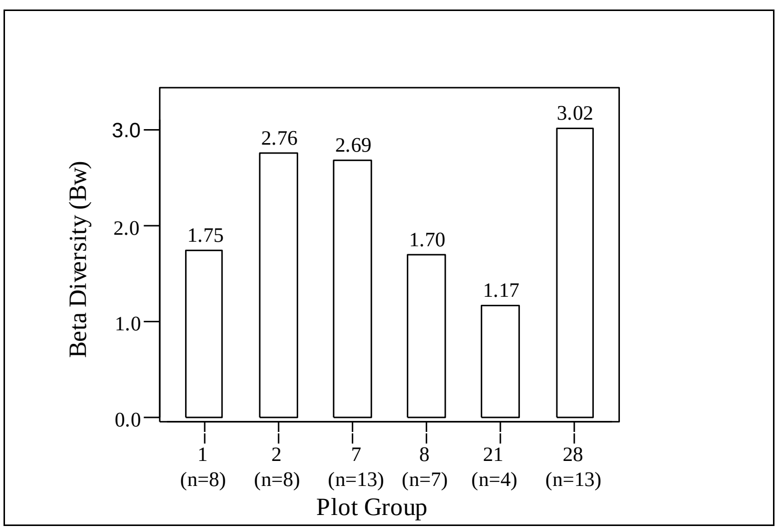
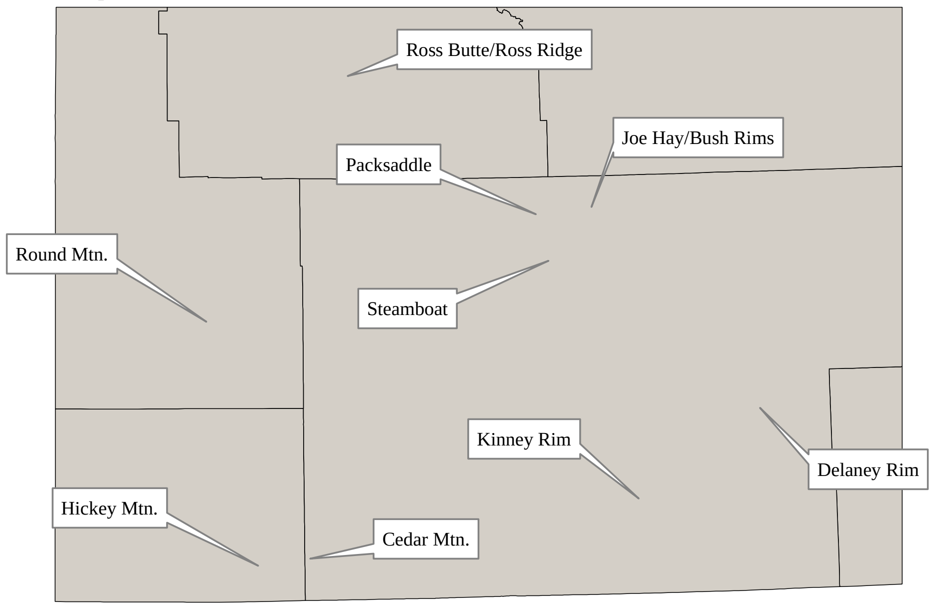


Figure 15. Locations of sample plots in the 6 plot groups.

