

SANUP PLATEAU GRAZING IMPACT STUDY

USDA-KAIBAB NATIONAL FOREST

SOUTHWESTERN REGION

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## SUMMARY

The grazing impact evaluation of the Sanup Plateau was initiated in April 1984 through a Memorandum of Understanding between the Grand Canyon National Park and Kaibab National Forest. Of the 290,000 acres within this western region of the Park, approximately 193,500 acres were inventoried. The remaining acres were not because of their inaccessibility to livestock and/or the area was not included in an existing allotment.

The main objective of this study was to compare plant community composition, forage production, range condition, effective ground cover, depth of A horizon, and total soil depth between relict and grazed sites to determine if grazing has influenced these various factors.

The means to accomplish this objective was to compare areas that have been historically inaccessible to livestock. During the course of the survey, ten inaccessible sites were inventoried. Two additional plots also sampled were physically accessible to livestock although they were so far from dependable water that for all practical purposes, they are also relict.

Of the sixteen map units identified in the survey, only three (units 182, 183, and 192) were correlated with relict condition. Within these three units, five samples occurred in unit 182, three in unit 183, and four in unit 192. A total of 44 samples which includes the 12 relict or lightly grazed plots, were used in the ordination.

Under grazed conditions, total canopy cover by grasses was greatly diminished in units 182 and 192. The mean canopy cover by grasses under relict and/or lightly grazed conditions for units 182 and 192 was 19.61 and 37.69 percent respectively as compared to 3.67 and 5.59 percent under grazed. This represents a net decrease in canopy cover by the grass species of five to six times over ungrazed or lightly grazed conditions. Unlike units 182 and 192 which represent the grassland biotic communities, unit 183 did not have significant differences in the graminoid component between grazed and ungrazed conditions. The data supports the conclusion that the shallow highly calcareous nature of the taxonomic components will not support desirable forage species regardless of grazing practices.

Not only was overall canopy cover by grasses diminished between grazed and ungrazed conditions but also canopy cover by cool season species. In most cases, these highly valuable forage species were virtually eliminated under grazed conditions. Within unit 182 under grazed conditions, the mean canopy cover by these species was .01 percent or less. In contrast under relict or ungrazed conditions within unit 182, the mean canopy cover by cool season grasses was found to be approximately 5 percent. Range condition for this unit was typically poor and very poor under grazed conditions and good to excellent under relict.

Unit 192 followed essentially this same pattern as unit 182 with large decreases of canopy cover by forage species as well as a general loss of cool season grasses under grazed conditions.

Total forage production was consistently higher on relic sites than grazed in all three units although production was extremely low on both grazed and ungrazed sites in unit 183. The mean production on unit 182 was reduced from 485 lbs/acre under relict condition to 112.5 lbs/acre under grazed. Unit 192 followed the same pattern with relict sites being inventoried with a mean production of 571.5 lbs/acre whereas grazed sites were inventoried at only 120 lbs/acre. Within both units, mean production was reduced by a factor of approximately four.

Effective ground cover differed greatly units 182 and 192 between grazed and ungrazed conditions, whereas unit 183 did not differ significantly. The mean ground cover for unit 182 and 192 under ungrazed conditions was 39.70 and 42 percent respectively. Within these units under grazed conditions, unit 182 was reduced to a mean of 18.2 percent and Unit 192 to 18.8 percent. This loss in ground cover can be attributed to grazing pressure with a reduction in the hits on the basal area of grass plants as well as reduced litter.

In conclusion, significant differences do occur between grazed and ungrazed conditions within the Sanup Plateau. This situation is the direct result of a continuous grazing system which allows livestock to use the same area every year with no rest. This has resulted in the virtual elimination of cool season species, reduced percentages of the warm season grasses, and generally poor range condition for those units being grazed that can support grassland communities.

## INTRODUCTION

This soils and range research evaluation of the Sanup Plateau was initiated in April 1984 through a Memorandum of Understanding between Grand Canyon National Park and Kaibab National Forest. With the passage of Public Law 93-620, the Secretary of the Interior was mandated to terminate grazing permits within those portions of the Sanup Plateau currently being grazed. Of the 290,000 acres within this western region of the Park, approximately 193,500 acres were inventoried. The remaining acres were not inventoried because of their inaccessibility to livestock and/or the area was not included in an existing allotment.

Although the overall objectives of the Sanup Plateau study include the determination of grazing capability, range condition, soil taxonomic units, and an estimated capacity, these resources are covered under a separate document entitled the "Range and Soils Evaluation of the Sanup Plateau." The objectives of this evaluation are narrower and include:

1. A description of the flora, soils, and other ecological parameters of plant communities within the Sanup Plateau Study Area.
2. Through the use of multivariate techniques, compare plant community composition, forage production, range condition, effective ground cover, depth of A horizon, and total soil depth between relic and grazed sites to determine if grazing has had an influence on these stated resources.

The extent of the impacts whether positive or negative of grazing on western rangelands and the relationship between factors contributing to those impacts have been a subject of controversy. To accomplish the stated objectives of this report and to reconstruct plant communities prior to grazing, one of the most widely accepted methods is to compare ecological data from grazed areas to adjacent areas which have been historically inaccessible to livestock. These relic areas, which have not been subjected to grazing, provide an understanding of the pre-livestock ecology. Relic areas represent the natural potential or climax condition because they are by definition unchanged by the influences of grazing practices. These sites also serve as benchmarks in attempts to improve the plant composition by non-structural range improvement projects.

This portion of the Grand Canyon National Park is dominated by steep vertical cliffs and the Sanup Plateau. The Plateau itself is a relatively level bench atop the esplanade sandstone roughly 1,000 feet below the canyon rim. Livestock gain access through five to seven long canyons that divide the plateau into several irregular benches. Dependable waters are normally located within several large canyons although there is at least one spring located off Twin Springs Point which is not associated with a large drainage. The area receives approximately 10 to 14 inches annually with a mean of 12 inches. Summer precipitation is associated with moist air derived from the Gulf of Mexico whereas winter precipitation is the result of large frontal systems originating in the Pacific Ocean. The driest months are normally May and June.

Vegetation is quite diverse due to the modified effects of soils, climate, and aspect. Compounding this is the fact that vegetation associated with the Mojave Desert and Great Basin and Range meet within the General area of the Sanup Plateau.

The dominant terrestrial ecosystem is considered a desert/shrub community with the key indicator species being blackbrush (Coleogyne ramosissima). Other shrubs including Utah Agave (Agave Utahensis) turpentine bush (Thamnosma montana), and snakeweed (Gutierrezia) are associated with this vegetative type, however their combined composition normally does not exceed that of blackbrush. Open woodland vegetation is characterized by single-leaf pinyon pine (Pinus monophylla) and Utah juniper (Juniperis osteosperma). The replacement of pinyon pine (Pinus edulis) by single-leaf pinyon pine and the conspicuous lack of big sagebrush (Artemisia tridentata) in the understory indicates a climatic shift to more Mojave Desert influence. This situation was especially prevalent within the portion of the survey area south of the Colorado River (i.e., Grand Wash Hook). Within this section, Joshua tree (Yucca brevifolia) was inventoried consistently within several map units. Where edaphic properties permitted (i.e., moderately deep and deep soil depths and the lack of significant internal coarse fragments) grassland communities prevailed. These vegetative associations were normally dominated by black grama (Boutelous eripoda) with lesser concentrations of such species as needle and thread (Stipa comata), Indian ricegrass (Oryzopsis hymenoides) and galleta (Hilaria jamesii).

The history of grazing use on the Sanup Plateau and the Grand Wash Hook, up until very recent times, is sketchy. The Grand Wash Hook area probably had cattle grazing as early as 1850 when the first cows were trailed through Arizona to California from Texas. (1) Use probably was accelerated with the construction of a railroad to Peach Springs around 1882. (1). Historical records indicate that by 1899, a severe drought coupled with overgrazing by cattle was making the economics of the ranching business marginal. (1). In 1901, most of the cattle were removed from the area. (1). How much of the Grand Wash Hook area within the Park boundaries was impacted after 1901 is unknown.

Cattle grazing on the Sanup Plateau probably began in the mid-1860's when a sawmill at Mt. Trumbull was established. (2) The Trumbull area provided excellent summer range, but when winter set in, cattle sought the lower elevations east and west of it which probably means portions of the Sanup. Large scale grazing of the Sanup Plateau probably did not begin until the introduction of sheep to the Arizona Strip. By the 1920's, estimates of up to half a million head of sheep were wintering in the Arizona Strip which includes the Sanup Plateau Study Area. (2). During this time period, the cattle industry also increased their herd sizes and the limitation of the strip country inevitably lead to conflicts between ranchers and sheepmen.

The only records available at this time concern the Parashaunt and Dripping Springs Allotments. The term permit for the Parashaunt appears to be 370 head with a season of use from 01 November to 01 June. Of the total 202,000 acres within this allotment, 118,000 acres (58 percent) occurs within the boundaries of the Grand Canyon National Park.

The Dripping Springs Allotment was established in 1938 and the term permit on this allotment is 42 head with a season of use from 01 November to 01 June. Of the 17,000 acres in this allotment, 7,000 acres (41 percent) occurs within the boundaries of the Grand Canyon National Park.

Records on the remaining two allotments (i.e., Home Ranch, Diamond Bar) are not available. It appears that the Home Ranch Allotment has received non-use for the last several years on that portion of the allotment within the Grand Canyon National Park. Of the 107,000 acres within the allotment, 49,000 acres (46 percent) falls within the Park. The Diamond Bar Allotment, although not the smallest ranch with acreage in the Park (20,000), does have the lowest percentage (29 percent). This allotment is confined to the Grand Wash Hook area which is south of the Colorado River.

## METHODS AND PROCEDURES

In order to compare a large number of grazed and ungrazed sites for similarities in plant community composition, simple correlation coefficients (e.g. Sorensen's) were deemed impractical and inefficient. Multivariate techniques, which accommodate numerous species and samples simultaneously are more efficient for describing plant community similarities and dissimilarities. For these reasons, plant community ecologists commonly rely on the visual recognition of variable patterns to interpret the environmental aspects of their data sets. Ordination techniques have been designed specifically for this purpose.

