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Effects of grazing on the habitat of Astragalus ceramicus var. apus in the sandhills of the Centennial Valley, Montana

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Effects of Grazing on the Habitat of
Astragalus ceramicus var. *apus*
in the Sandhills of the Centennial Valley, Montana.

By

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ABSTRACT

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Effects of Grazing on the Habitat of Astragalus ceramicus var. apus in the Centennial Valley, Montana.

Director: Vicki Watson, Ph.D. VW

Sandhills blowout habitat and the mechanisms of maintaining this habitat were studied for an early successional species, Astragalus ceramicus var. apus, on a currently-grazed and recently-rested allotment in the Centennial Valley of southwestern Montana. Physiographic characteristics were investigated to ensure similarities between allotments. Vegetation patterns were found to be similar across the landforms: swale, dune face, dune ridge and blowout, between allotments, but percentages of vegetation cover were higher and bare ground lower on the ungrazed allotment. The differences were attributed to grazing cessation. The variables that best predicted blowouts with and without A. ceramicus var. apus were percent bare ground and percent total cover for both allotments. Astragalus ceramicus var. apus was found in blowouts where bare ground is greater than 50 percent and total vegetative cover between 40 and 80 percent. No trends were discerned with respect to blowout area or aspect between blowouts with and without the species. Stem number and stem densities were found to be higher on the ungrazed allotment, even though more habitat appeared available on the grazed allotment.

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Chapter 1

Introduction

The Centennial Sandhills are one of 2 major sandhill complexes found in Montana. Although the long sweeping arcs of the original dunes are still visible, many ridgelines have been broken up. The result is a mosaic of low hills up to 12 meters tall (Plate 1). These dunes are stabilized by vegetation; however, recent reworking by wind has resulted in saucer shaped depressions in the sand termed blowouts (Pool, 1913; Cooper, 1958; Malakouti et al., 1978). This disturbance pattern returns patches of the landscape to earlier successional stages.

The sandhills have many plant species in common with the adjacent vegetation on silty alluvial soils; however, five plant species listed as rare in Montana occur in the early successional, sandy soils of dune blowouts (Lesica et al., 1984). Astragalus ceramicus var. apus, a regionally rare endemic, is one of these species. A. ceramicus var. apus (henceforth refered to as Astragalus ceramicus or variety apus) a member of the family Fabaceae, is confined to sandy soils throughout its range (Hitchcock and Cronquist, 1981). Outside of the Centennial Valley, variety apus is known only from the sand dunes of the Snake River Plain in south-central Idaho (Barneby, 1964). In Idaho it is currently under monitor status (Idaho Nat. Heritage Program, 1987).

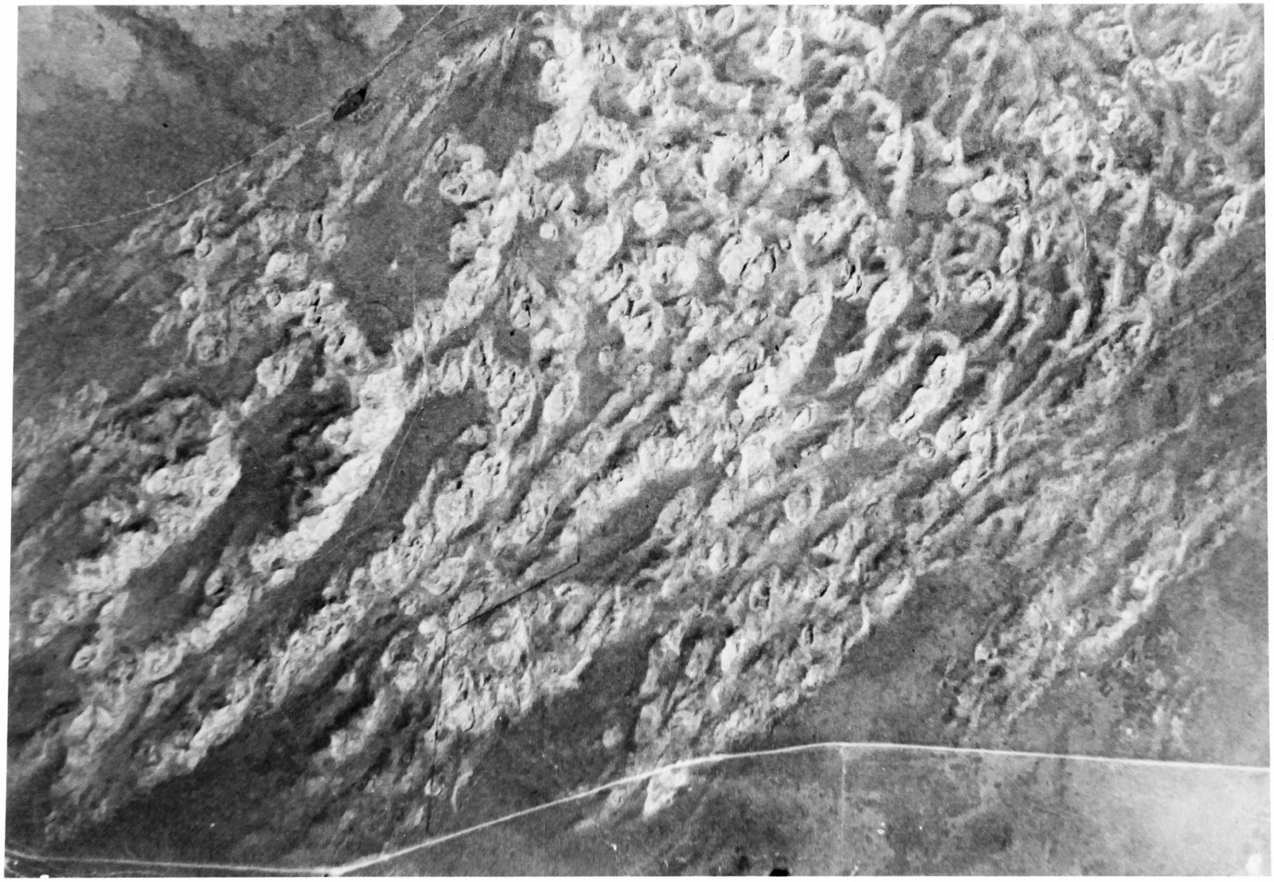


Plate 1. Aerial photograph of the Centennial Valley Sandhills Study Site.

Astragalus ceramicus var. *apus* is considered rare by the Montana Natural Heritage Program (Shelly, 1987) This status however, provides no protection for rare plants as there are no Montana State Laws that specifically pertain to the protection of rare plants, although certain statutes imply consideration for their protection (Lesica et al., 1984).

The unique flora of the Centennial Sandhills was brought to the attention of The Nature Conservancy in 1983 (Peter Lesica, per.comm.). Since that time, The Nature Conservancy has worked in conjunction with the Bureau of Land Management (B.L.M.) in efforts to document and preserve the area's diversity.

Effective preservation of a species or community means maintaining those policies directed at long-term retention of the habitat that supports the species or community of interest. The habitat of *A. ceramicus* appears to be the mosaic of blowouts found throughout the Centennial Sandhills. This mosaic is likely maintained through a number of forces such as the grazing of cattle and other herbivores, draught and fire.

This study was undertaken to gain baseline information about the status and ecology of *A. ceramicus* in relation to its habitat. The following objectives were deemed of importance:

1) Define the habitat of *A. Ceramicus* var. *apus* in

terms of its relation to succession in the sandhill blowouts.

2) Interpret the possible effects of a decline in cattle grazing on that habitat.

3) Determine the historical climatalogical and grazing influences at the study site.

Results of this study will help land managers make proper decisions regarding conservation practices in the sandhills complex.

Chapter 2

Literature Review

Blowouts

Blowouts and soil instability are common features of sandhill and sand dune systems (Weaver, 1968; Stubbendieck, 1986). Numerous workers have observed that blowouts and sand movement occur through the disruption of vegetative cover, leaving bare soil open to erosion by wind and precipitation (Rydberg, 1895; Cowels, 1899; Pool, 1914; Oosting, 1954; Cooper, 1958; Wolfe, 1972; Malakouti et al.,1978; Raup and Argus, 1982).

Disturbance

Early workers felt the principle disturbance factors in the sandhills of Nebraska were cattle grazing and fire (Rydberg, 1895; Pool, 1914). Studies on both inland and coastal dune systems reveal that a multitude of disturbance mechanisms may be operating at various degrees of intensity including: scraping by rabbits, burrowing by mammals, rooting by wild boar, climate and human impacts (Cowels, 1899; Ramaley, 1939; Moore, 1971; Bratton, 1980; Platt, 1975; Bonham and Lerwick, 1976; Watkinson et al., 1985).

Disturbance produces a mosaic of "patchy vegetation" as defined by White and Pickett (1985). In the case of blowouts, this is represented by a variety of physical sizes and shapes. Within these blowouts, vegetation may be at various successional stages with respect to other blowouts and to the surrounding less disturbed areas (Lemen and Freeman, 1986).

Succession

Succession is defined as the temporal sequence of changes in species composition of a community (Drury and Nisbet, 1973). Well documented work in forest succession uses the term gap, defined as within community disturbance with subsequent recruitment of new individuals, (Bray, 1956; Williamson, 1975; Ehrenfeld, 1980; Shugart and West, 1981). In forests, gaps may be created by a single treefall or through a larger loss of area within the community.

In grasslands, disturbance mechanisms may be different, but the results are similar. As Frankel and Soule (1981) state, "the browsing and grazing activities of herbivores can set back succession and maintain early successional habitats by creating light gaps and bare spots, thus preventing the disappearance of 'open habitat'". Several studies on grasslands document vegetation response to release from grazing pressure and the subsequent increase in vegetative cover and reduction of open habitat (Watt 1957, 1974; Van der Maarel, 1970).

Vegetation and Soils

Species of low competitive ability are sometimes favored under disturbance and stress regimes (Watt, 1957,1974; Levin, 1976). Numerous plant species have been shown to be early successional species, generally adapted to more open habitats resulting from disturbance (Watt, 1974; Huiskes, 1977; Stubbendieck, 1986; Keeler, 1987). Blowout species are notably tolerant of the stress associated with sand movement, and rhizomatous species appear to dominate these habitats (Rydberg, 1895; Pool, 1914; Weaver, 1968).

Once a common species of blowouts of the Nebraska Sandhills, the rarity of the blowout penstemon (*Penstemon haydenii* S. Watson) may in part, be due to the decline of open blowout habitat brought about by improved range management and fire control practices (Stubbendieck, 1986).