Group 1



Group 2

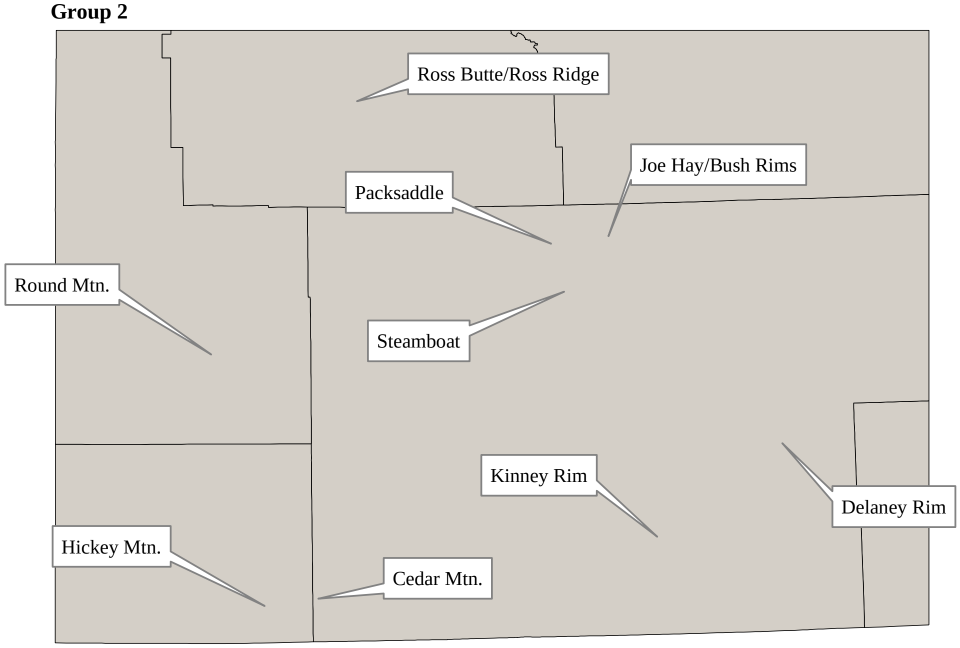
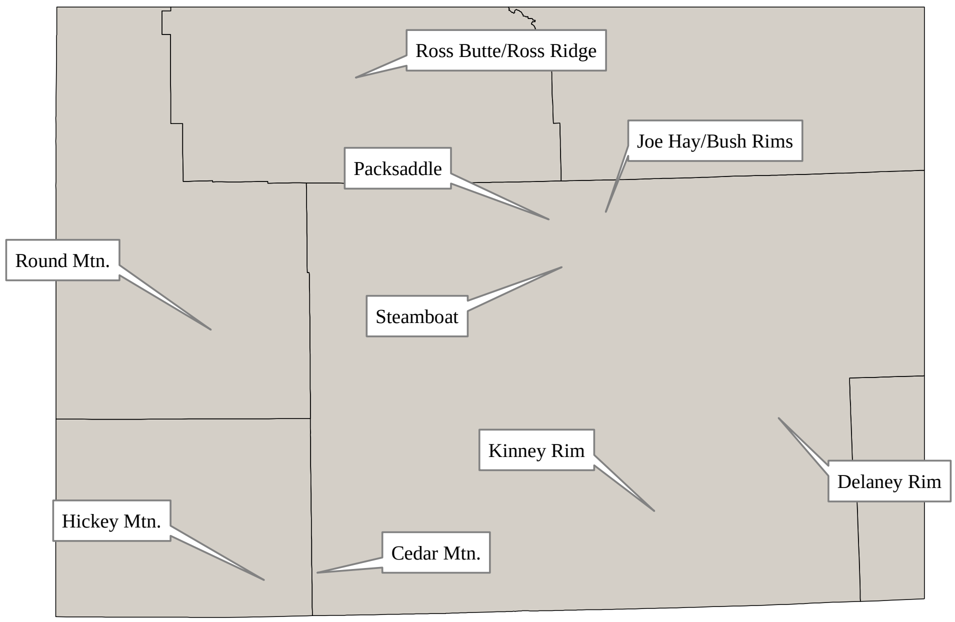


Figure 15 (continued).