The ordination technique, reciprocal averaging (3), or "correspondence analysis," was chosen for elucidating plant community patterns in this study (4). Reciprocal averaging was selected in favor of other very similar techniques such as principal components analysis, because of its superior results with large, heterogeneous data sets, plus its convenience, objectivity and ease of interpretation.

Ordination serves to reduce the inherently high dimensionality of community data to a low dimensional space (of typically one to three major axis) in which similar species and samples are close together and dissimilar entities are far apart. A two-step procedure for deriving results is standard. The first ordination is used to summarize and graphically display community patterns, whereas the second reveals the community patterns which are then related to environmental information in order to produce an ecological interpretation of the ordination results.

The data used in the ordinations for this study were the canopy coverages by species described for each 1/10 acre plot surrounding the soil pits. Canopy coverage was assumed to be a more complete account of the plant community on a site than that derived from a pace transect. Although pace transects are perfectly valid for relative frequency analyses and the determination of range condition, not all species present on a site are typically encountered.

In order to eliminate the effects of relatively rare species, only those species which occurred on at least three plots were employed in our ordination analyses.

Due to the extremely similar morphology of wolfberry (Lycium andersoni) and desert almond (Prunus fasciculatum), these two species were combined for analysis. Only minor amounts of ecological information were sacrificed by this procedure. In most cases, the two species typically occurred together in nature and have very little differences in their ecology.

In order to determine if there were significant differences in effective ground cover, forage production, depth of the A horizon and/or total soil depth between grazed and relic sites, a stepwise discriminant analysis was employed. Discriminant analysis is a multivariate technique which provides statistical tests for measuring the success with which a set of variables can actually discriminate between two or more groups when combined into discriminant functions.

Because all of the variables might not be necessary to achieve satisfactory discrimination between the grazed and relic sites, and that it was extremely important to select the most important of the various variables, the stepwise procedure was used. The stepwise procedure begins by selecting the single best discriminating variable according to the criteria. At each subsequent step variables already selected may be removed from the function if their ability to discriminate between groups becomes inferior to some combination of other variables. The stepwise procedure ends when either all variables are selected or the remaining variables are not able to contribute to the discrimination (i.e., if they are statistically insignificant).

The criterion used for discrimination in this analysis was Wilk's Lambda. This method utilizes the overall multivariate F-ratio among the group centroids. Discriminating variables are selected which maximize this ratio and concomitantly minimizes the Wilk's Lambda, which is a measure of group discrimination. (9).

Inclusion of range condition scores in this discriminant analysis was considered and rejected because range condition scores are based on the concept of natural potential and are calculated to reflect a site's "ecological distance" from this natural state. Any attempt to use range condition scores as criteria for distinguishing between grazed and ungrazed sites would be pointless, since the differences are inherent.

The first step in the sampling of the soils and vegetation of the Sanup Plateau was a reconnaissance and familiarization of the study area. The vegetation was visually abstracted into terrestrial ecosystems. Once intensive sampling was initiated within the study area, plots were objectively located within plant communities.

At each data point, a standard soil profile description and canopy coverage for perennial species was determined. (5). Descriptions for each horizon included horizon designation, depth, color (dry and moist), texture, structure, consistence (dry, moist, and wet), lower boundary, roots, pores, and pH (Truog Soil Reaction Test).

A fifty pace line transect was taken also at each pit location. Information on the percent grasses, forb, shrub basal area, coarse fragments, rock outcrop, and bare soil was collected. This data was then used to determine the effective ground cover within the ecosystem the profile is located in.

Canopy average was recorded for each perennial species in the following manner. At the plot center which is where the soil profile was described, 375m<sup>2</sup> (0.1 acre) plot was paced off. The plot was then divided into quarters and the amount of canopy cover by a particular species determined. Data from each subplot was aggregated together to get the total canopy cover for that species. A cover value listed as a trace was assigned a value of 0.01 percent.

Range condition is based on a 50 paced transect, much like the transect used in soils to derive effective ground cover, however, several differences do exist and they are:

1. At each point, the closest perennial plant (i.e., tree, forb, or gramineoid) is recorded. As an example, if a hit on litter is recorded, the closest plant within an 180° arc in front of that point would also be shown within the dot tally section on the pace form. If a hit on the basal area of any plant occurs, then a dot tally is not required. This method allows the determination of plant frequency.

2. The ability to determine range condition scores is based on the correct placement of the species into its appropriate category (i.e., decreaser, increaser, or invader). Table 1 is the species classification list used to develop range conditions ratings during the Sanup Plateau inventory.

These scorecards are the cumulative result of previous inventories within the same biotic communities and/or areas on adjacent National Forest Systems lands that are similar to it. (7).

Table- 1. Species Classification List Used to Determine Range Condition  
Within the Sanup Plateau Study Area. 1/

I. Decreasers

| SYMBOL(S)                 | SCIENTIFIC NAME <sup>2/</sup>                      | COMMON NAME               |
|---------------------------|----------------------------------------------------|---------------------------|
| Grasses:                  |                                                    |                           |
| (ANDR)                    | <u>Andropogon</u>                                  | Bluestem species          |
| (Bocu)                    | <u>Bouteloua curtipendula</u>                      | Side-oats grama           |
| (Boer)                    | <u>Bouteloua eriopoda</u>                          | Black grama               |
| (Hiri)                    | <u>Hilaria rigida</u>                              | Big Galleta               |
| (Mupo)                    | <u>Muhlenbergia porteri</u>                        | Bush muhly                |
| (Orhy)                    | <u>Oryzopsis hymenoides</u>                        | Indian ricegrass          |
| (Pofe, POA)               | <u>Poa fendleriana</u>                             | Muttongrass               |
| (SiHy)                    | <u>Sitanion hystrix</u>                            | Squirreltail, Bottlebrush |
| (Stco)                    | <u>Stipa comata</u>                                | Neddle and thread         |
| (Stde)                    | <u>Stipa coronata</u> var. <u>depauperata</u>      | Neddlegrass               |
| (Lyph)                    | <u>Lycurus phleoides</u>                           | Wolftail                  |
| Forbs:                    |                                                    |                           |
| Shrubs (including cacti): |                                                    |                           |
| (Atca)                    | <u>Artriplex canescens</u>                         | Four wing saltbush        |
| (Eula)                    | <u>Ceratoides lanata</u> ( <u>Eurotia lanata</u> ) | Winterfat                 |
| (Cegr)                    | <u>Cenonothus greggii</u>                          | Desert buckbrush          |
| (Cemo)                    | <u>Cercocarpus montanus</u>                        | Mountain mahogany         |
| (Come)                    | <u>Cowania mexicana</u>                            | Cliffrose                 |
| (Erfa)                    | <u>Eriogonum fasciculatum</u>                      | California buckwheat      |
| (Fapa)                    | <u>Fallugia paradoxa</u> (0-15%)                   | Apache plume              |
| Trees:                    |                                                    |                           |

1/ All plants not identified as to species are to be considered as invaders unless otherwise classified. This list is tentative and is subject to revision.

2/ Nomenclature follows Lehr, J.H. 1978.  
A catalogue of the flora of Arizona Desert Botanical Garden, Phoenix, AZ.

## II. Increasers

| SYMBOL(S)                 | SCIENTIFIC NAME 2/                                                           | COMMON NAME        |
|---------------------------|------------------------------------------------------------------------------|--------------------|
| Grasses:                  |                                                                              |                    |
| (Star)                    | <u>Stipa arida</u>                                                           | Needlegrass        |
| (Stsp)                    | <u>Stipa speciosa</u>                                                        | Desert Needlegrass |
| (Hija)                    | <u>Hilaria jamesii</u> (I-15%)                                               | Galleta            |
| (Spco)                    | <u>Sporobolus contractus</u>                                                 | Spike dropseed     |
| (Spcr)                    | <u>Sporobolus cryptandrus</u>                                                | Sand dropseed      |
| (Spfl)                    | <u>Sporobolus flexuosus</u>                                                  | Mesa dropseed      |
| (Trel)                    | <u>Tridens muticus</u> var. <u>elongatus</u><br>( <u>Tridens elongatus</u> ) | Tridens            |
| (Trmu)                    | <u>Tridens muticus</u>                                                       | Tridens            |
| (Bogr)                    | <u>Boutelous gracilis</u>                                                    | Blue grama         |
| Forbs:                    |                                                                              |                    |
| Shrubs (including cacti): |                                                                              |                    |
| (Artr)                    | <u>Artemisia tridentata</u> (I-5%)                                           | Sagebrush          |
| (Cora)*                   | <u>Coleogyne ramosissima</u>                                                 | Blackbrush         |
| (EPHE, Epvi,<br>Epne)     | <u>Ephedra spp.</u>                                                          | Mormon-tea         |
| (NOLI)                    | <u>Nolina bigelovii</u> (I-15%)                                              | Beargrass          |
| (Qutu)                    | <u>Quercus turbinella</u>                                                    | Shrub live oak     |
| (Quun)                    | <u>Quercus undulata</u>                                                      | Wavy leaf oak      |
| (Rhtr)                    | <u>Rhus trilobata</u> (I-10%)                                                | Squawbush          |

\*Note: Cora was classified as increaser to 10% on shallow soils and then an invader. It was classified as strictly an invader on deeper soils.