This dependency on early successional habitat is not uncommon. Population reductions of *Rannunculus ophioglossifolius* on a Nature Reserve in England came about due to the cessation of grazing (Dring and Frost, 1972). Subsequent to the elimination of grazing, the grass *Glyceria fluitans* began to grow in abundance and eliminated the open habitat preferred by *R. ophioglossifolius*. Upon removal of the grass 30 years later, the seedbank of *R. ophioglossifolius* was found to be intact, and germination was induced by the creation of artificial gaps in the vegetation (Dring and Frost, 1972).

Establishment and survivorship of some plants has been correlated with open habitat in relation to disturbance factors, such as the perennial herb Mentzelia nuda in the sandhills of Nebraska (Keeler, 1987). A rare perennial from the alpine of Colorado, Braya humulis var. humulis (C.A. Meyer)Robins was also found to have more robust populations in areas of moderate disturbance (Neely and Carpenter, 1986). Thus, disturbance factors and the open habitats they create, may be key factors in the establishment and survivorship of early successional species.

Vegetation pattern within blowouts, is in part, influenced by the soil characteristics of texture and percentage organic matter (Malkouti et al., 1978; Barnes et al., 1984). Organic matter is especially important with respect to soil stabilization in relation to wind erosion of sandy soils (Malakouti et al., 1978). Soil texture and soil organic matter also contribute to the availability of soil moisture (Heinisch, 1981; Barnes and Harrison, 1982; Barnes et al., 1984). The distribution of vegetation along topographic and edaphic gradients appears to be controlled, in part, by soil texture and water relations in conjunction with plant morphology and physiology (Barnes et al., 1984).

Heyward (1937) and Veno (1976) link increases in vegetative cover of xeric communities such as sandhills with litter buildup. This accumulation of litter may serve to improve the soils stability, general nutrient content, and ability to retain water.

Grazing

Researchers in Nebraska have found that grazing reduces both vegetative biomass and cover on sandhill sites (Bragg, 1978; Potvin and Harrison, 1984). Following removal of grazing, litter has been shown to increase as much as three-fold in the sandhills of Nebraska (Potivin and Harrison, 1984). In Hawaii, Mueller-Dombois (1980) also measured an increase in litter and a decrease in visible rocks and soil in the coastal grasslands when grazing was eliminated. Thus, grazing and its influence on vegetative cover and litter buildup may influence soil stability, especially in sandy areas.

Fire

As with grazing, vegetative biomass and litter is reduced for several years after a fire occurs in sandhill grasslands (Bragg, 1978). Fire, in combination with past heavy grazing regimes, results in the very slow recovery of grassland areas (Bragg, 1978). The limitation of fire allows for stabilization of coarse soils and an increase in vegetative productivity in the Nebraska sandhills (Burzlaff, 1962).

Drought

Early studies on the sand grasslands of Colorado demonstrated that drought in combination with heavy grazing slowed secondary succession by up to three times that of recovery from drought alone (Albertson et al., 1957). Severe drought is likely to affect vegetation in areas that have moderate to low rainfall (Weaver, 1968).

Chapter 3

STUDY SITE

Location and Ownership

The study site is located in the Centennial Valley of southwestern Montana, R2W T13S covering most of sections 22 and 23 plus the northern portion of section 27. The ownership and management of the study site is complex.

All of section 22, the west half of section 23 and the northern quarter of section 27 are public land (Figure 1), fenced and managed by the Bureau of Land Management (B.L.M.). This area henceforth referred to as the ungrazed allotment, has had little or no grazing in the past 5 years (Dave Ferris pers.comm.), and light grazing for the 5 years previous to that.

Directly east, the south central portion of section 23 is also B.L.M. while the rest of 23, all of 24 and the western third of 19 is privately owned by the Staudenmeyer's Centennial Livestock Co (Figure 1). This pasture is fenced and managed by the Staudenmeyer Cattle Co. and will be referred to as the grazed allotment. This area has been continuously grazed for the past 10 years (Les Staudenmeyer pers. comm.). Grazing permit and use figures for the two pastures are given in appendix A.

The study area (Figure 1) is delineated by the boundary of the sandhills on the northwest and east, and by the fences to the northeast, south and west.

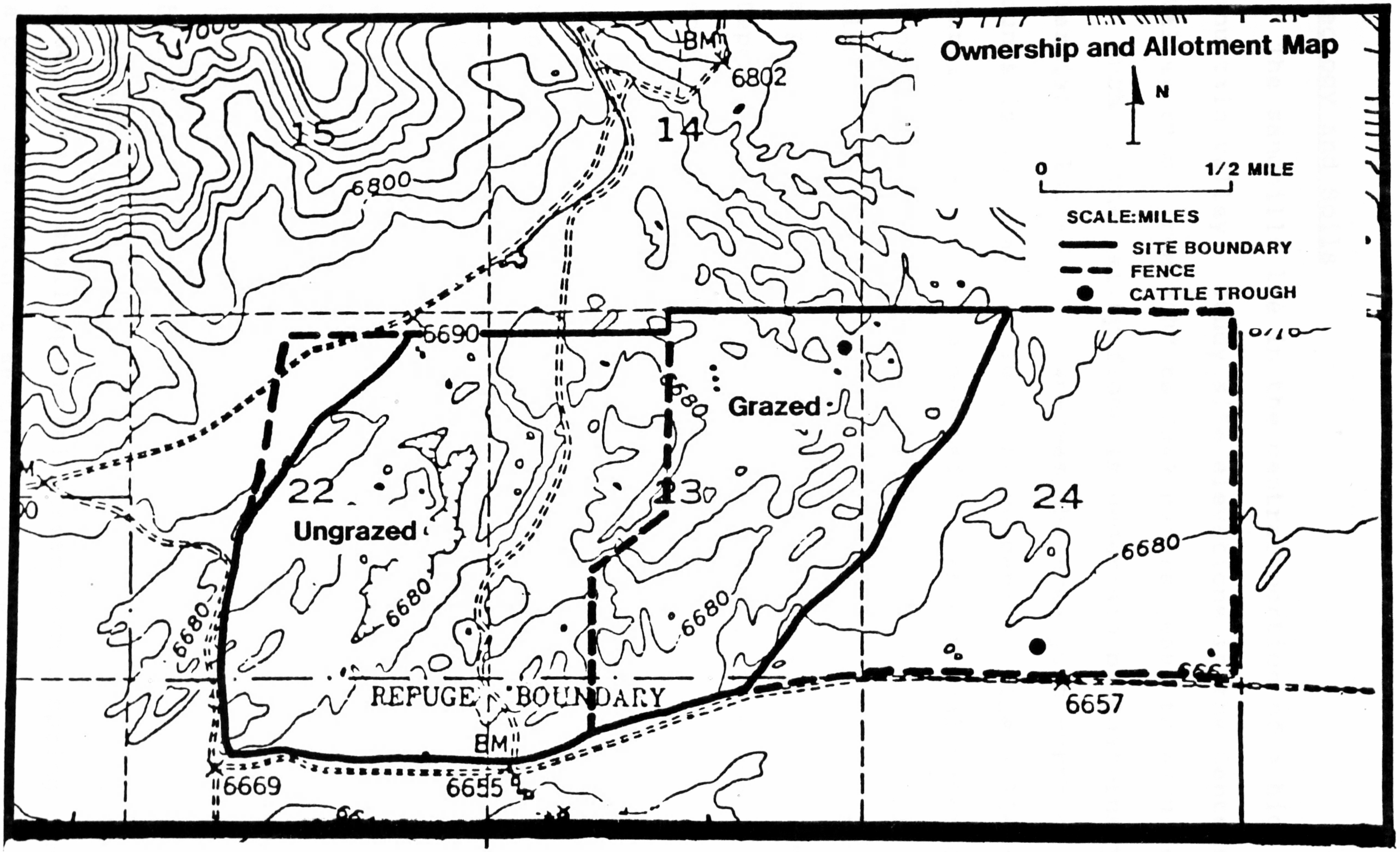


Figure 1. Map of Centennial Valley sandhills study site, showing allotment boundaries, fences and cattle trough locations.

Geology and Soils

The sandhills lie in the central portion of a high mountain valley. Study site elevations in the Centennial Valley range from 2037 to 2049 meters (6680 to 6720 feet).

Much of the valley floor is underlain by Quaternary and Tertiary glacial till, whereas the area just north of the dunes is underlain by Tertiary volcanics. The valley's surficial geology is dominated by depositional material from past glaciations. The most recent, the Pinedale Glaciation (70,000 to 15,000 years ago), is thought to be a possible source of the dunes (Sonderegger et al., 1982). Depositional patterns indicate paleowinds from the southwest (Witkind and Prostka, 1980).

A soil survey for the area (Tippy el al., 1978), classified the dune soils as Typic Cryopsamments with rapid permeability and a pH ranging from 7.1 to 7.8. The small swales between the dunes are Pachic Cryoboralls where enough organic matter has accumulated in the surface soils, while the larger swales and valleys are Typic Cryoborolls. In all cases compaction hazard is low; however, erosion ranges from slight to severe depending on the slope gradient.

Hydrology

Although no free flowing water is present within the study site, a small ephemeral stream from a spring runs to a point just north of section 22 to feed a stock pond. A buried pipe line also feeds a cattle trough in the center of section 23, while a windmill in the southeastern portion of this section feeds another cattle trough (Figure 2).

Climate

The valley's climate is greatly influenced by the surrounding mountain ranges. The Centennial Mountains, which rise abruptly to the south, and the more rolling Gravelly Range to the north, both influence storm patterns due to the altitude of the peaks which rise to 3003 m (9850 ft). The valley also lies in the rain shadow of the Beaverhead and Tendoy Mountain Ranges to the west. The study site is dominated by continental weather patterns (Chambers, 1963) with cloud cover rarely exceeding three days duration (Tippey et al., 1978).

A National Weather Station is located 8.25 km (5 mi) south of the study area at Lakeview. Mean annual precipitation from 1940 to 1986 ranged from 34.16 to 69.09 cm (13.45 to 27.20 in) with a mean of 52.02 cm (20.48 in). Mean maximum and minimum temperatures for the years 1952 to 1986 were -4.9 and -17.4 C (23.1 and 0.7 F) in January and 23.5 and 4.4 C (74.4 and 39.9 F) in July (U.S. Department of Commerce). Snow or frost is possible in any month of the year.