Group 7



Group 8

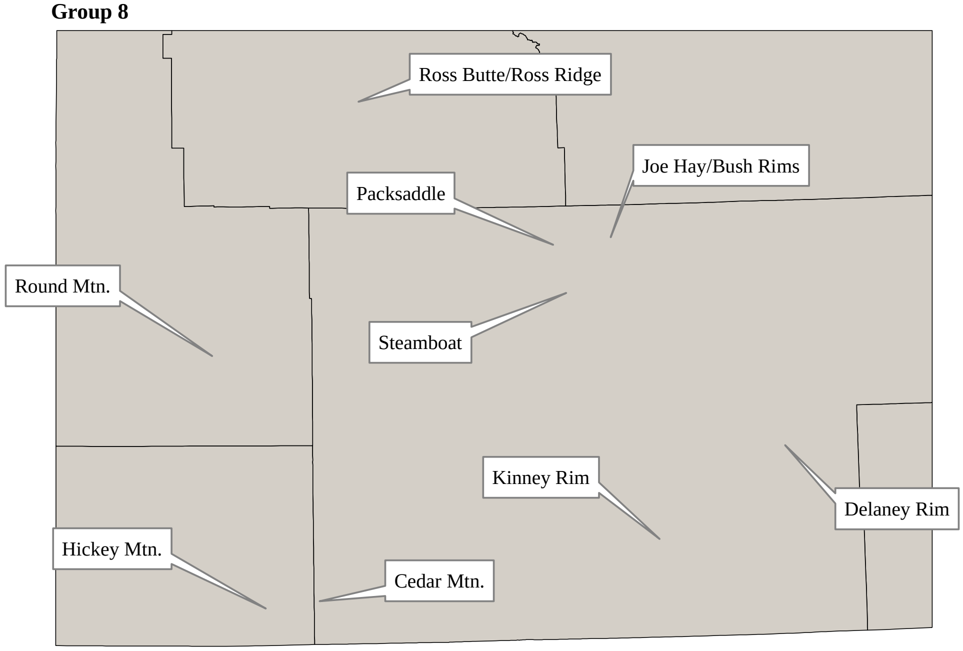
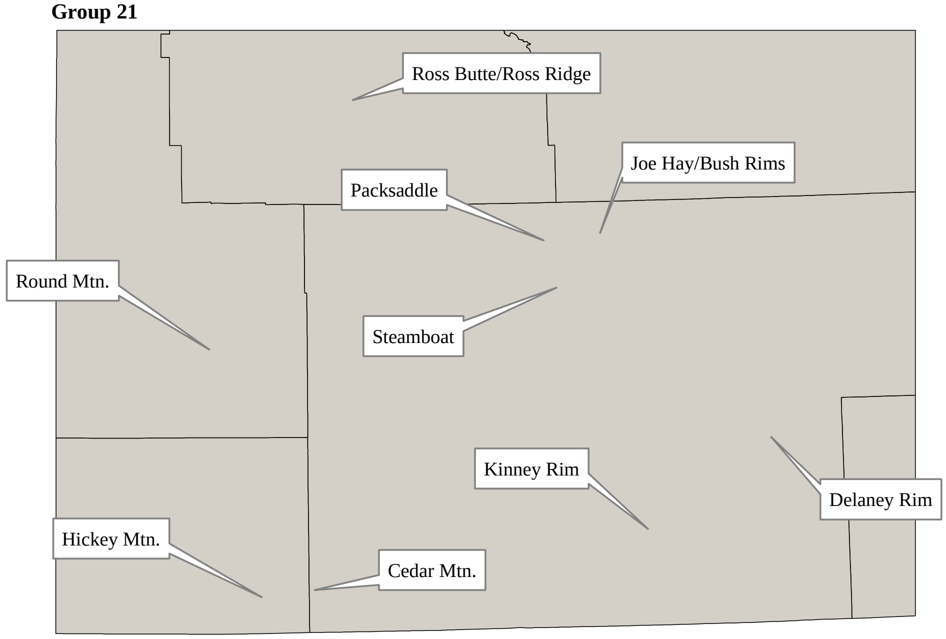


Figure 15 (continued).