### III. Invaders

| SYMBOL(S)    | SCIENTIFIC NAME 2/                                            | COMMON NAME          |
|--------------|---------------------------------------------------------------|----------------------|
| Grasses:     |                                                               |                      |
| (ARIS)       | <u>Aristida</u>                                               | Three-awn species    |
| (Trpu)       | <u>Erioneuron pulchellus</u><br>( <u>Tridens pulchellus</u> ) | Fluffgrass           |
| (Muri)       | <u>Muhlenbergia richardsonii</u>                              | Mat muhly            |
| (Scbr)       | <u>Scleropogon brevifolius</u>                                | Burrograss           |
| Forbs:       |                                                               |                      |
| (Ardr)       | <u>Artemisia dracunculus</u>                                  | False tarragon       |
| (Arlu)       | <u>Artemisia ludoviciana</u>                                  | Lyre-leaf sage       |
| (Bamu)       | <u>Baileya multiradiata</u>                                   | Desert marigold      |
| (Copa)       | <u>Comandra pallida</u>                                       | Bastard toadflax     |
| (Dyac)       | <u>Dyssodia acerosa</u>                                       | Dogweed              |
| (ERIG)       | <u>Erigeron spp.</u>                                          | Fleabane             |
| (Erin)       | <u>Eriogonum inflatum</u>                                     | Desert trumpet       |
| (Hasp)       | <u>Haplopappus spinulosus</u>                                 | Spiny goldenweed     |
| (Hylu)       | <u>Hymenopappus filifolius var. lugens</u>                    | --                   |
| (Hyac)       | <u>Hymenoxys acaulis</u>                                      | Bitterweed           |
| (Lase)       | <u>Lactuca serriola</u>                                       | Prickly lettuce      |
| (LEPI)       | <u>Lepidium montanum</u>                                      | Peppergrass          |
| (Leer, Asar) | <u>Leucelene ericoides</u> ( <u>Aster arenosus</u> )          | White aster          |
| (Lile)       | <u>Linum lewisii</u>                                          | Flax                 |
| (MACH)       | <u>Machaeranthera sp.</u>                                     | Purple aster         |
| (Meal)       | <u>Mentzelia albicaulis</u>                                   | White-stem stickleaf |
| (MENT)       | <u>Mentzelia spp.</u>                                         | Stickleaf            |
| (PENT)       | <u>Penstemon spp.</u>                                         | Beardstongue         |
| (PHLO)       | <u>Phlox austromontana</u>                                    | Phlox                |

### III. Invaders (Continued)

| SYMBOL(S)                 | SCIENTIFIC NAME 2/                                          | COMMON NAME             |
|---------------------------|-------------------------------------------------------------|-------------------------|
| Forbs:                    |                                                             |                         |
| (SPHA)                    | <u>Sphaeralcea sp.</u>                                      | Globemallow             |
| (Stpi)                    | <u>Stanleya pinnata</u>                                     | Prince's plume          |
| Shrubs (including cacti): |                                                             |                         |
| (AGAV, Agut)              | <u>Agave utahensis</u>                                      | Utah century plant      |
| (Arpu)                    | <u>Arcostaphylos pungens</u>                                | Manzanita               |
| (Befr)                    | <u>Berberis fremontii</u>                                   | Algerita, Desert holly  |
| (CHRY, Chna,<br>Chvi)     | <u>Chrysothamnus spp.</u>                                   | Rabbitbrush             |
| (ECHI, Ecen)              | <u>Echinocereus Engelmannii</u>                             | Hedgehog                |
| (ECHI, Ectr)              | <u>Echinocereus troglodidatus</u>                           | Hedgehog                |
| (ENCE, Enfa)              | <u>Encelia farinosa</u>                                     | Brittlebush             |
| (ERIOG)                   | <u>Eriogonum spp.</u>                                       | Buckwheat               |
| (Glne, Fone)              | <u>Forsellesia nevadense</u><br>( <u>Glossopetalon n.</u> ) | Greasebush              |
| (GUTI, Gusa)              | <u>Gutierrezia spp.</u>                                     | Snakeweed               |
| (LYCI, Lyan,<br>Lypa)     | <u>Lycium spp.</u>                                          | Wolfberry               |
| (Mosc)                    | <u>Mortonia scabrella</u>                                   | Scurfy mortonia         |
| (OPUN, Opph)              | <u>Opuntia spp.</u>                                         | Prickly pear cactus     |
| (CHOL, Opac)              | <u>Opuntia spp.</u>                                         | Cholla, Buckhorn cholla |
| (Pain)                    | <u>Parthenium incanum</u>                                   | Mariola                 |
| (Prfa)                    | <u>Prunus fasciculatum</u>                                  | Desert Almond           |
| (Thmo)                    | <u>Thamnosma montana</u>                                    | Turpentine bush         |
| (YUCC, Yuba)              | <u>Yucca baccata</u>                                        | Soapweed                |
| (Yuan, Yubr)              | <u>Yucca anguitissima</u>                                   |                         |

### III. Invaders (Continued)

| SYMBOL(S) | SCIENTIFIC NAME 2/           | COMMON NAME        |
|-----------|------------------------------|--------------------|
| Trees:    |                              |                    |
| (Chli)    | <u>Chilopsis linearis</u>    | Desert willow      |
| (Juos)    | <u>Juniperus osteosperma</u> | Utah juniper       |
| .(Pimo)   | <u>Pinus monophylla</u>      | Single leaf pinyon |

## RESULTS

There were more plots studied on the Sanup than were used in this analysis. Many plots were eliminated from formal analysis because they had been recently burned or the data was incomplete. Ten relic sites were inventoried on six isolated mesas. Also considered to be little grazed by livestock were plots 182-10 and 182-9 because of their distance from any dependable water source. The relic sites studied were representative of mapping units 182, 183 and 192.

The vegetation of units 182 and 192 was characterized by relatively high canopy coverages by grass species (Table 2). The vegetation of unit 183, however, was predominantly shrubs.

Table 1 also shows some broad vegetative differences between grazed and relic sites within each mapping unit. Within unit 182, grazed sites had a greater abundance of shrub cover and lower abundance of grass cover than the relic sites in the same mapping unit which were not grazed. Within unit 183 there were only negligible differences. Unit 192 typically follows the same pattern as unit 182 in that under grazing pressure, there is a net decrease in the canopy cover of grasses with a corresponding increase in the shrub component.

Table 2. Mean absolute canopy cover by forage classes in Map Units 182, 183, and 192.

| Canopy Cover             | 182    |       |  | 183    |       |  | 192    |       |
|--------------------------|--------|-------|--|--------|-------|--|--------|-------|
|                          | Grazed | Relic |  | Grazed | Relic |  | Grazed | Relic |
| Trees                    |        |       |  | .02    |       |  | .91    |       |
| Shrubs<br>(incl. cactus) | 15.35  | 5.56  |  | 33.26  | 29.17 |  | 4.33   | 2.56  |
| Forbs                    | .12    | .04   |  | .004   | .18   |  | 3.37   | .10   |
| Grasses                  | 3.67   | 19.61 |  | .64    | .71   |  | 5.59   | 37.69 |
| Total                    | 19.13  | 25.20 |  | 33.93  | 30.06 |  | 11.14  | 40.34 |

The ordination techniques were used to more specifically define these differences in composition between mapping units and also between grazed and ungrazed sites within a map unit.

An overview type of ordination was first conducted employing data from all the plots representative of these three M.U.'s with relic sites. This preliminary ordination included 44 samples: 16 from unit 182, 14 from unit 183, and 14 from unit 192. There were 12 samples which were from relic and/or lightly grazed areas. This breaks down to five in unit 182, three in unit 183, and four in unit 192.

It must be understood that ordination scores are relative ratings of each site in terms of their species composition. They are scored according to how similar they are, such that the most similar are closest together and the most different are furthest apart. The first axis explains the most variation in the data with the second accounting for the second most and the third the most. Although the axis are not labeled, they could be considered relative similarities or dissimilarities for each site.

The first ordination (Figure 1) employed 24 of the 41 species totalled for the 44 samples. The first axis of this ordination accounted for approximately 25 percent of the variation in the data matrix, the second axis accounted for nearly 18 percent and together they accounted for a total of nearly 43 percent of the variation.

Figure 1 illustrates the large difference between plots in unit 183, which were dominated by shrubs and those plots in units 182 and 192 which were characterized by having an abundance of grasses. Plots, such as those in unit 183, which clustered at the upper left corner of the ordination graph, had high canopy cover values of blackbrush (Coleogyne ramosissima), turpentine bush (Thamnosma montana) and agave (Agave utahensis). Plots, such as those in units 182 and 192, which were ordinated predominantly at the lower center and lower right side of Figure 1, had high canopy coverage values of snakeweed (Gutierrezia sp.), Indian ricegrass (Oryzopsis hymenoides), three-awn (Aristida spp.), and globemallow (Sphaeralcea sp.). Those nine plots which clustered at the upper right corner of the ordination graph were all (with only one exception) plots from relic sites. These nine plots differed from the others in having relatively high canopy cover values of the valuable forage plants: the needlegrasses (Stipa spp.), black grama (Bouteloua eriopoda), and winterfat (Ceratoides lanata).

Only one plot, relic site #182-25, appeared to be a real "outlier" in Figure 1. Although this plot was classified as unit 182, it was not typical in having a relatively high abundance of shrubs and thus showed more vegetative similarities to plots in unit 183 than to plots in unit 182. That plot 182-25 is actually at an ordinated position on the first two axes which is unlike any other plot is largely due to its high abundance of the valuable forage species, winterfat. The reason plot 182-25 ordinated so radically different from either plots within units 182 or 183 is that it was described immediately on the break between these two units, hence its classification of outlier. For that reason, it was inventoried not only with high canopy cover percentages of desirable grass species but also blackbrush.

In order to eliminate the effect of compositional differences between plots in different mapping units (or vegetative communities) and further elucidate the compositional differences due to grazing, we ordinated samples in each mapping unit separately.

Figure-1. Ordination Results for Map Units 182, 183 and 192.