Vegetation

The sandhills have many plant species in common with the adjacent areas on alluvial and volcanic derived soils.

The alluvial soils to the south, east and west of the site are dominated by the shrub Artemesia tripartita Rybd. and the grasses Stipa comata Trin. & Rupr. and Festuca idahoensis Elmer. The area to the north is composed of volcanic soil which is dominated by A. tridentata Nutt. and S. comata and F. idahoensis. The northern portions of the study site are generally dominated by A. tridentata which is gradually replaced by A. tripartita toward the southern boundary. Stipa comata and F. idahoensis are the dominant grasses throughout the site and grow as dense swards in the swales and valleys, less densely on dune faces and only very sparsely in the dune blowouts. There are no truly dominant forb species.

The dune blowouts are dominated by the shrubs Chrysothamnus nauseosus (Pall.)Britt. and C. vicidifloris (Hook.)Nutt. with lesser amounts of Tetradymia canescens DC. and the Artemesias. Various grasses are associated primarily with the blowouts, these include: Poa sandbergii Vasey and Elymus flavecens Scribn & Smith.

Species Demography and Description

The range of Astragalus ceramicus var. apus was thought to extend only to an area of about 60 miles in diameter in the Snake River Plain in Idaho until its discovery in the Centennial Valley of southwestern Montana. It is distinct from var. filifolius by its sessile fruits (Barneby, 1964).

Astragalus ceramicus var. apus is a slender, wiry, perennial plant whose stems rise 2-17 cm above the soil surface from rhizome-like branches. These branches generally lie less than 3-5 cm beneath the soil (Figure 2) and may be traced back to a buried root crown. From 1-3 (5) grasslike involute leaves subtend a raceme of small pink flowers, which later form showy, inflated, red and white, oblong-ellipsoid mottled pods. These pods dry at maturity, become papery, and eventually fall to be dispersed by wind or other mechanisms (Barneby, 1964).

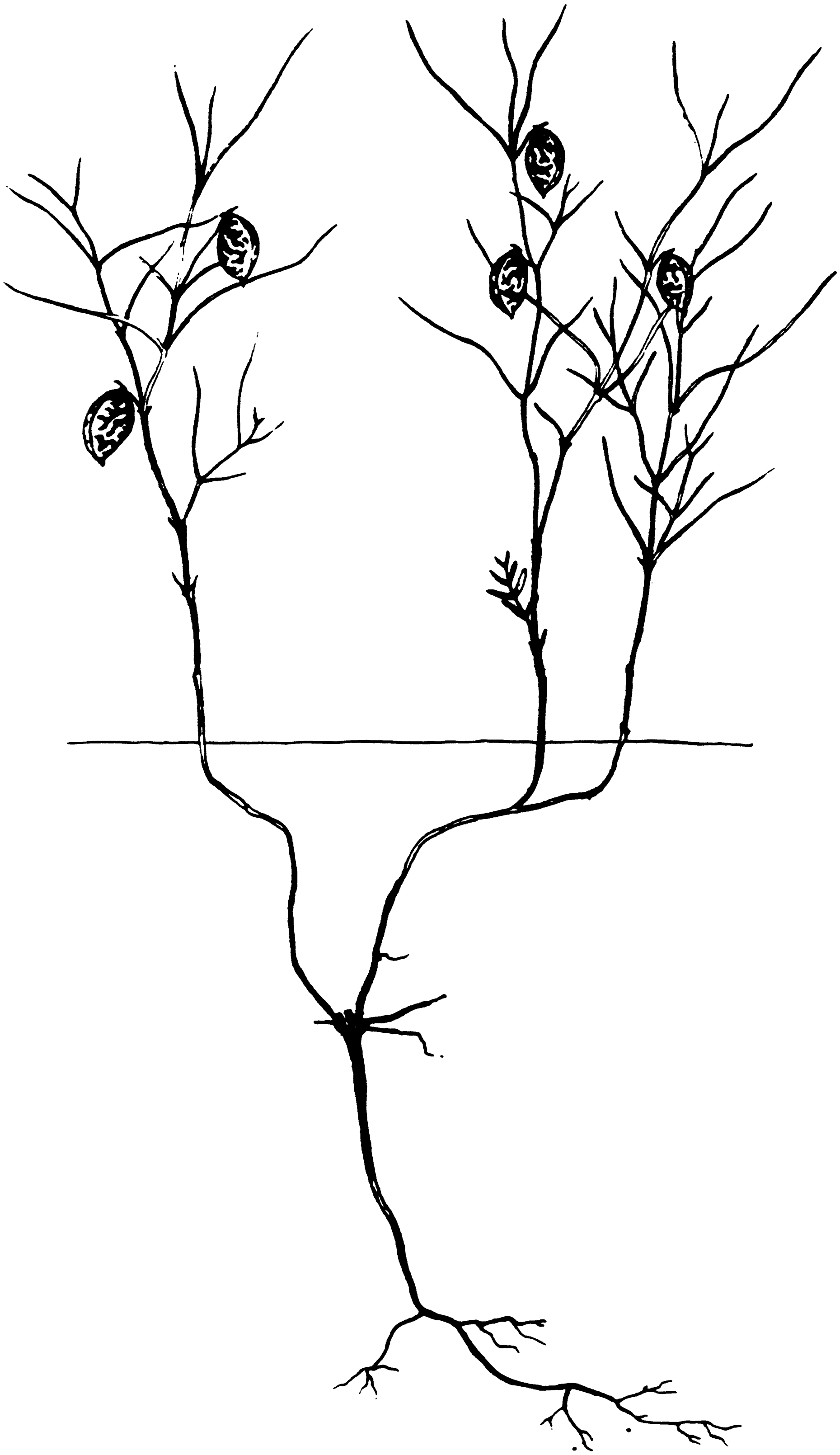


Figure. 2 Drawing of Astragalus cermicus var. apus, habit.

Chapter 4

Sample Design and Methods

The objectives of the study as presented in the introduction were; to define the habitat of A. ceramicus var. apus in terms of its relation to succession in the sandhill blowouts, evaluate the possible effects of a grazing cessation on the habitat, and estimate the historical climatalogical and grazing influences at the study site.

Table 1 outlines the number and types of data collected at the study site in July and August of 1987. The following sections will detail how these data were collected, the hypotheses posed in order to meet objectives, and the analysis used for each data set.

Transect Data

Factors such as slope, aspect and differences in physiography may influence vegetation distribution. In order to determine if the two allotments might differ with respect to physiographic features, a grid was walked on north-south compass lines across both allotments. Vegetation was sampled in meter square plots every 150 meters after random starts. Each plot was given a landform designation (swale, dune face, dune ridge, or blowout) and measurements of percent slope and aspect were recorded along with ocular estimates of shrub, grass, forb, and total vegetation canopy cover and bare ground

SAMPLE DESIGN: Data Collection

Transect Data: Collected on ungrazed and grazed allotments.

Sample Size

Ungrazed	141 m^2 plots	255 total plots
Grazed	114 m^2 plots	

Data collected

% slope
aspect
landform: swale
dune face
dune ridge
blowout

% cover: shrub, grass, forb, bare, total
* grazing

* Data obtained on private allotment only.

Blowout Data: Collected for each allotment (ungrazed and grazed)

Sample Size

40 blowouts with A. ceramicus
25 blowouts without A. ceramicus

Data Collected

% slope
aspect
blowout are

% cover: shrubs, grasses, forbs, bare, total
soil core on a subsample of blowouts

* # stems A. ceramicus
* species area

* Collected only in blowouts with A. ceramicus.

Table 1. Sample design listing numbers and types of data collected.

(soil with no visible litter) to the nearest 5 percent (Daubenmire, 1959). Additionally, estimates of the percentages of area grazed (0-4, 5-14, 15-24, 25-49, 50-74, 75-95, 96-100 percentage catagories) were recorded within each plot on the grazed allotment.

The questions to be explored with the transect data are as follows:

Transect Questions

1. Ungrazed and grazed allotments have similar physiographic characteristics of slope, aspect, and landform.
2. Ungrazed and grazed allotments have similar cover measures.
3. Ungrazed and grazed allotments have similar vegetation cover on similar landforms.
4. The percentage of cover grazed by cattle is not related to percent cover measures.

Blowout Data

Colonies of Astragalus ceramicus var. apus occur in blowouts dispersed throughout the study area. To document the distribution of A. ceramicus in the study area, all colonies were located through a complete systematic ground search and mapped on an aerial photograph. Forty colonies were randomly selected from each allotment for further study.

Since A. ceramicus does not occur in all blowouts, I located and mapped these uncolonized blowouts, and randomly selected 25 from each allotment for comparison studies with the colonized blowouts.

In order to discern any possible physiographic or vegetative differences between colonized and uncolonized blowouts within the allotments, I measured blowout area, percent slope, aspect and percent cover of the selected blowouts on the two allotments.

The area of each blowout was estimated by measuring the major axis and the minor axis (The longest distance across a blowout and its perpendicular, respectively.), assuming an elliptical shape for calculations. Determination of the boundary of the blowouts was subjective, but in most cases perimeters were marked by sand rims and sharp changes in vegetative cover. Slope was estimated using a hand held Suunto clinometer and aspect was determined with a Brunton compass.

In each of the selected blowouts (colonized and uncolonized), area covered by shrubs, grasses, forbs, and total vegetation canopy cover and bare ground was estimated to the nearest 5 percent in randomly placed 0.61 m circular plots (Daubenmire, 1959). The number of plots chosen for each blowout (from 3-12) was determined by the blowout size and vegetative heterogeneity. Thus, very small blowouts with homogeneous cover received fewer plots than large heterogeneous blowouts. These plots will be used to obtain a mean value for each cover variable within a blowout.

A 10 cm soil core was obtained from the selected colonized and uncolonized blowouts from each allotment and placed in plastic storage bags. Each bag was air dried for 2 days to prevent post-sampling microbial action, before sealing for later analysis.

In the colonized blowouts I also measured colony area (area occupied by A. ceramicus) and size of colony (number of stems). Because A. ceramicus has a deeply buried root crown and stems at various levels, it is impossible to determine numbers of distinct plants; however, it is assumed that the number of stems present bears a relation to the vigor and biomass of A. ceramicus in that blowout.

When plants did not encompass the entire blowout, colony area was estimated in a manner similar to blowout area. The major axis was measured as the distance between the furthest removeded A. ceramicus stems, and the minor axis as the distance across the colony of a line perpendicular to the first.