Group 21



Group 28

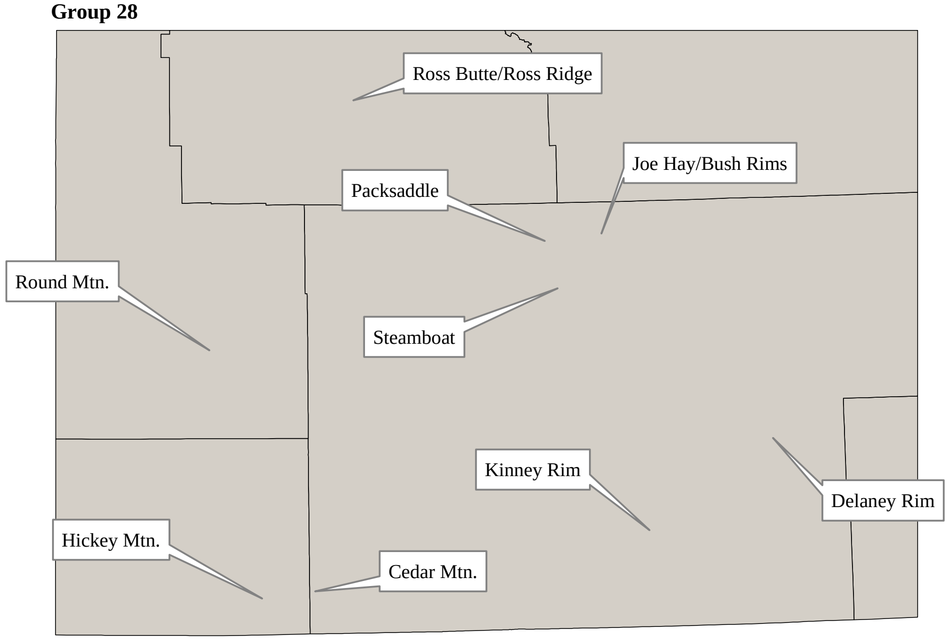
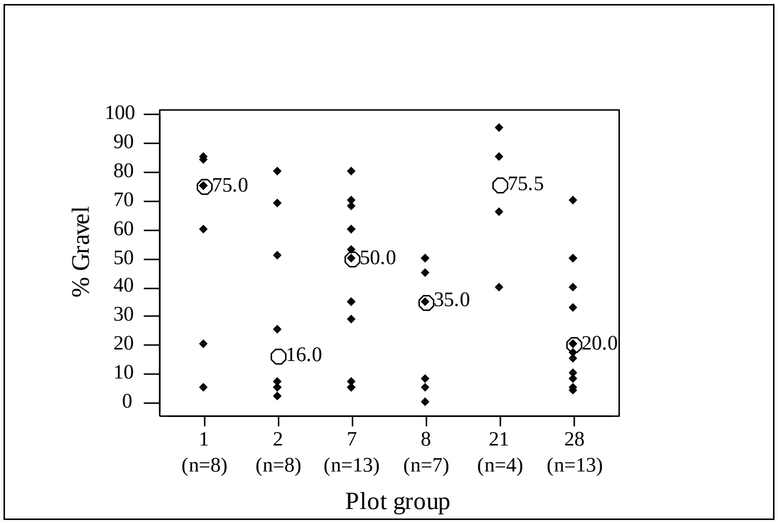


Figure 16. Percent cover of different ground-cover categories in the 6 plot groups. Diamonds are values for individual plots. Circles and numbers are medians for groups.

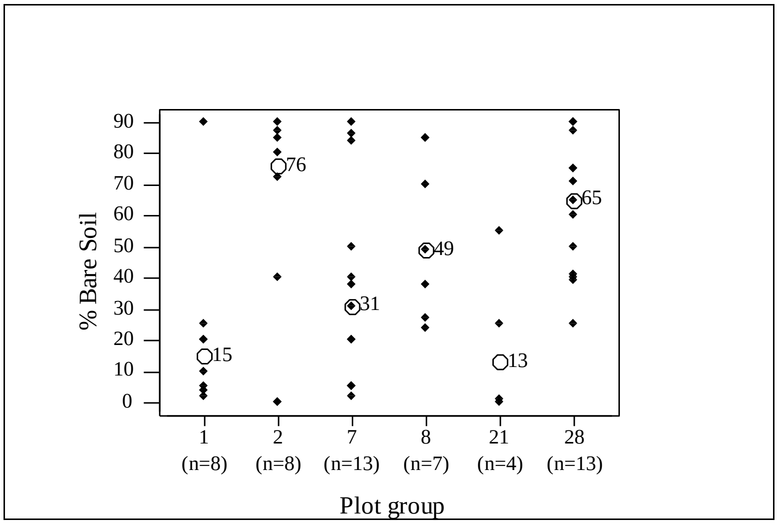
a. Gravel.



Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups but pairwise comparisons were unable to find significant differences between pairs of groups. See Table 23a for details.

Figure 16 (continued).