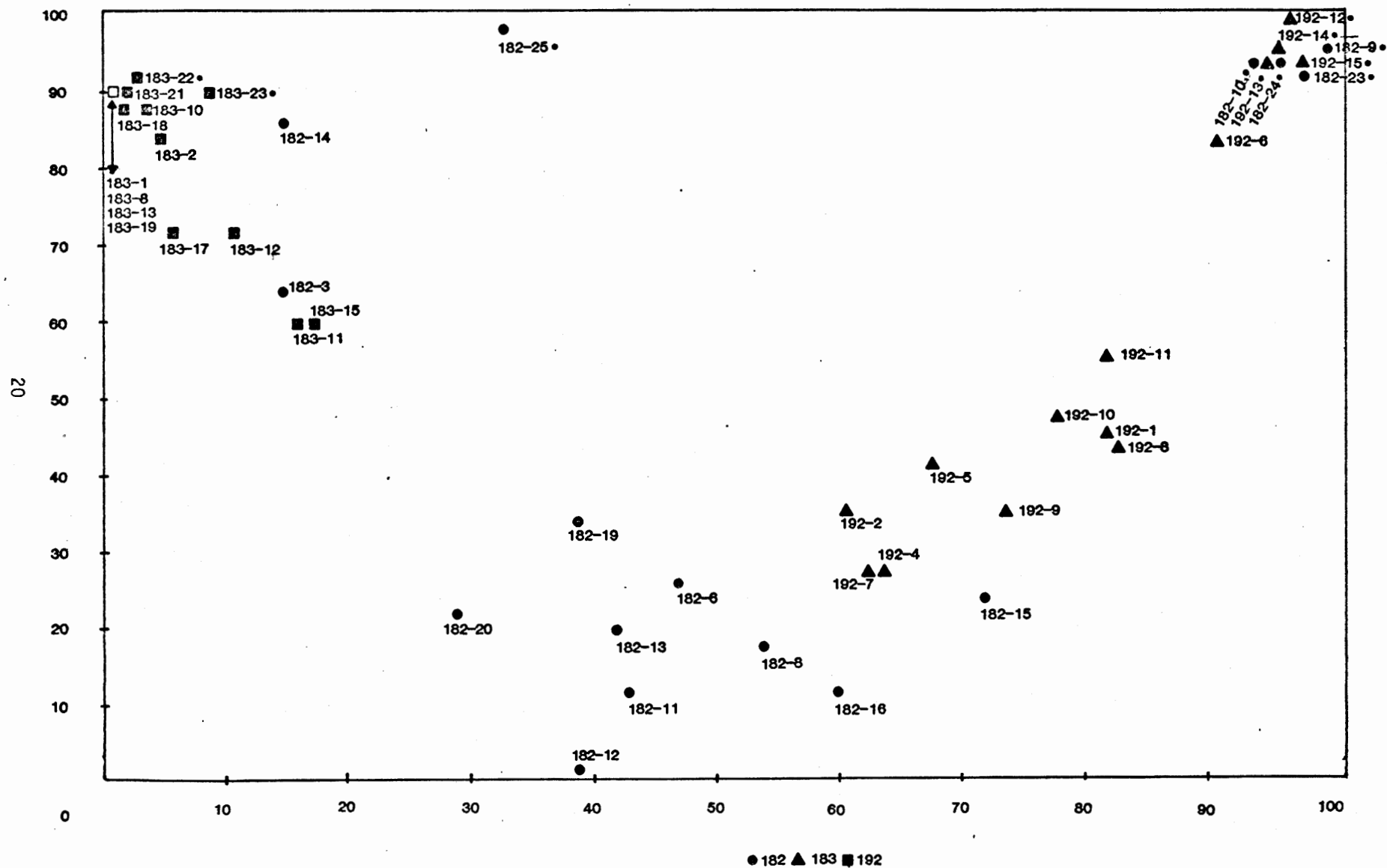


Figure-2. Ordination Results for Map Unit 182

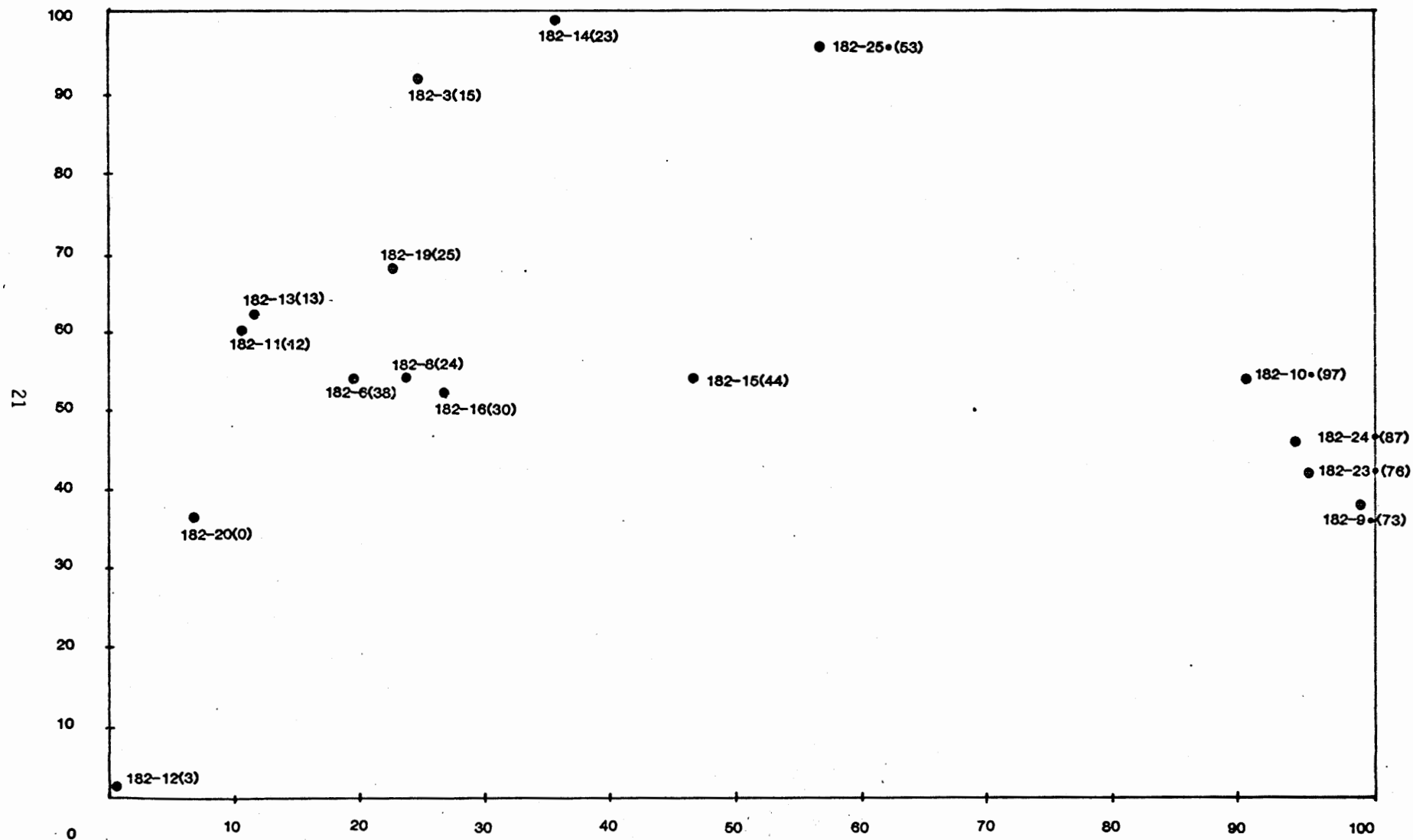


Figure 2 graphically depicts the location of plots in unit 182 on the first two axes of the second ordination. This ordination employed 16 samples, five of which were relics. It employed 20 species which occurred on no less than three plots. The first axis accounted for approximately 29 percent and together they accounted for approximately 50 percent of the total variation.

As can be seen in figure 2, four of the five relic sites in it are clustered together at the far right end of the ordination graph. These four relic sites were compositionally different from the majority of the plots in unit 182 in having relatively high abundances of the high quality forage grasses including needlegrasses, black grama and squirreltail (Sitanion hystrix).

The majority of plots in unit 182 were from grazed sites and these generally ordinated to the left side of the graph in Figure 2. These grazed plots were predominantly different from the relic sites (on the right end) in having relatively high canopy coverage by the least desirable forage plants: burrograss (Scleropogon brevifolius), wolfberry (Lycium spp.), and snakeweed.

Table 2 shows the canopy cover values recorded for each of the 16 plots in unit 182. In Table 2, samples and species are both arranged in order of their ordination scores on the first axis. This was done to effectively illustrate the compositional differences in vegetation between plots. As already mentioned, ordination scores arrange the most similar entities close together and the most dissimilar farthest apart.

That the large difference in composition between the relic plots and the rest of the plots in unit 182 is due to grazing is suggested by the range condition scores calculated for these plots. The range condition scores, which inherently reflect a sample's condition relative to its natural potential, are shown in parentheses in figure 2 and distinctly increase in value from left to right on the first axis.

As previously mentioned in the discussion of the preliminary ordination, the relic site 182-25 may not be typical of unit 182 in that it has high values of blackbrush and winterfat. Although this plot is compositionally unique compared to the rest of the plots in unit 182, it is similar to the grazed plots in having a large abundance of shrub species. However, unlike the grazed plots, it was allied closely to the relic plots in having the highly valuable forage species. In fact, plot 182-25 had the highest canopy coverage by winterfat of all the relic plots in this unit.

Of the 16 samples in unit 182, 14 were employed in the discriminant analysis for this mapping unit. Two samples were omitted due to lack of complete data. As previously mentioned, five of these 14 samples were from relic sites.