The hypotheses to be tested for the blowout data are as follows:

Blowout Hypotheses

1. Within each allotment, A. ceramicus is not associated with cover variables measured, or with a particular percentage of cover for blowouts with A. ceramicus and those without the species.

2. Within each allotment, blowout size for blowouts with A. ceramicus are similar to those without the species.

3. Between allotments, blowouts with A. ceramicus have similar slopes and aspects.

4. Between allotments, blowouts with A. ceramicus are of similar size.

5. Between allotments, percent vegetation cover is similar for blowouts with A. ceramicus.

6. Soils from blowouts with A.ceramicus are similar in texture and organic matter to those without the species across the study site.

7. Between allotments, the number of stems of A. ceramicus and species areas of blowouts are similar.

Soil Sample Preparation and Analysis

Soil samples were analyzed for texture following the Bouyoucos Hydrometer Method (Salter et al., 1966). Samples were dried for 12 hours at 60^{o} C. Fifty gram samples were weighed out and mixed in flasks with 50 mls of a dispersion reagent (40 g hexemetaphosphate + 10 g sodium carbonate in 1 liter of dH_2O), and left to stand overnight. This soil suspension was then washed into mixing cups. Distilled dH_2O was added to obtain a 500 ml sample. After mixing from 1-5 minutes, the samples were washed into a hydrometer cylinder and enough dH_2O added to bring the solution up to 1000 mls. The cylinder was capped and rotated by hand for 15 seconds before being placed on the bench, at which time a "start time" was recorded. Measurements were taken with the Bouyoucos hydrometer at 40 seconds and 2 hours from the start time. Temperature measurements of the samples were recorded at these same time intervals. A blank of one liter of 0.5% dispersion reagent was prepared for each sample run.

Total organic matter was determined following Ball (1964). Twenty gram soil samples were placed in metal crucibles and dried overnight at 60^{o} C. Samples were reweighed and then ashed in a muffle furnace for 24 hours at 375^{o} C and again weighed. Although this method was designed to avoid loss of water attached to clay micelles, each sample was spritzed with dH_2O and returned to the drying oven for an additional 12 hours at 60^{o} C. A final weight measurement was then taken, insuring that any water of hydration lost on ignition was replaced.

Historical Information

Grazing records dating back to 1939 were obtained for both allotments from B.L.M. records. Additional information on past grazing history of the allotments was obtained through personal and phone interviews with longtime valley residents and ranchers.

The B.L.M. provided aerial photographs of the site that were taken at approximately 10 year intervals starting in 1942. These photographs were studied in detail in an attempt to determine if there were any significant changes in blowout sizes or vegetation through time in the past 55 years. This information would be useful to study the historical effect grazing or climate might have had on topography or vegetation physiognomy.

Data Analysis

Box-plots and summary statistics will be used to display physiographic data and vegetation cover on the grazed and ungrazed allotments from the transect data.

Within allotments, data from the 40 blowouts with and 25 blowouts without A. ceramicus will be analyzed using discriminant analysis to determine which variables best explain presence or absence of A. ceramicus in the blowouts. Box-plots and scatter plots will be used to display cover measures, slopes, and aspects.

The data from the 80 blowouts with A. ceramicus will be displayed using box-plots to discern if blowout area, colony area, stem number or vegetation cover vary between the two allotments.

Measurements of soil texture and organic matter content from a random sample of blowouts containing A. ceramicus and those without the species will be displayed utilizing box-plots.

Where evaluation of box-plots suggest that means of compared populations are different, the non-parametric equivelant of a t-test, the Wilcoxon-Rank Sum (Mann-Whitney U) test will be given, as sample variances were often non-homogeneous. When comparing more than two groups, the nonparametric Kruskal-Wallis test is used.

All data was analyzed using SPSSX and SYSTAT statistical packages.

Chapter 5

Results and Discussion

Discussion of study follows the format of the sample design questions and hypotheses.

Transect Results

Physiographic Characteristics

Comparisons of slopes and aspects will give some insight into the physiographic similarities and differences between the two allotments. Gradient analysis studies (Whittaker, 1975) have shown that vegetation distribution is affected by the features of aspect, elevation and in some cases slope.

The box-plots and summary statistics for aspect on the two allotments showed similar medians and means and almost complete overlap in distribution (Figure 3). Box-plots of percent slope showed more variablilty for the two allotments (Figure 3). Although the medians were again about equal, the grazed allotment shows a higher frequency of values at greater slopes (above 10 percent), and a slightly higher mean, (5.45). The differences however, are not statistically significant between the two allotments with respect to average slope ($P = 0.324$).

It appears then, that as far as slope and aspect are concerned, the two sites are not statistically significantly different. Steeper slopes on the grazed

TRANSECT DATA

	ASPECT (°)		PERCENT SLOPE	
	UNGRAZED	GRAZED	UNGRAZED	GRAZED
N OF CASES	141	114	141	114
MINIMUM	10.000	15.000	0.000	0.000
MAXIMUM	360.000	360.000	20.000	30.000
MEAN	192.092	183.991	4.631	5.447
STANDARD DEV	100.558	97.786	4.439	5.659

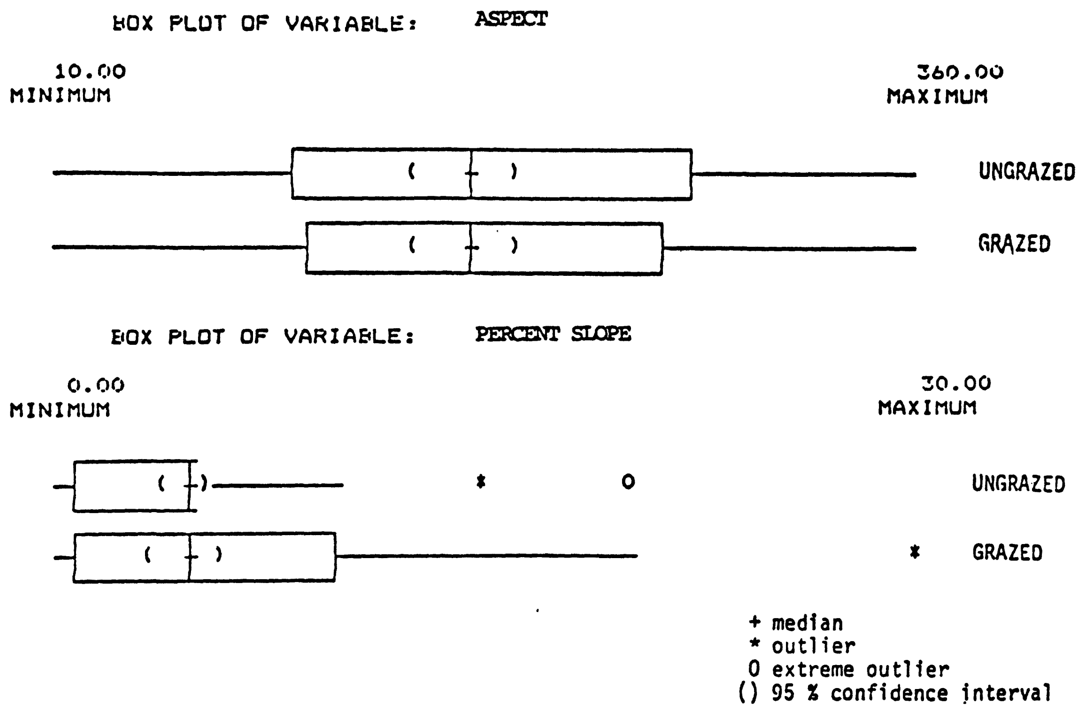


Figure 3. Box-plots and summary statistics of aspect in degrees and percent slope on the ungrazed and grazed allotments.

allotment would likely have more cover on west and northwest to northeast aspects and less on other aspects.

Ground observations and aerial photographs (Plate 1, p. 2), showed a trend towards more broken terrain with more individual dunes on the grazed allotment. My measurements would not have revealed this information as I only recorded a landform designation and did not discern whether a dune might have more than one plot on it. This attribute might affect the number of optimal places for blowout formation within each allotment.

<u>Cover Measures</u>

The overall means for percent forb, grass, shrub and total cover are up to 10 percentage points lower and bare ground 20 percentage points higher for the grazed versus ungrazed allotment (Table 2). Box-plots (Figure 4), and statistical tests for these variables between the allotments demonstrate the differences between means (P = 0.958, 0.000, 0.000, 0.000, 0.000) for forb, grass, shrub, total, and bare, respectively).

If we assume from the physiographic data that the two sites are similar and there are no other factors affecting the allotments differentially, then it is reasonable to attribute cover differences to cessation of grazing on the B.L.M. (ungrazed) allotment. Similar cover changes resulting from the cessation of grazing have been observed

TRANSECT DATA

UNGRAZED ALLOTMENT:

PERCENT:	SHRUB	GRASS	FORB	BARE	TOTAL
N OF CASES	141	141	141	140	139
MINIMUM	0.000	15.000	0.000	0.000	55.000
MAXIMUM	99.000	99.000	80.000	95.000	100.000
MEAN	13.574	83.837	15.213	14.193	89.878
STANDARD DEV	14.391	16.762	15.022	22.719	9.288

GRAZED ALLOTMENT:

PERCENT:	SHRUB	GRASS	FORB	BARE	TOTAL
N OF CASES	114	114	114	114	114
MINIMUM	0.000	5.000	0.000	0.000	15.000
MAXIMUM	35.000	99.000	45.000	99.000	99.000
MEAN	5.439	75.254	12.982	34.289	80.781
STANDARD DEV	7.454	21.013	9.306	33.827	15.781

Table 2. Summary statistics for cover measures of transect data on the ungrazed and grazed allotments.