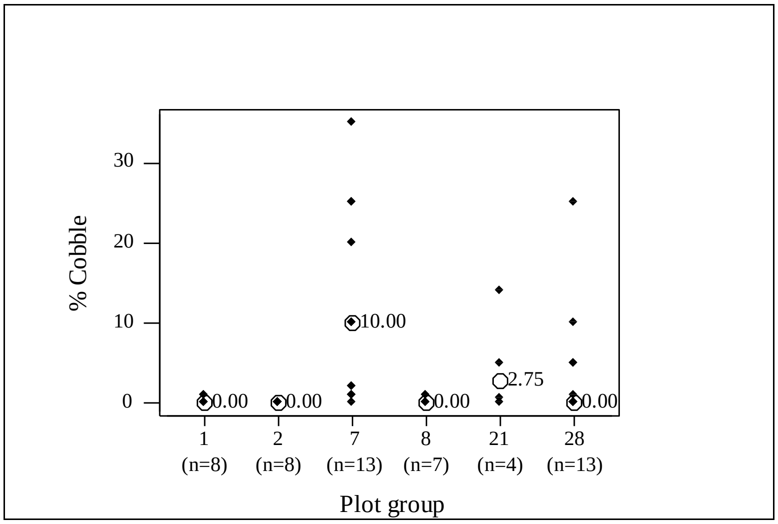
b. Bare Soil.



Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups but pairwise comparisons were unable to find significant differences between pairs of groups. See Table 23b for details.

Figure 16 (continued).

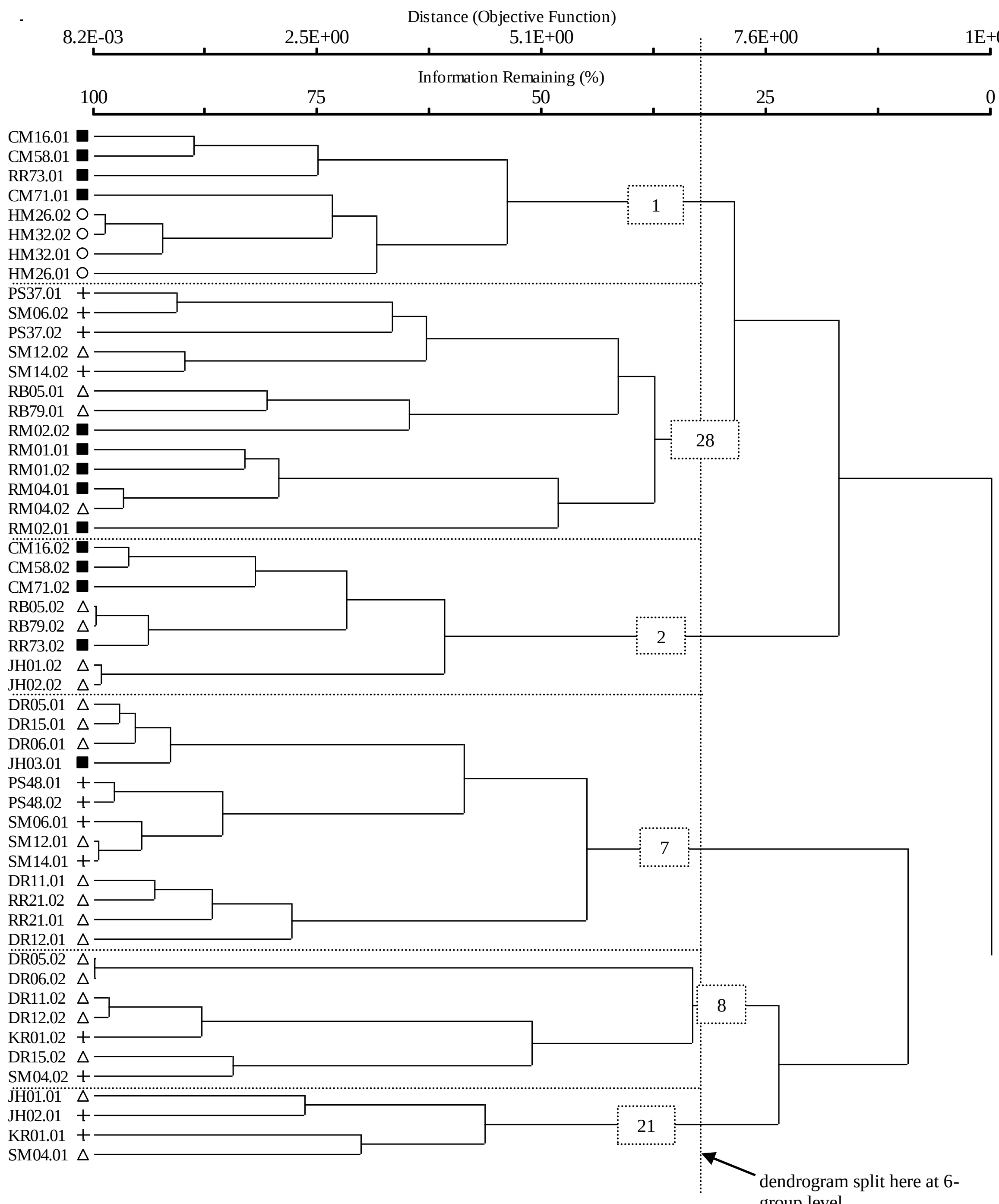
c. Cobble.