Table 2. Absolute canopy coverage by plant species in Map Unit 182.

|                                   | GRAZED     |            |            |            |           |            |           |           |            |            |            | RELIC      |            |            |            |           |
|-----------------------------------|------------|------------|------------|------------|-----------|------------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|-----------|
|                                   | 182<br>-12 | 182<br>-20 | 182<br>-11 | 182<br>-13 | 182<br>-6 | 182<br>-19 | 182<br>-8 | 182<br>-3 | 182<br>-16 | 182<br>-14 | 182<br>-15 | 182<br>-25 | 182<br>-10 | 182<br>-24 | 182<br>-23 | 182<br>-9 |
| <u>Bouteloua eriopoda</u>         |            | .01        |            | .10        | 3.        | 2.         | 2.        |           | .01        |            | .50        | .30        | 6.         | 24.        | 30.        | 6.        |
| <u>Stipa spp.</u>                 |            |            |            |            | .01       | .01        | .01       |           |            | .01        |            | 6.         | 10.        | 5.         | 5.         | .10       |
| <u>Sitanion hystrix</u>           |            | .01        | .01        | .01        | .01       |            | .10       | .01       |            |            |            | .10        | .01        | .10        | .50        | .01       |
| <u>Ceratoides lanata</u>          |            |            |            |            |           |            |           |           |            |            |            | 5.         |            | 2.         |            | .01       |
| <u>Atriplex canescens</u>         |            |            | .01        |            |           |            | 3.        |           | .20        |            | .10        |            | .20        | 3.         | 1.         |           |
| <u>Muhlenbergia porteri</u>       | .50        | .01        | .01        |            | 1.        |            |           |           |            |            |            | .10        | .01        |            | 2.         |           |
| <u>Sphaeralcea sp.</u>            | .01        |            | .01        | .01        | .01       |            | .10       |           | 1.0        |            |            | .01        | .01        | .10        | .01        |           |
| <u>Oryzopsis hymenoides</u>       |            |            | .10        | .01        | .01       | .01        | .50       |           | .01        |            |            |            | .30        | .01        |            |           |
| <u>Hilaria sp.</u>                | .01        |            | .20        |            | 1.0       |            | 2.        |           | 4.         |            | 3.         |            | 2.         |            |            |           |
| <u>Coleogyne ramossissima</u>     | .01        | 2.         | .20        | .01        |           | 5.         |           | 10.       | .10        | .10        | .20        | 13.        | .01        |            |            |           |
| <u>Yucca baccata</u>              |            | .40        | .60        | 2.0        |           |            |           | .20       |            |            |            | 2.         |            | .01        |            |           |
| <u>Aristida spp.</u>              | 1.         |            | .01        |            |           |            |           |           | .10        |            |            |            |            | .40        |            |           |
| <u>Opuntia sp. (prickly pear)</u> |            |            |            | .50        | .01       |            | .01       |           |            |            |            | .20        |            | .01        |            |           |
| <u>Sporobolus spp.</u>            |            |            | .01        | 1.         |           |            |           |           |            | .01        |            | .01        |            | .10        |            |           |
| <u>Ephedra spp.</u>               |            |            | .20        | 1.0        | 5.0       | .20        |           | 1.5       | .01        |            |            |            | .01        |            |            |           |
| <u>Opuntia sp. (cholla)</u>       |            | .40        | .10        | .01        | 1.5       | .10        |           | .5        |            | .01        | .01        | .01        | .10        | .30        |            | .10       |
| <u>Gutierrezia sp.</u>            | 4.         | .5.        | 23.        | 18.        | 25.       | 16.        | 22.       | 5.        | 3.         |            | 20.        |            |            |            |            |           |
| <u>Lycium spp.</u>                | 5.         |            | .40        | .60        | 3.        | .50        | 2.        |           | .60        |            |            |            |            |            |            |           |
| <u>or Prunus fasciculata</u>      |            |            |            |            |           |            |           |           |            |            |            |            |            |            |            |           |
| <u>Scleropogon brevifolius</u>    | 12.        | 5.         |            |            |           |            | .01       |           |            |            |            |            |            |            | .80        |           |
| Other spp.                        | .01        | .03        | .11        | .12        | 1.49      | .11        | .10       | .03       | .21        | .21        | .01        |            |            | .01        | .05        | .01       |
| Total Canopy Coverage             | 22.54      | 12.85      | 24.97      | 23.37      | 41.04     | 23.93      | 31.83     | 17.24     | 8.34       | .34        | 4.02       | 26.74      | 18.65      | 34.94      | 39.46      | 6.23      |

Group means and standard deviations for plots in M.U. 182 are shown in Table 3 below:

|                                        | <u>Grazed</u> | <u>Relic</u> |
|----------------------------------------|---------------|--------------|
| Mean effective ground cover            | 18.2          | 39.7         |
| Standard deviation (S.D.) ground cover | 9.4           | 7.9          |
| Mean production                        | 112.5         | 485.0        |
| S. D. production                       | 123.2         | 197.6        |
| Mean depth of A horizon                | 3.2           | 3.5          |
| S. D. depth of A horizon               | .79           | .58          |
| Mean total soil depth                  | 26.5          | 21.0         |
| S. D. total soil depth                 | 6.4           | 6.9          |

In the discriminant analysis of samples from unit 182, production was the first (and therefore most important) variable to enter the analysis. Effective ground cover and total depth were entered as significant discriminating variables in the second and third steps, respectively.

| <u>Step</u> | <u>Variable</u>        | <u>Wilk's Lambda</u> | <u>Signif</u> |
|-------------|------------------------|----------------------|---------------|
| 1           | Production             | .3902                | .0010         |
| 2           | Effective ground cover | .3038                | .0014         |
| 3           | Total soil depth       | .2479                | .0023         |

The one discriminant function calculated had an associated eigenvalue of 3.0 and canonical correlation of .867. The canonical correlation is a measure of the association between the discriminant function and the variables which define the group memberships, i.e., it is a measure (between 0 and 1.0) of the function's ability to discriminate between groups. The Wilk's lambda transformed into a chi-square statistic for this discriminant function was 14.54 with 3 degrees of freedom and a significance of .0021.

The discriminant function coefficients for each variable involved were:

|                |       |
|----------------|-------|
| Eff. gr. cover | .665  |
| Production     | .605  |
| Total depth    | -.521 |

The results of this analysis showed that the relic sites in unit 182 had significantly higher forage production and effective ground cover than the grazed sites. The relics, however, had significantly lower total soil depths than the grazed sites. As a final step in the discriminant analysis procedure, the ability of the discriminant function to successfully predict group memberships is calculated. Given the data for the three significant discriminating variables, the discriminant function was able to correctly classify 100% of the cases in unit 182, as either grazed or relic.

Figure 3 graphically depicts the location of plots in unit 183 on the first two axes of the third ordination. This ordination employed 14 samples, three of which were relics. It employed 13 species which occurred on no less than three plots. The first axis accounted for approximately 46% of the variation in the data matrix, the second axis accounted for nearly 17% and together they accounted for approximately 64% of the total variation.

Figure-3. Ordination Results for Map Unit 183

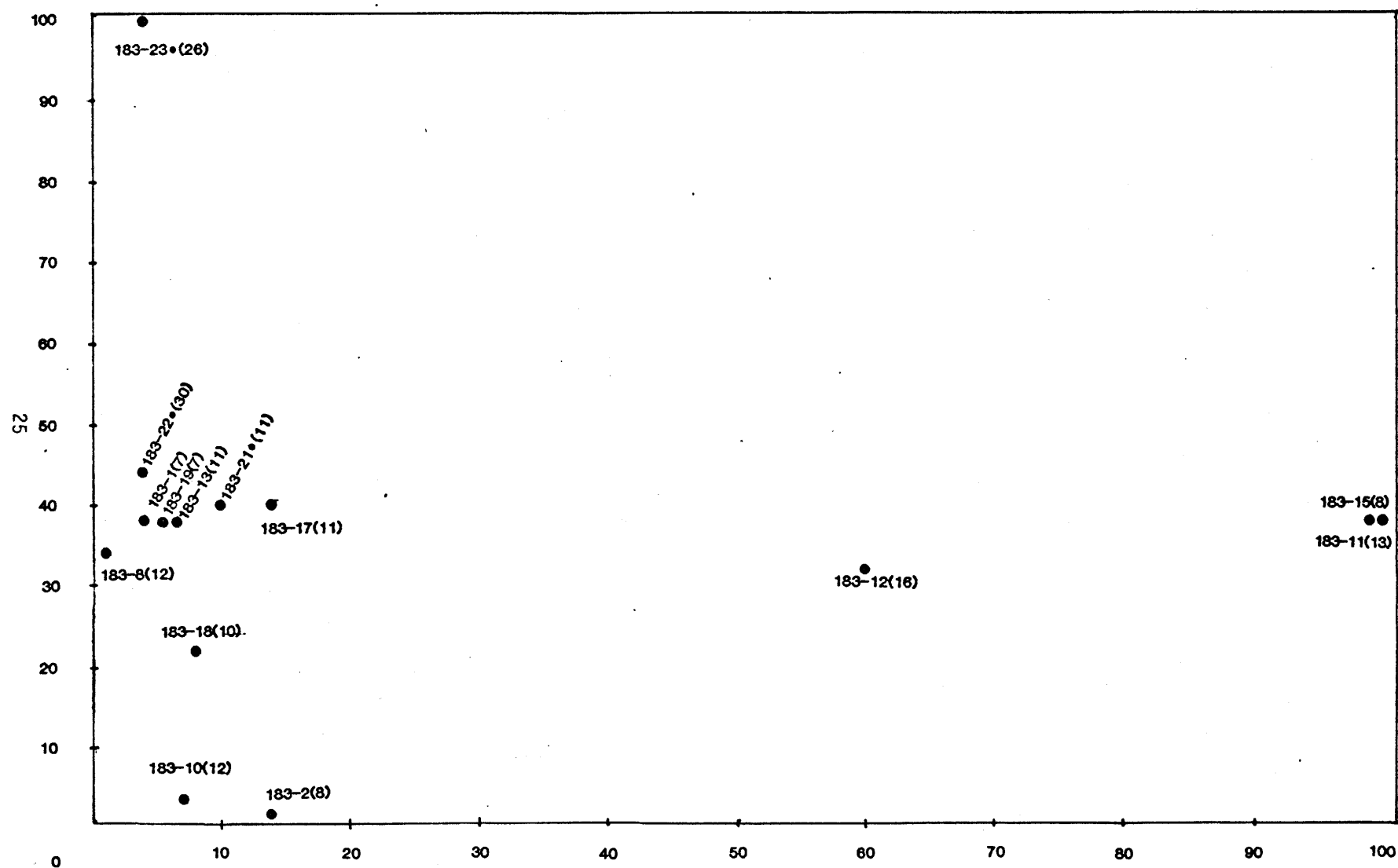


Table 4. Absolute canopy coverage by plant species in M.U. 183.