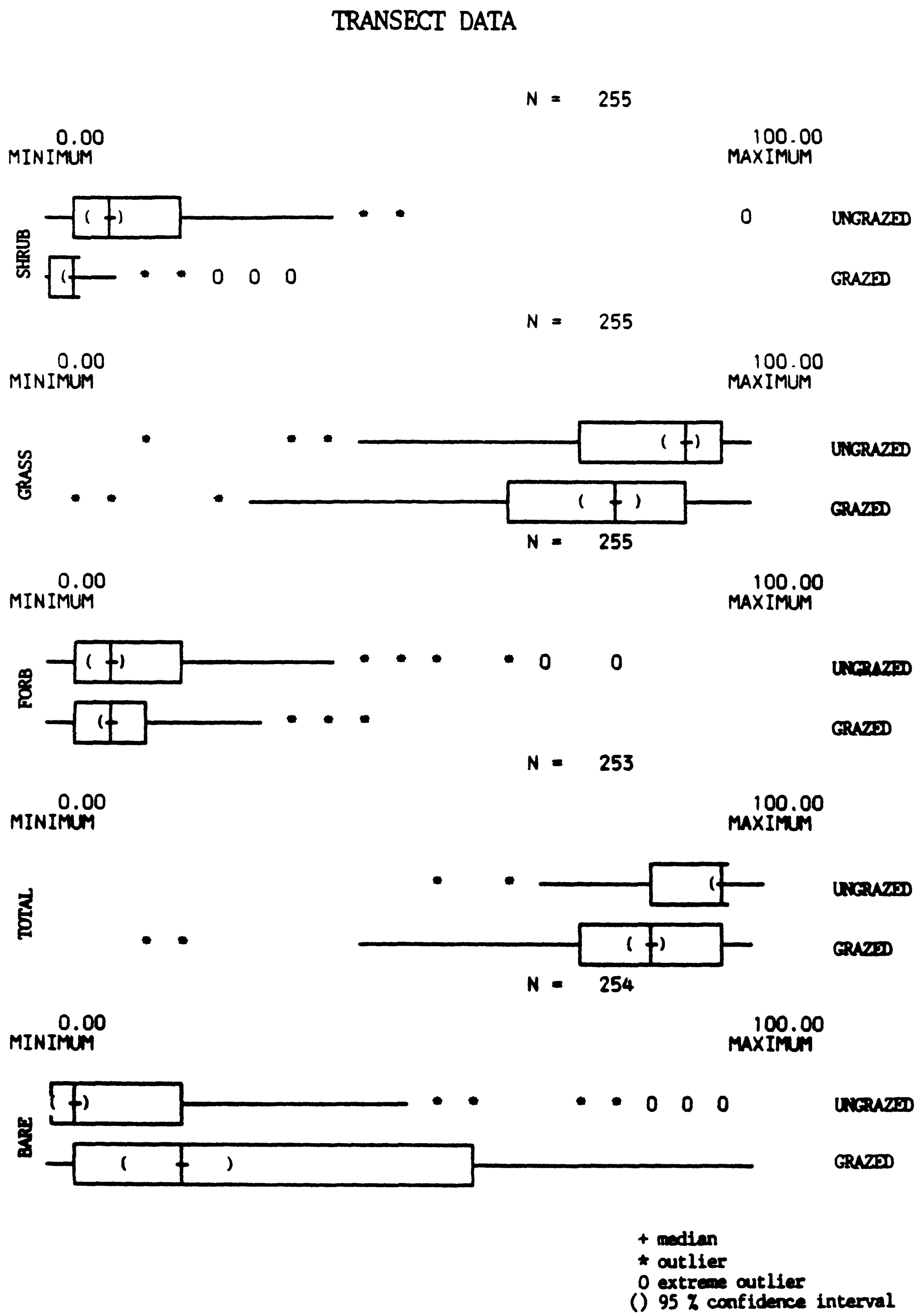


Figure 4. Box-plots of percent cover measures for transect data on the ungrazed and grazed allotments.

by other workers (Mueller-Dombois, 1980; Potvin and Harrison, 1984).

Landforms

It is important to determine if the distribution of landforms are similar between allotments prior to an analysis of cover measures on landforms. A similar distribution of landforms was found on each allotment, insuring a valid comparison (Table 3), (X^2 = 0.896 with 3 df P = 0.826).

A comparison of percent cover measures by landform, swale, dune face, dune ridge, and blowout (Figures 5, 6, 7, 8 and 9) again illustrates the lower overall vegetative cover and higher bare cover averages on the grazed allotment as seen in the previous cover measure analysis. In this case however, it also demonstrates how the cover is distributed between the different landforms. Percentages of all the vegetative cover measures are highest at swale locations, decrease as one moves from dune faces to dune ridges, and are lowest in the blowouts. The variable bare ground shows the reverse trend; the highest percentages are found in blowouts, and the lowest in the swales.

Between the two allotments most measures were similar with respect to landform, except for percent bare cover in blowouts. Measurements on blowouts in the grazed allotment have significantly higher bare ground values

TRANSECT DATA

	ALLOTMENT		
LANDFORM	UNGRAZED	GRAZED	TOTAL
SWALE	(48) 34.0	(33) 29.0	81
DUNE FACE	(45) 31.9	(37) 32.5	82
DUNE RIDGE	(30) 21.3	(27) 23.7	57
BLOWOUT	(18) 12.8	(17) 14.9	35
TOTAL	(141) 100 %	(114) 100 %	255

* Numbers in parentheses are counts.

Table 3. Percent frequencies and counts of landforms on the ungrazed and grazed allotments.

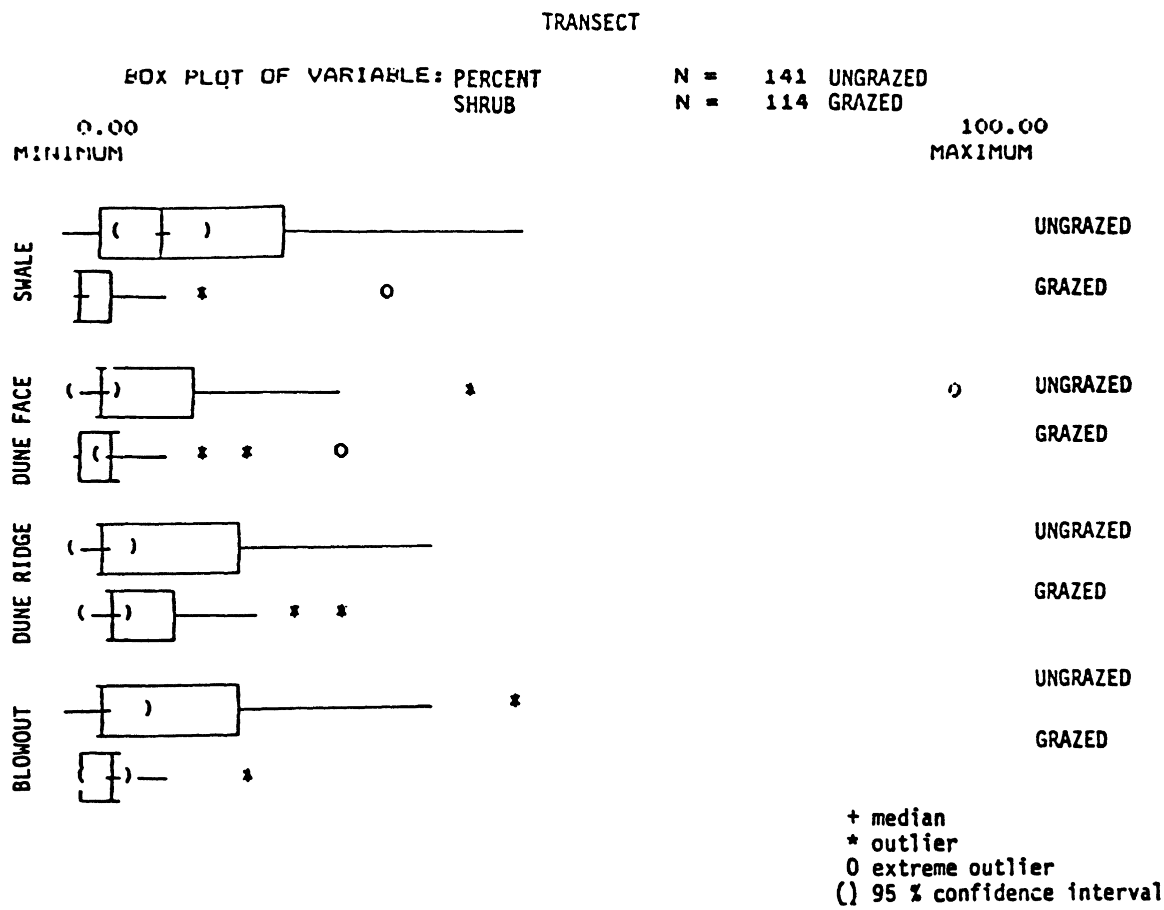


Figure 5. Box-plots of percent shrub cover by landform for transect data on the ungrazed and grazed allotments.

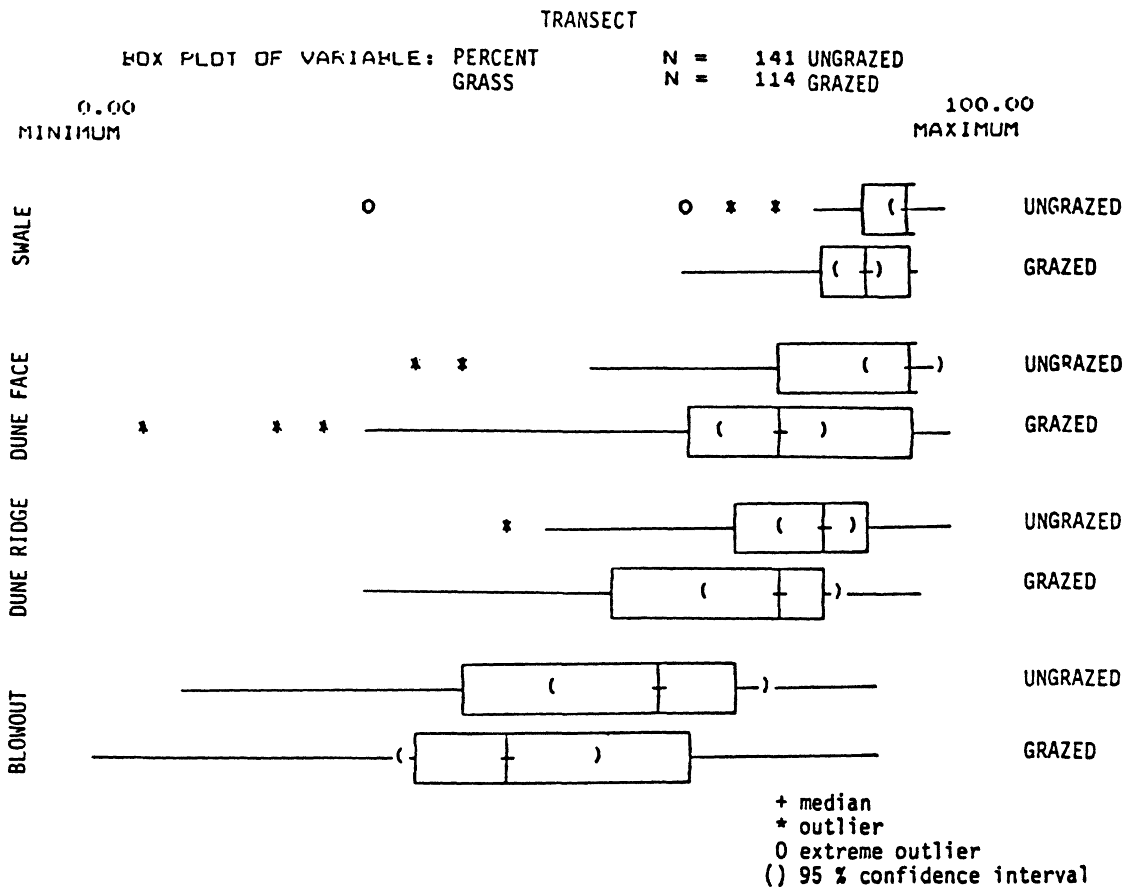


Figure 6. Box-plots of percent grass cover by landform for transect data on the ungrazed and grazed allotments.