Kruskal-Wallis test showed that significant differences (p=0.05) exist among groups. Pairwise comparisons showed this pattern of significant differences. (Lines beneath mean ranks link groups that do not differ significantly). See Table 23c for details.

Groups (by mean rank)	2	1	8	28	21	7
Rank Sum	120	159	144	335.5	125	527.5
N	8	8	7	13	4	13
Mean Rank	15.00	19.88	20.57	25.81	31.25	40.58

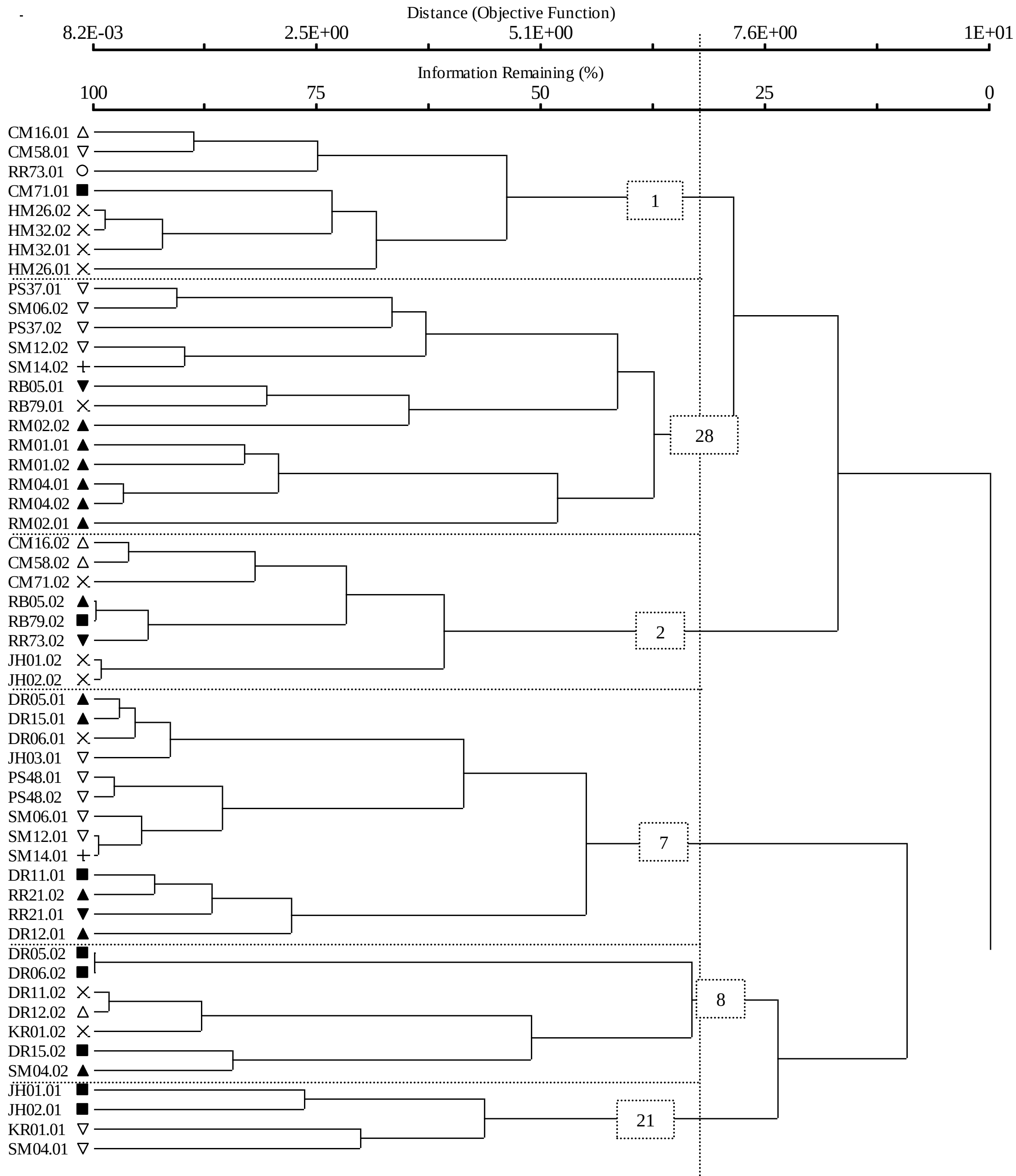
Figure 17. Classification of sample plots based on relative canopy cover, showing substrate types. Plot group numbers are shown on dendrogram branches. Symbols denote the bedrock types on which the plots were located.