|                                    | GRAZED    |           |            |            |            |            |            |           |            |            |            | RELIC      |            |            |
|------------------------------------|-----------|-----------|------------|------------|------------|------------|------------|-----------|------------|------------|------------|------------|------------|------------|
|                                    | 183<br>-8 | 183<br>-1 | 183<br>-19 | 183<br>-13 | 183<br>-10 | 183<br>-18 | 183<br>-17 | 183<br>-2 | 183<br>-12 | 183<br>-15 | 183<br>-11 | 183<br>-23 | 183<br>-22 | 183<br>-21 |
| <u>Thamnosma montana</u>           | 2.        | .30       |            | .01        |            |            |            | .50       |            |            |            |            |            |            |
| <u>Stipa spp.</u>                  |           |           |            | .01        |            |            |            |           |            |            |            | 2.         | .10        | .01        |
| <u>Opuntia spp. (prickly pear)</u> |           | .10       | .20        |            | 2.5        | .50        |            |           |            | .01        |            | .01        |            |            |
| <u>Agave utahensis</u>             | .50       |           |            |            |            |            | .20        |           |            | .10        | .10        | .50        |            | 3.         |
| <u>Opuntia spp. (cholla)</u>       | .20       | .10       |            | .01        | 1.5        | 1.         |            | 2.        | .01        | .10        | .10        |            |            |            |
| <u>Coleogyne ramosissima</u>       | 25.       | 25.       | 40.        | 20.        | 30.        | 29.        | 30.        | 20.       | 35.        | 12.        | 15.        | 20.        | 20.        | 35.        |
| <u>Sphaeralcea sp.</u>             |           |           |            |            |            |            |            |           | .01        |            |            | .01        | .01        | .01        |
| <u>Ephedra spp.</u>                | 1.        | .50       |            | .40        | 2.         | 2.         | .50        | 4.        | 5.         | 1.         | 1.         | .50        | .10        | 2.         |
| <u>Yucca baccata</u>               | .30       | .30       | 2.         | .70        | 3.         | 1.5        | .80        | 3.        | 4.         | 2.         | 3.         | .10        | .30        | 4.         |
| <u>Oryzopsis hymenoides</u>        |           |           |            |            |            |            |            |           | .01        | .01        |            | .01        | .01        |            |
| <u>Sitanion hystrix</u>            |           | .01       |            |            |            |            |            |           | .01        | .01        | .01        |            |            |            |
| <u>Gutierrezia spp.</u>            |           |           |            |            |            |            | 1.0        |           | 10.        | 8.         | 10.        | .50        |            |            |
| <u>Leucelene ericoides</u>         |           |           |            |            |            |            |            |           | .01        | .01        | .01        |            |            |            |
| Other spp.                         | 2.01      | .20       | .30        |            |            | 2.0        | 7.01       | .01       | .50        |            |            | .92        | .10        |            |
| Total Canopy Cover                 | 31.01     | 26.51     | 43.50      | 21.13      | 39.0       | 36.0       | 39.51      | 29.51     | 54.55      | 23.24      | 29.22      | 24.55      | 21.62      | 44.02      |

The majority of the plots in unit 183 including two of the relic sites clustered together at the left end of the first axis in the ordination graph. These plots were dominated by blackbrush, turpentine bush, and cactus species. One relic plot (183-23) was compositionally unique in having a relatively large abundance of the needlegrasses and thus ordinated as an "outlier" at the upper left corner of the graph.

Also illustrated in this figure is the vegetative difference between three plots (183-12, -11, and -15) and the majority of the plots within unit 183. This difference was predominantly due to relatively high canopy coverages by squirreltail, snakeweed and Leucelene ericoides on these three plots.

Table 4 shows the canopy cover values recorded for each of the 14 samples in unit 183. In Table 3 the species are arranged according to their ordination scores on the first axis, in order to most effectively illustrate their ecological relationships. Although the ordination of samples did not clearly show compositional differences between grazed and relic sites on the first axis these two groups were separated in Table 3 for comparative purposes. Within the grazed and relic groups the samples are arranged according to their relative positions on the first axis.

As can be derived from both Figure 3 and Table 4, vegetative differences between grazed and ungrazed sites in unit 183 were not manifested. There is, however, one difference between grazed and relic sites which can be seen most readily in Table 4. All three relic sites in M.U. 183 had some quantity of the needlegrasses present whereas only one of the 11 grazed sites did.

Of the 14 samples in unit 183, 13 were employed in the discriminant analysis for this mapping unit. One sample was omitted due to lack of complete data.

Group means and standard deviations for plots from M.U. 183 are shown in Table 5 below

|                              | <u>Grazed</u> | <u>Relics</u> |
|------------------------------|---------------|---------------|
| Mean effective ground cover  | 37.9          | 44.0          |
| S. D. effective ground cover | 12.1          | 5.3           |
| Mean production              | 5.0           | 16.7          |
| S. D. production             | 10.5          | 28.9          |
| Mean depth of A              | 1.9           | 1.7           |
| S. D. depth of A             | .99           | .58           |
| Mean total depth             | 8.6           | 13.0          |
| S. D. total depth            | 2.2           | 1.0           |

In the discriminant analysis of samples from unit 183, total soil depth was the first (and therefore most important) variable to enter the analysis. Forage production was entered into the analysis at step 2 and these were the only two variables to significantly discriminate between grazed and relic sites.

Table 6 below summarizes the stepwise procedure:

| Step | Variable         | Wilk's Lambda | Significance |
|------|------------------|---------------|--------------|
| 1    | Total soil depth | .0594         | .0077        |
| 2    | Production       | .4346         | .0155        |

The one discriminant function calculated had an associated eigenvalue of 1.3 and a canonical correlation coefficient of .752. The chi-square statistic for this function was 8.33 with 2 degrees of freedom and a significance of .0155. The discriminant function coefficients for the two variables involved were:

Production .5284  
Total depth .979

The results of this analysis showed that the relic sites had significantly greater total soil depths and forage production; however, with respect to production, the difference is actually small (i.e., approximately 10 lbs/acre) even though the analysis labeled it significant.

Given the data for the two significant variables, the discriminant function was able to correctly classify 92.31% of the samples in unit 183 as either grazed or relic sites.

Figure 4 graphically depicts the location of plots in unit 192 on the first two axes of the fourth ordination. This ordination employed 14 samples, four of which were from relic sites. It employed 18 species which occurred on at least 3 plots. The first axis accounted for approximately 42 percent of the variation in the data matrix, the second axis accounted for nearly 20 percent, and together they accounted for approximately 62 percent of the total variation.

As shown in Figure 4, all four relic plots plus one grazed plot clustered together at the far left side of the first axis in the ordination graph. These five plots were vegetatively different from the majority of plots in unit 192 in having relatively high canopy coverage and frequency of the needlegrasses, winterfat, and black grama. The majority of plots in unit 192 were grazed and their positions at the right side of the ordination graph reflects their compositional difference from the relic sites on the left. The grazed plots were all compositionally similar to one another in being dominated by galleta (*Hilaria* spp.), cholla, and three-awns (*Aristida* spp.).

Table 7 shows the canopy cover values recorded for each of the 14 plots in unit 192. In Table 4, samples and species are both arranged in order of their ordination scores on the first axis. As with previous results, this was done in order to most effectively illustrate the compositional differences between plots and the ecological relationships between plant species.

That the large difference in vegetation between the relic sites and the rest of the plots in unit 192 is due to grazing is largely reflected by the range, condition scores shown in parenthesis in Figure 7.

With only 2 exceptions, the range condition scores are highest among the five plots clustered at the left and lowest among the majority of grazed plots at the right. Although plot 192-6 had a low range score, it manifested compositional similarities to the ungrazed relic sites. Apparently plot 192-6, which

was grazed, showed vegetative similarities to the relic samples due to its relatively low abundance of snakeweed in conjunction with a moderate amount of black black grama. The second exception was plot 192-9 which had a fairly high range score but showed compositional similarities to plots with much lower range scores. Apparently this similarity to plots with relatively low range scores was due at least in part to its large abundance of snakeweed.

Of the 14 samples in unit 192, only 9 had the complete set of data necessary for a discriminant analysis involving the four variables: effective ground cover, production, depth of A, and total depth.

Group means and standard deviations for plots from unit 192 are shown in Table 8 below:

|                              | <u>Grazed</u> | <u>Relic</u> |
|------------------------------|---------------|--------------|
| Mean effective ground cover  | 18.8          | 42.0         |
| S. D. effective ground cover | 10.1          | 9.1          |
| Mean production              | 120.0         | 571.5        |
| S. D. production             | 64.7          | 261.1        |
| Mean depth of A              | 2.8           | 4.0          |
| S. D. depth of A             | .45           | .82          |
| Mean total soil depth        | 31.4          | 24.2         |
| S. D. total soil depth       | 8.8           | 4.6          |

In the discriminant analysis for M.U. 192 production was the first (and therefore most important) variable to enter the analysis. Total depth and the depth of the A horizon were entered as significant discriminating variables in the second and third steps, respectively.

Table 9 below summarizes the stepwise procedure:

| <u>Step</u> | <u>Variable</u> | <u>Wilk's Lambda.</u> | <u>Significance</u> |
|-------------|-----------------|-----------------------|---------------------|
| 1           | Production      | .3281                 | .0068               |
| 2           | Total depth     | .2544                 | .0165               |
| 3           | Depth of A      | .1977                 | .0328               |

The one discriminant function calculated had an associated eigenvalue of 4.05 and a canonical correlation coefficient of .896. The chi-square statistic for this function was 8.91 with 3 degrees of freedom and a significance of .0304.

This discriminant function coefficients for each variable involved were:

|             |       |
|-------------|-------|
| Production  | .675  |
| Depth of A  | .612  |
| Total depth | -.715 |

The results of this analysis showed that the relic sites had significantly higher forage production and deeper A horizons than the grazed sites in unit 192. The total soil depths were significantly lower on the relic sites in unit 192 than on the grazed sites.