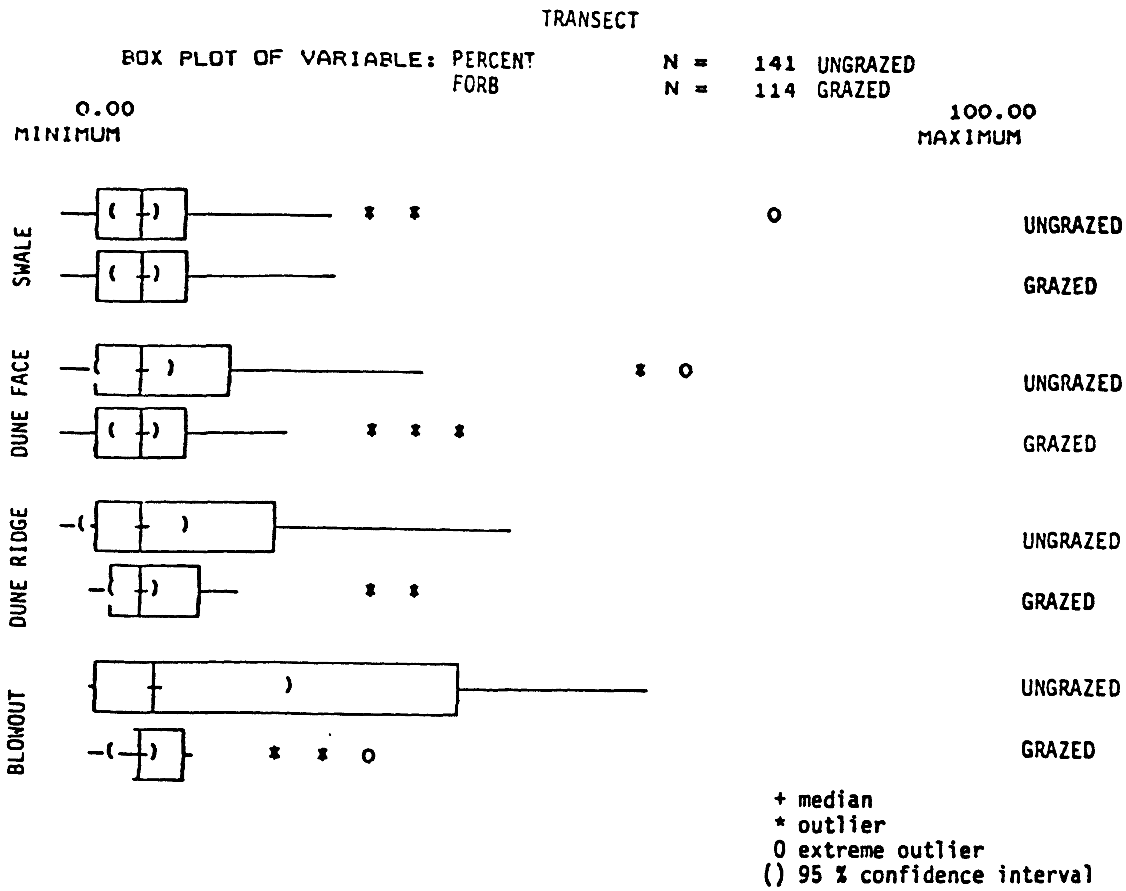


Figure 7. Box-plots of percent forb cover by landform for transect data on the ungrazed and grazed allotments.

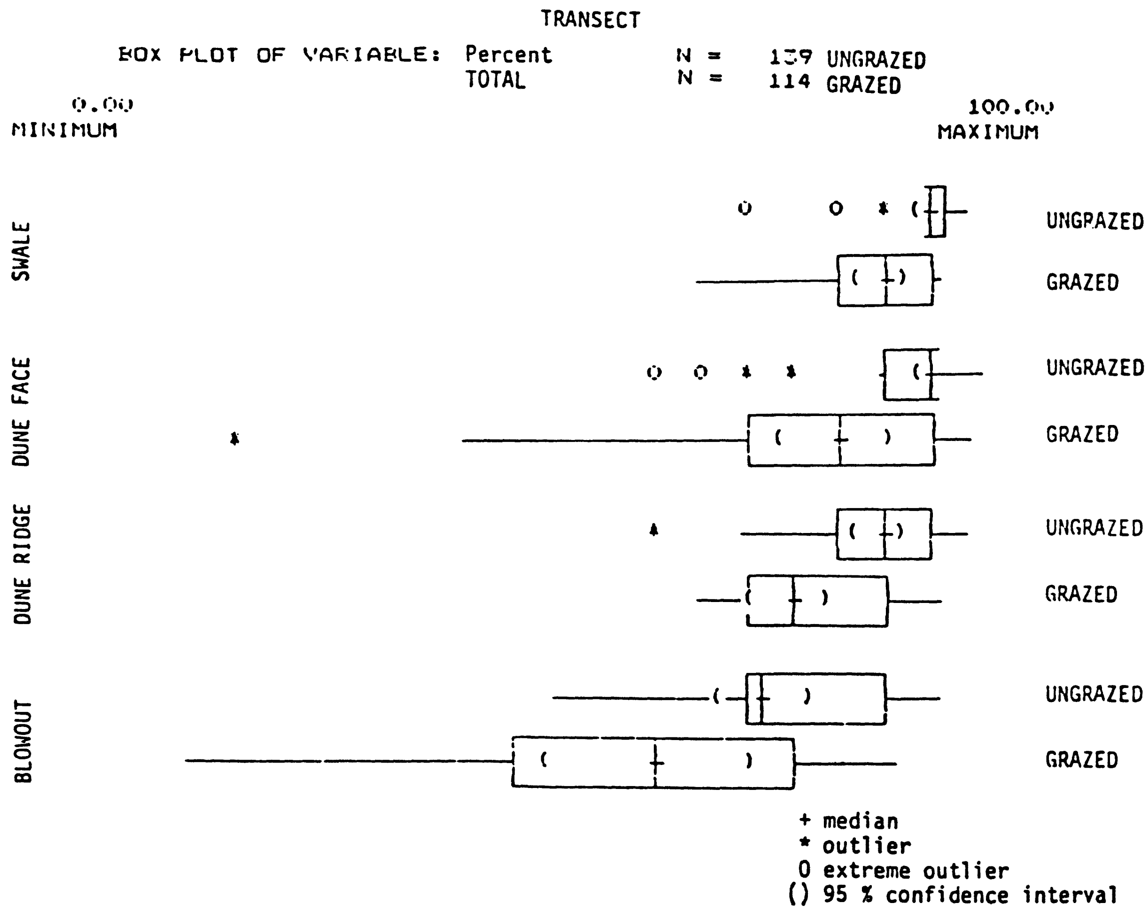


Figure 8. Box-plots of percent total cover by landform for transect data on the ungrazed and grazed allotments.

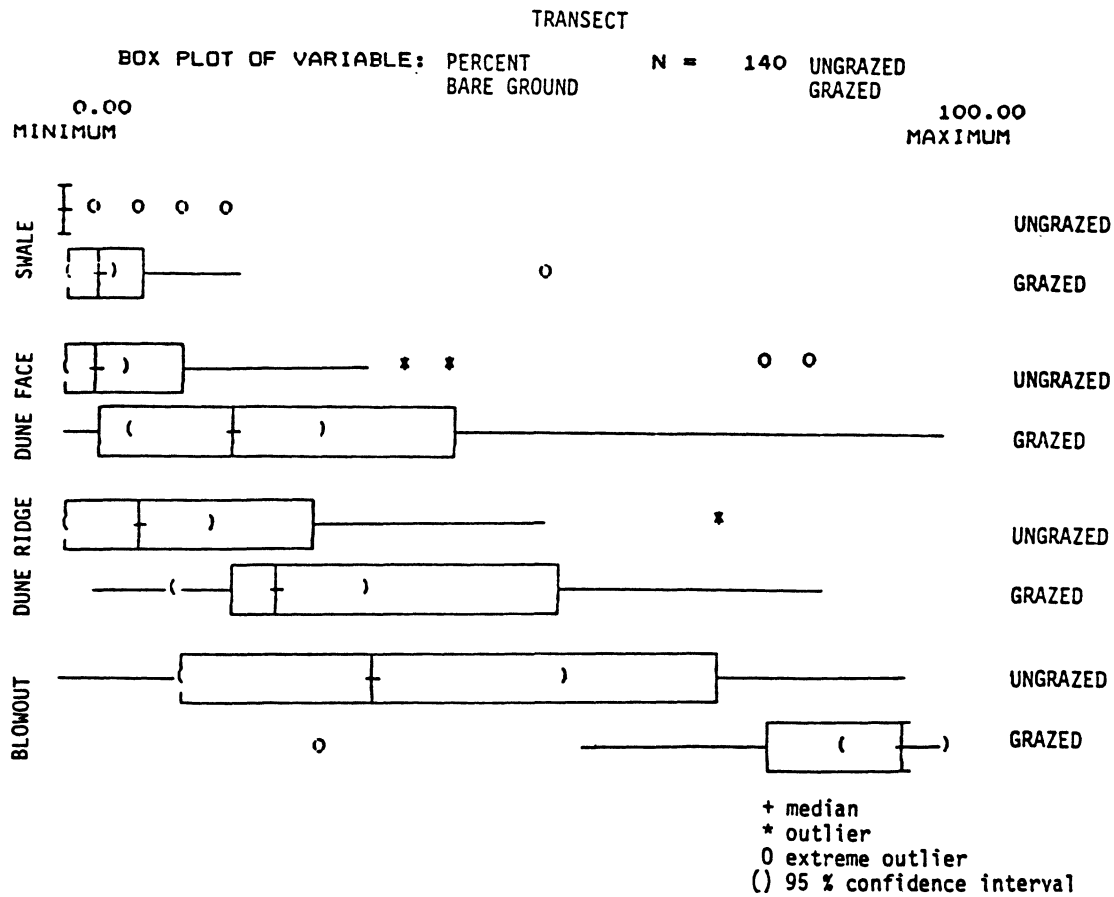


Figure 9. Box-plots of percent bare ground by landform for transect data on the ungrazed and grazed allotments.