Substrate Types (see Table 3)

+ Oil shale. △ Sandstone. ■ Tuffaceous Sandstone. ○ Landslide Deposits

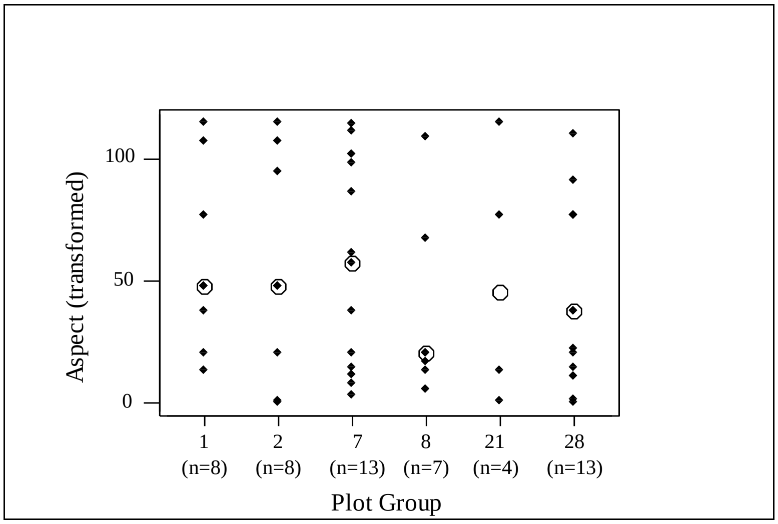
Figure 18. Classification of sample plots based on relative canopy cover, showing soil textural classes types.
Plot group numbers are shown on dendrogram branches. Symbols denote the soil textural classes on which the plots were located.



Soil Textural Classes:

■ Clay Loam ○ Loam + Loamy Sand X Sandy Clay Loam ▼ Silty Clay ▲ Silty Clay Loam
△ Silt Loam ▽ Sandy Loam

Figure 19. Aspects (transformed) of plots within each of the 6 groups based on canopy cover.



Kruskal-Wallis test showed no significant difference (p=0.50) among groups. See Table 25 for details.

APPENDIX 1. DETAILED DESCRIPTIONS OF SAMPLE PLOTS USED IN THE ROCK SPRINGS FIELD OFFICE CUSHION-PLANT VEGETATION SURVEY.

The plot descriptions are contained in a separate digital file, "RS_CusPl_Plot_App1".

APPENDIX 2. PHOTOGRAPHS OF SAMPLE PLOTS FROM THE ROCK SPRINGS FIELD OFFICE CUSHION-PLANT VEGETATION SURVEY.

The photographs are contained in a separate digital file, “RS_ CushPl_Photo_ App2”.