Given data for the 3 significant variables, the discriminant function was able to correctly predict 100% of the samples in unit 192 as grazed or relic sites.

Figure-4. Ordination Results for Map Unit 192

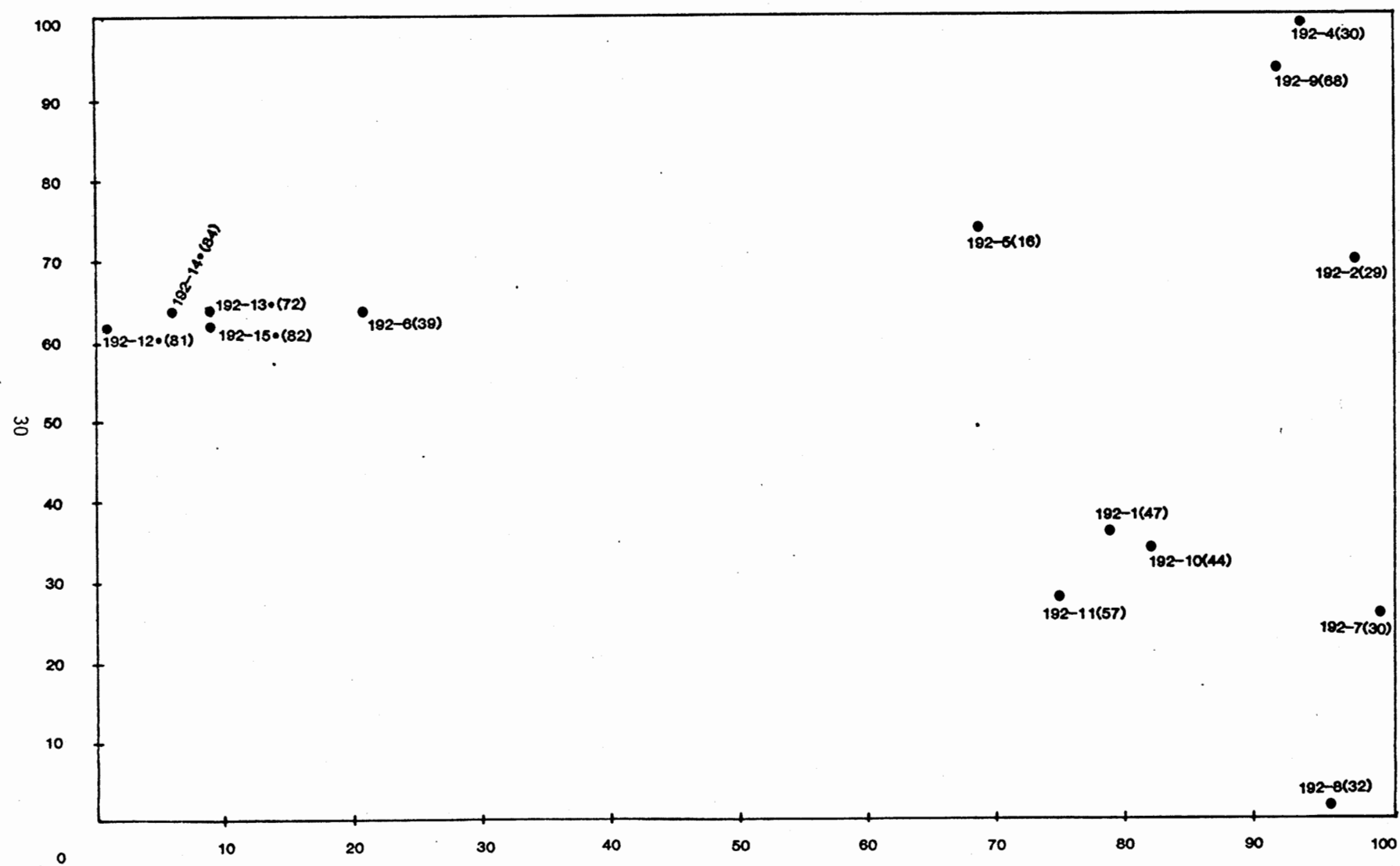


Table 7. Absolute canopy coverage by plant species in Map Unit 192.

|                                    | GRAZED    |           |           |           |           |            |           |            |           |           | RELIC      |            |            |            |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|------------|-----------|------------|-----------|-----------|------------|------------|------------|------------|
|                                    | 192<br>-7 | 192<br>-2 | 192<br>-8 | 192<br>-4 | 192<br>-9 | 192<br>-10 | 192<br>-1 | 192<br>-11 | 192<br>-5 | 192<br>-6 | 192<br>-13 | 192<br>-15 | 192<br>-14 | 192<br>-12 |
| Stipa spp.                         |           |           |           |           |           |            |           | .01        |           |           | 6.         | 5.         | 8.         | 15.        |
| Ceratoides lanata                  |           |           |           | .01       |           |            |           |            |           |           | .20        |            | .10        |            |
| Bouteloua eriopoda                 | .50       | 1.        | .60       | 2.        | 7.        | 5.         | 1.        | 6.5        | 2.        | 4.        | 25.        | 25.        | 30.        | 35.        |
| Opuntia spp. (prickly pear)        |           | .10       |           |           |           |            |           | .20        |           |           | .10        |            | .20        | .60        |
| Ephedra spp.                       |           |           |           |           | .01       |            |           | .50        |           |           |            | .10        | .10        | .20        |
| Yucca baccata                      |           | 1.        |           |           | 1.        | .50        |           | .30        |           |           | .50        |            | .30        | 1.         |
| Sporobolus spp.                    | .02       | .11       |           |           |           | .01        | .80       |            | .10       | .30       |            | .10        | .10        | .01        |
| Oryzopsis hymenoides               |           |           |           | .01       |           |            |           | .01        |           |           | .01        |            |            |            |
| Sphaeralcea spp.                   | .01       | .10       | .10       |           |           | .30        | .01       | .10        | .01       |           | .10        | .10        |            | .10        |
| Gutierrezia sp.                    | 2.        | 3.        | .20       | 5.        | 3.        | 3.         | .20       | 2.         | 3.        | .40       | 2.         | .50        | 2.         | .01        |
| Sitanion hystrix                   |           | .01       |           |           | 1.5       | 2.         |           | 3.5        |           | .01       | .10        |            | .01        | .01        |
| Leucelene ericoides                | .01       |           |           | .01       | .30       | 1.1        |           | 1.2        | .01       |           |            |            |            |            |
| Atriplex canescens                 | 3.        | 2.        | 3.        | .10       | 1.        | 3.         | 1.        | 3.         | .10       | .01       | .40        | 1.         | .20        | .30        |
| Juniperus osteosperma              |           | .50       |           |           | 3.        | 3.         |           | 3.5        |           |           |            |            |            |            |
| Aristida spp.                      | .50       | .01       | .20       | 1.        | 2.        | 1.         | 1.        |            | .40       |           |            | .30        |            |            |
| Lycium spp. or Prunus fasciculatum |           |           | .10       | .10       | 3.        |            |           |            | .10       |           |            | .30        |            |            |
| Opuntia spp. (cholla)              | .30       | .80       |           | .10       | .50       | .50        |           |            | .01       |           | .01        |            |            | .01        |
| Hilaria spp.                       |           | 2.        |           | 3.        | 8.        |            |           |            | .10       | .10       |            |            |            |            |
| Other spp.                         | 4.0       |           |           | .30       |           | .11        |           |            | .20       | .20       | 1.0        |            | .10        | .11        |
| Total Canopy Cover                 | 10.34     | 10.63     | 4.20      | 11.63     | 30.31     | 19.52      | 4.01      | 20.82      | 6.03      | 5.02      | 35.42      | 32.40      | 41.11      | 52.44      |

## DISCUSSIONS AND CONCLUSIONS

Of the three mapping units which had representative relic areas identified, two (i.e. units 182 and 192) were essentially grassland communities and one (i.e., unit 183) was dominated by shrubs. Within unit 183, there were no major differences in canopy cover by any forage class (trees, shrubs, forbs, or grasses) between grazed and ungrazed sites. Within the two grassland type units, there were differences in canopy cover by one or more forage classes which manifested itself between grazed and relic sites.

Within unit 182, the grazed sites had a higher mean canopy cover by shrubs than did the relic sites which had a higher mean canopy cover by grasses. It is known that grazing by livestock tends to reduce cover by grasses when palatable species are present, and that reduced cover by grasses favors the establishment of shrubs. These results are not surprising, as it is common throughout the southwest to find former grasslands dominated by shrubs after long term uncontrolled grazing.

Similarly, within unit 192, a difference in canopy cover by forage classes was evident between grazed and relic sites. The mean canopy cover by grasses was three to four times higher on the relic sites than on the grazed. In contrast to unit 182, the difference in mean canopy cover by shrubs between grazed and relic sites was only minor. The mean canopy cover by forbs was higher on the grazed sites in unit 192 than on the relics. Why the decrease in grass cover should seem to favor forbs instead of shrubs in this mapping unit is not clear. One explanation could be the fact that unit 182 is within the semi-desert shrub community and the availability of a seed source is greater whereas unit 192 is not. Soil properties would have a minimal influence since the classifications are similar. However, unit 182 unlike 192 does have a shallow component associated with it and in most cases, shallow soils tend to favor the dominance of shrub species. (1)

The major significant difference in the effects of grazing between the various grassland units was in the extent to which palatable species decreased and unpalatable species increased. In unit 183, the shrub dominated community, the extent to which grazing affected a change in plant composition was negligible. In this unit, the only plants which were present on all the relic sites but were present on only one of the grazed sites were the Stipa species. That the Stipa species are typically decreasers under grazing pressure by cattle is known and reflected in the range scorecard. However, on neither the grazed nor the relic sites were the Stipa species abundant. This mapping unit seemed to be nearly devoid of any perennial grass species even in its natural state. In most cases, these forage species comprised less than .10 percent on relict sites.