(lower amounts of litter) (Figure 9, p. 38). This may be due to the stronger affect of disturbance mechanisms in areas of early successional status and lower vegetative cover, then in those with higher vegetative cover (Weins, 1976).

While the pattern of vegetation distribution is similar between allotments, the percentages of vegetation cover arelower, and the percent of bare ground higher on the grazed allotment. The main factor that affects this allotment only, is likely to be grazing since it is not conceivable that in this case climate factors of precipitation or temperature could differ significantly over such short distances. It is possible that soil fertility differs between allotments. It seems likely, however, that manure left by cattle would actually improve the soils on the grazed allotment at least locally. The organic matter content for the site as a whole was quite low.

Cattle Grazing

Box-plots of percentages of each cover measure on the grazed allotment by grazing intensity (percent grazed cover), showed no obvious associations. The Pearson's r and Spearman's rho statistics of the means of the percent grazed cover intervals for each variable were very near zero (Appendix B).

It would seem that the more vegetative material grazed off, the more bare ground (low litter cover) would be expected. Litter may accumulate over a number of years, however, and I evaluated grazing intensity for only one month (August) out of a single grazing season which usually starts in late July and ends in October. Consequently, it would be difficult to discern any pattern unless cattle grazed the exact same location year after year, which although possible is unlikely. Indeed, no trend of lower vegetative cover measures with increased grazing was illustrated by the data (Appendix B).

Blowout Results

Cover Measures

In order to discern if there were any differences with respect to the variables measured between blowouts with and without *A. ceramicus*, linear discriminant analysis was performed on the data from each allotment.

Variables that best predicted the presence or absence of *A. ceramicus* in blowouts on the ungrazed allotment were in order: bare ground, total cover and grass cover. The variable bare ground correctly classified 90.8% of the blowouts in the analysis (Table 4). Little additional predictive value is gained by the addition of the other two variables. The box-plots (Figure 10) display the significant differences between blowouts with *A. ceramicus* and those without it (P = 0.006, 0.002, 0.021, 0.000,

BLOWOUT DISCRIMINANT ANALYSIS

ACTUAL	NUMBER OF CASES	PREDICTED No A. ceramicus	PREDICTED A. ceramicus	ALLOTMENT	PERCENT CORRECTLY CLASSIFIED
No *A. ceramicus*	25	21 (84.5%)	4 (16.0%)	UNGRAZED	90.8%
A. ceramicus	40	2 (5.0%)	38 (95.0%)		
No *A. ceramicus*	25	16 (64.0%)	9 (36.0%)	GRAZED	81.5%
A. ceramicus	40	3 (7.5%)	37 (92.5%)		

UNGRAZED ALLOTMENT VARIABLES: BARE GROUND
GRAZED ALLOTMENT VARIABLES: BARE GROUND, TOTAL COVER, BLOWOUT AREA

Table 4. Matrix of results for discriminant analysis of the variables: blowout area, percent shrub, grass, forb, total and bare ground on the ungrazed and grazed allotments.

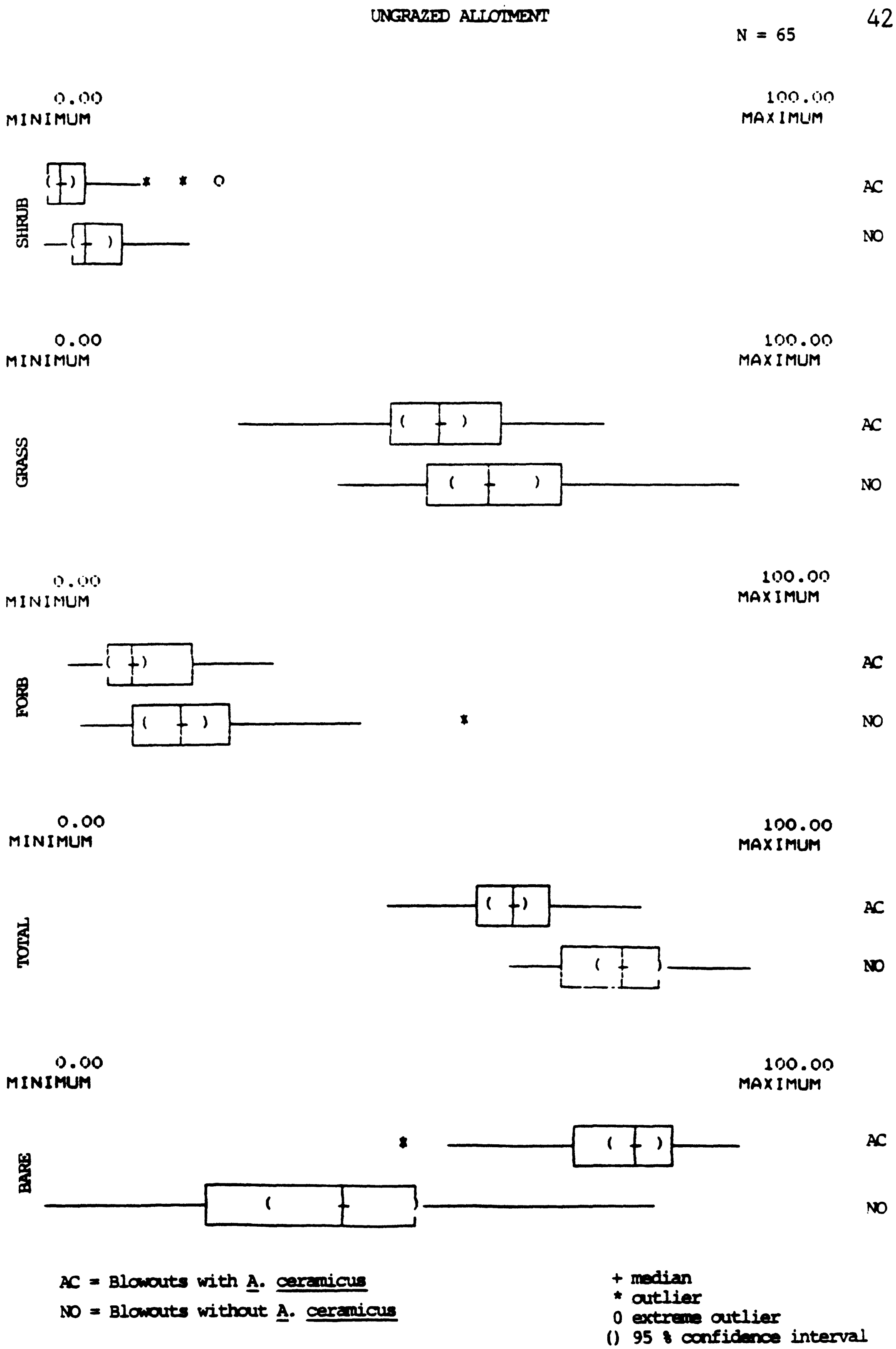


Figure 10. Box-plots of percent cover measures for blowouts with and without A. ceramicus, ungrazed allotment.

0.000 for shrub, grass, forb, total cover and bare ground respectively). The most distinct differences are more bare ground and less grass and total cover in blowouts with A. ceramicus (summary statistics Table 5).

The variables which best predicted the presence or absence of A. ceramicus in blowouts on the grazed allotment were in order: percent bare ground, total cover, and blowout area (Table 4, p.41). Although bare ground had the most predictive value for both allotments, it had a lower predictive value on the grazed allotment. This may be due to an overall decrease in percent vegetation cover and an increase in bare ground on all landforms on the grazed allotment as described by the transect data. This increase in bare ground might lessen the distinctions between all blowouts within the grazed allotment. The three variables together correctly classified 81.5% of the blowouts (Table 4, p.41).

Box-plots (Figure 11) and summary statistics (Table 6) for blowouts with A. ceramicus and those without it on the grazed allotment show much more overlap and fewer significant differences for cover measures than did the ungrazed allotment (P = 0.881, 0.118, 0.871, 0.082 and 0.000 for shrub, grass, forb, total cover, and bare ground, respectively). Blowouts without A. ceramicus had lower measures of bare ground and higher measures of grass and total cover.