In the two grassland map units (i.e., units 182 and 192), the effects of grazing on plant community composition were great. In both map units, the most consistent differences in composition between grazed and relic sites were the generally higher abundances of the needlegrasses, squirreltail, black grama and winterfat on the relic sites, and generally higher abundance of burrograss, snakeweed and cacti on the grazed sites. As expected, those plants with greater canopy coverage on the relic sites were plants known for their palatability and vulnerability under grazing by cattle and are consequently classified as decreasers. The needlegrasses, squirreltail, black grama and winterfate were either totally absent from grazed sites or were found with relatively diminished canopy coverage values.

Those plants which were either absent or were found at relatively lower canopy coverages on the relic sites in the two grassland map units were all known for their low palatability and high regenerative success under the pressures of cattle grazing. The plants which dominated these grazed sites were predominately classified by the range scorecards as either increasers or invaders.

Several studies have compared grazed and ungrazed conditions within the Grand Canyon National Park. (1, 10, and 11). One study concluded from their comparison of the vegetation on Fishtail Mesa on the north rim of the Grand Canyon, that grazing had reduced the cover of Artemisia tridentata (sagebrush), "practically eliminated Poa longiligula (muttongrass) and allowed an increase in Bouteloua gracilis (blue grama)" (10). Unfortunately sagebrush, muttongrass, and blue grama were not major components of the plant communities in this study.

Another investigation found from the comparison of the vegetation on Boysag Point in the Grand Canyon to that of the north rim that grazing mainly decreased the proportion of cool season grasses such as the needlegrasses, squirreltail, and muttongrass (11). Furthermore, they concluded that plant species richness and forage production were much higher in their relict conditions.

The final study concluded that livestock grazing affected a replacement of cool season perennial grasses by weedy cool season annual grasses (1). Because the growth and abundance of annual plant species are so undependable from year to year, the Forest Service does not distinguish between their existence and that of bare ground for input into range condition analysis. If the Sanup Plateau had collected data on annual plants, such as the cheatgrasses (Bromus tectorum and B. rubens), the results of this study would be in complete concurrence. The observations were that the cheatgrasses were in fact present on some but not all of the relic sites as was the introduced weed, Russian thistle (Salsola iberica). None of these "weedy" species were present in anything more than trace amounts on the relic mesas that were inventoried, however, they were often dominant components of the grazed plant communities surveyed.

Discriminant analysis of data on effective ground cover, production, depth of A and total soil depth from our grazed and relic sites consistently employed forage production as a discriminating variable. One study subjected much of the published data for forage production on grazed and either ungrazed or long protected sites to statistical analysis. (12). They found that range protected from livestock grazing produce 46 percent more herbage (significant at the p .05 level) than do similar areas which are moderately grazed.

Only the discriminant function calculated for grazed and relic sites in unit 182 included effective ground cover as a significant discriminating variable. In this analysis, effective ground cover was much higher on the ungrazed than the grazed sites. This difference in effective ground cover was due to mainly the higher concentrations of litter on the relic sites.

Only the discriminant function calculated for grazed and relic sites in unit 192 included depth of the A horizon as a significant discriminating variable. The relic sites in unit 192 had significantly deeper A horizons than did the grazed sites in the same unit. This difference is probably due to the lack of surface compaction that was inventoried on the grazed.

Like forage production, total soil depth was the only other variable to be consistently employed as a significant discriminating variable between grazed and ungrazed sites in all three discriminant functions. Unlike forage production which was consistently higher on all the relic sites, total soil depth was greater only on the relic sites in unit 183. In the other two units (182 and 192), total soil depths were actually greater on the grazed site than on the relics. This rather confusing situation can be explained by the following facts:

(1) Unit 183 was nearly always sampled at the breaks into large canyons on the grazed sites, since that is where it manifested itself. On the relic sites, the middle of the delineation would normally be sampled; hence the deeper mean soil depths.

(2) Because the relic sites on units 182 and 192 were essentially located on isolated mesas and buttes, the benefit of wind deposition that would be occurring on the Sanup Plateau would not occur.

REFERENCES CITED

1. King, R. W. 1983. Ecological Survey of Relict and Long-Protected Range Sites in the Blackbrush Formation in Northern Arizona. M. S. Thesis, Northern Arizona University, Flagstaff, AZ 150 p.
2. Adjacent Lands Study. 1981. USDI - Grand Canyon National Park 50 p.
3. Hill, M. O. 1973. Reciprocal Averaging: An Eigenvector Method of Ordination. J. Ecol. 61:237-249.
4. Gauch, H. G. Jr., R. H. Whittaker, and T. R. Wentworth, 1977. A Comparative Study of Reciprocal Averaging and Other Ordination Techniques. J. Ecol 65: 157-174.
5. Terrestrial Ecosystem Survey Handbook. 1981. USDA - Forest Service, Southwestern Region, Albuquerque.
6. Allotment Analysis Handbook. 1981. USDA - Forest Service, Southwestern Region, Albuquerque.
7. Baxter, C. D., D. G. Brewer, R. K. Jorgensen, and W. A. Robbie. Range Capacity and Terrestrial Ecosystem Evaluation of the Havasupai Traditional Use Lands. USDI - Grand Canyon National Park and USDA - Kaibab National Forest. 185 p.
9. Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical Package for the Social Sciences. McGraw - Hill, New York.
10. Jameson, D. A., J. A. Williams, and E. W. Wilton. 1962. Vegetation and Soils of Fishtail Mesa, Arizona. Ecology 43: 403 - 410.
11. Schmutz, E. M., C. C. Michaels, and B. I. Judd. Boysag Point: A Relict Area on the North Rim of Grand Canyon in Arizona. Arizona Agricultural Experimental Station; Paper No. 1110; Tucson. 7 p.

APPENDIX A

PLANT SPECIES LIST FOR  
SANUP PLATEAU STUDY AREA

## SANUP PLATEAU PLANT LIST

Nomenclature follows Lehr (1978) and Lehr and Pinkava (1980)  
Common Synonyms are given in parentheses.

### TREES:

Chilopsis linearis

Fraxinus anomala

Juniperus osteosperma

Pinus edulis

Pinus monophylla

Tamarisk pentandra

### CACTUS:

Coryphantha vivipara

Echinocactus sp.

Echinocereus Engelmannii

Echinocereus troglodidiatus

Mammillaria sp.

Opuntia acanthicarpa

Opuntia basilaris

Opuntia erinacea

Opuntia phaeacantha

Opuntia whipplei

### SHRUBS:

Agave utahensis

Arcostaphylos pungens

Artemisia tridentata

Atriplex canescens

Baccharis sergiloides

Berberis fremontii  
Bernardia incana  
Brickellia californica  
Brickellia longifolia  
Brickellia scabra  
Ceanothus greggi  
Ceratoides lanata (Eurotia l.)  
Cercocarpus montanus  
Chrysothamnus spp.  
Chrysothamnus viscidiflorus  
Coleogyne ramosissima  
Cowania mexicana  
Encelia frutescens var. resinosa  
Ephedra nevadensis  
Ephedra viridis  
Ephedra spp.  
Eriogonum fasciculatum  
Eriogonum spp.  
Fallugia paradoxa  
Forsellesia nevadense (Glossopetalon)  
Garrya flavescens  
Gutierrezia sarathrae  
Gutierrezia spp.  
Haplopappus laricifolius  
Krameria parvifolia  
Larrea tridentata  
Lycium andersonii  
Lycium pallidum  
Mimosa biuncifera

Mortonia scabrella

Nolina bigelovii

Parthenium incanum

Prunus fasciculatum

Quercus turbinella

Rhus trilobata

Salvia dorrii

Thamnosma montana

Yucca angustissima

Yucca baccata

Yucca brevifolia

FORBS:

Allonia incarnata

Arabis sp.

Artemisia dracunculus

Artemisia ludoviciana

Asclepias asperula

Asclepias latifolia

Baileya multiradiata

Camissonia sp

Castilleja sp

Comandra pallida

Cryptantha confertifolia

Descurainia sophia

Dyssodia acerosa

Erigeron spp.

Eriogonum inflatum

Erodium cicutarium

Euphorbia albonarginata  
Euphorbia sp.  
Gaillardia pinnatifida  
Gaura sp  
Glandularia goodingii (Verbena g.)  
Haplopappus gracilis  
Hymenopappus filifolius var. lugens  
Hymenoxys acaulis  
Ipomopsis aggregata  
Ipomopsis longiflora  
Lactuca serriola  
Lepidium montanum  
Leucelene ericoides (Aster arenosus)  
Linum Lewisii  
Machaeranthera sp.  
Melampodium leucanthum  
Menodora scabra  
Mentzelia albieaulis  
Mentzelia pumila  
Mirabilus multiflora  
Nicotiana trigonophylla  
Oenothera caespitosa  
Oenothera sp  
Pectis sp.  
Penstemon eatoni  
Perityle ciliata  
Peteria thompsonae

Phacelia constancei

Physalis sp.

Plantago purshii

Psilostrophe sparsiflora

Salsola iberica

Sanuitala aberti

Senecio douglassi

Sphaeralcea grossulariaefolia

Sphaeralcea sp.

Stanleya pinnata

Swertia albomarginata

Tiquilia cauesleus  
(Coldenia caneseus)

Vicia exigua

GRASSES:

Andropogon sp.

Aristida fendleriana

Aristida longiseta

Aristida purpurea

Bouteloua barbata

Bouteloua curtispindula

Bouteloua eriopoda

Bouteloua gracilis

Bromus rubens

Bromus tectorum

Enneapogon desvauxii

Erioneuron pulchellus (Tridens p.)

Hilaria jamesii

Hilaria rigida

Muhlenbergia porteri

Muhlenbergia repens

Oryzopsis hymenoides

Poa fendleriana

Scleropogon brevifolius

Sitanion hystrix

Sporobolus contractus

Sporobolus cryptandrus

Sporobolus flexuosus

Sporobolus giganteus

Stipa arida

Stipa comata

Stipa coronata var. depauperata

Stipa speciosa

Tridens muticus

Tridens muticus var. elongatus (T. elongatus)

Vulpia octoflora (Festuca octoflora)