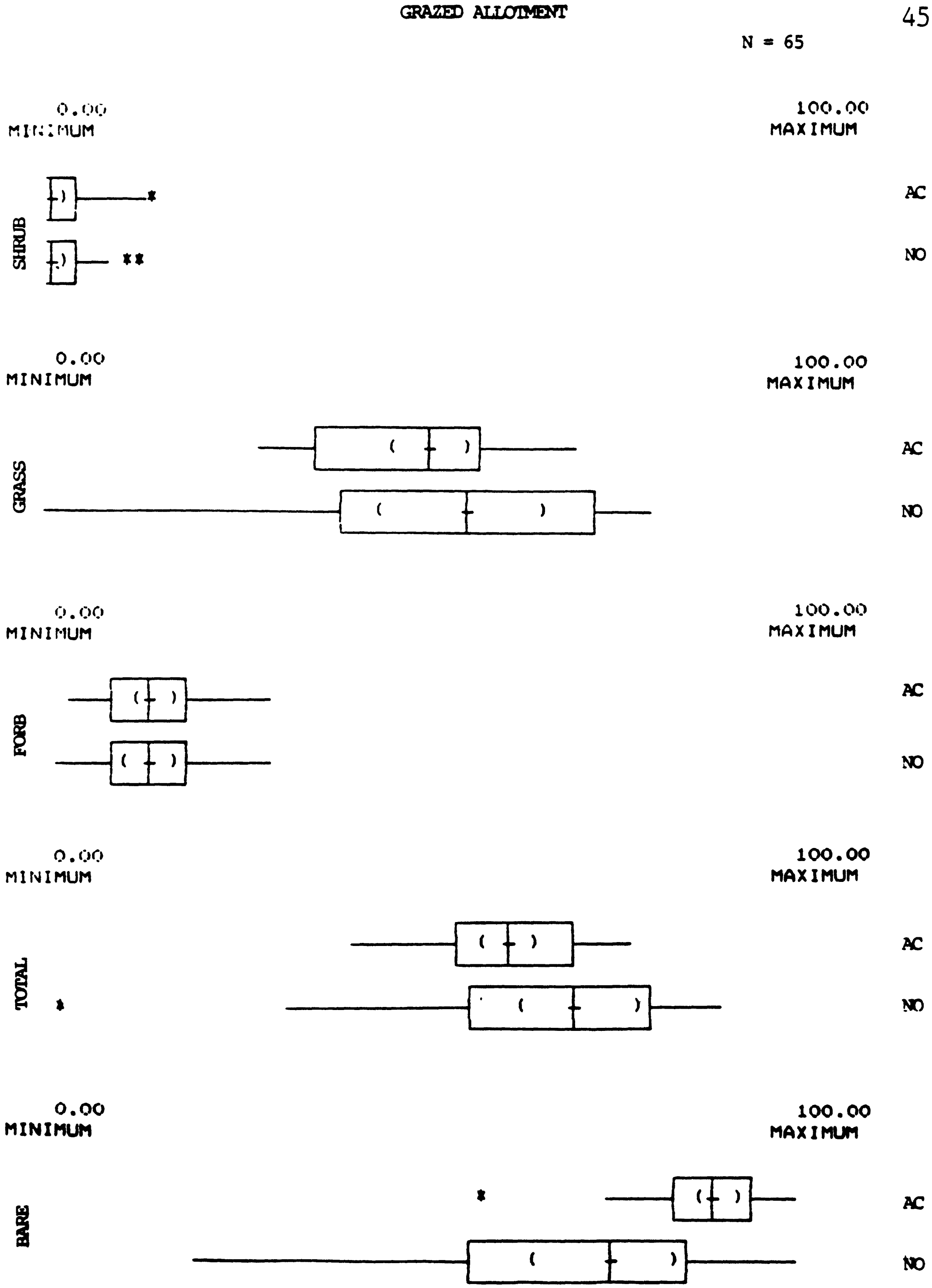
Blowouts with A. ceramicus

	SHRUB	GRASS	FORB	TOTAL	BARE
N OF CASES	40	40	40	40	40
MINIMUM	0.000	28.333	5.000	48.333	51.000
MAXIMUM	25.833	76.667	32.143	81.667	95.800
MEAN	5.630	54.410	15.840	65.753	80.215
STANDARD DEV	5.648	11.663	7.078	7.883	10.391

Blowouts without A. ceramicus

	SHRUB	GRASS	FORB	TOTAL	BARE
N OF CASES	25	25	25	25	25
MINIMUM	0.000	42.857	8.000	65.417	1.167
MAXIMUM	20.714	96.333	59.000	96.800	83.333
MEAN	9.059	65.833	23.172	80.260	40.130
STANDARD DEV	5.783	13.947	12.888	9.214	23.307

Table 5. Summary statistics for percent cover measures of blowouts with and without *Astragalus ceramicus* on the ungrazed allotment.



AC = Blowouts with A. ceramicus
NO = Blowouts without A. ceramicus

+ median
* outlier
0 extreme outlier
() 95 % confidence interval

Figure 11. Box-plots of percent cover measures for blowouts with and without A. ceramicus, grazed allotment.

Blowouts with A. ceramicus

	SHRUB	GRASS	FORB	TOTAL	BARE
N OF CASES	40	40	40	40	40
MINIMUM	0.000	30.000	6.250	42.000	58.750
MAXIMUM	15.000	70.000	30.000	77.500	99.000
MEAN	4.121	50.011	16.501	62.677	88.338
STANDARD DEV	4.283	11.834	5.922	9.689	7.789

Blowouts without A. ceramicus

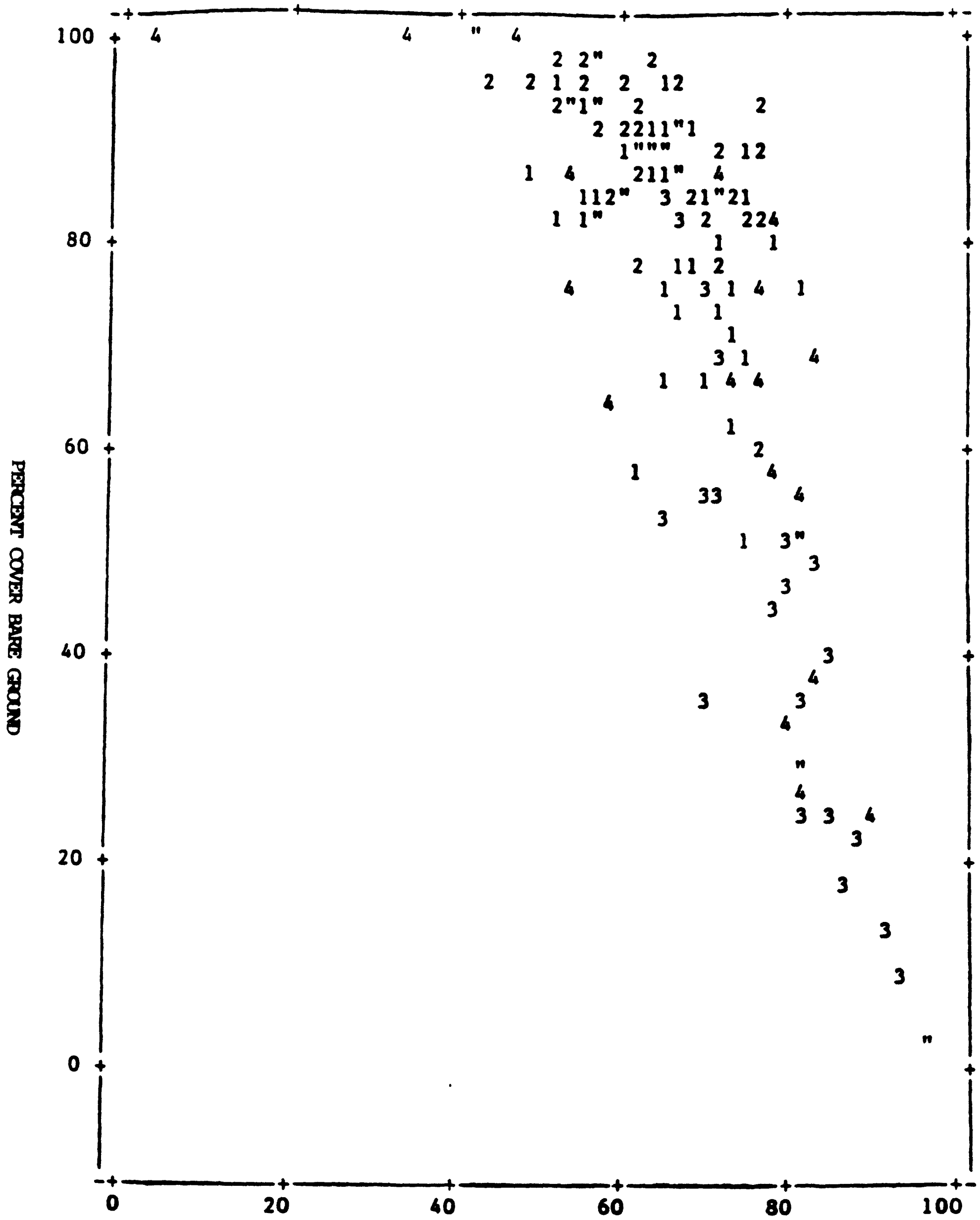
	SHRUB	GRASS	FORB	TOTAL	BARE
N OF CASES	25	25	25	25	25
MINIMUM	0.000	0.000	3.667	3.667	22.500
MAXIMUM	14.000	80.000	30.000	89.833	99.000
MEAN	3.989	54.866	16.210	65.991	69.451
STANDARD DEV	4.036	20.833	7.328	19.054	23.751

Table 6. Summary statistics for percent cover measures of blowouts with and without Astragalus ceramicus on the grazed allotment.

The study suggests, that the presence of A. ceramicus is associated with blowouts which have high percentages of bare ground and a lower total vegetation cover in comparison with blowouts lacking the species. These results are very consistent with studies cited in the literature on disturbance dependent species (Dring and Frost, 1972; Stubbendieck, 1986; Keeler, 1987). Possible controlling factors may include requirements of seed germination or low competitive ability of plants. Germination experiments and removal studies might be of use in studying these aspects of the plant's ecology (Harper, 1983).

Cover Percentage

A scatter plot of the percent cover bare ground versus total vegetation (Figure 12), demonstrates that blowouts with A. ceramicus have bare ground percentages equal to or exceeding 50 percent and total cover between 42 and 80 percent. Under the assumption that these are limiting habitat parameters, when bare ground is reduced or total cover is increased, is the species likely to compete well and maintain viable populations? As stated previously, the species of the genus Astragalus are generally not suited to competition (Barneby, 1964), and this species in particular has a low leaf area making it less effective at light interception. It seems likely that this may be one



1 = Blowouts with A. ceramicus, ungrazed allotment

2 = Blowouts with A. ceramicus, grazed allotment

3 = Blowouts without A. ceramicus, ungrazed allotment

4 = Blowouts without A. ceramicus, grazed allotment

Figure 12. Scatter-plot of percent bare ground and percent total cover for blowouts with and without A. ceramicus on the grazed and ungrazed allotment.

reason the species is not present in more vegetated blowouts.

Blowout Size

Box-plots and summary statistics (Appendix C), showed no trend with respect to blowout size between blowouts with and without A. ceramicus. The minimum and the maximum blowout areas were 23.6-3501.6 m^2 for blowouts with the species and 65.9-1949.1 m^2 for those without it. Thus it appears that if other habitat conditions are met, A. ceramicus is able to establish itself in small as well as large blowouts.

Blowout Aspects and Slopes

Box-plots and means of aspect did not appear different for blowouts with and without A. ceramicus (Figures 13 and Table 7). It is interesting to note that in all cases the mean, median, and mode are quite similar and lie near 220° or south-west. This is also the direction from which the prevailing wind blows indicating perhaps the importance of wind in blowout formation. Box-plots and summary statistics (Figure 14 and Table 8) of the slopes of blowouts with and without A. ceramicus did not differ statistically. Overall however, slopes of the blowouts without A. ceramicus were somewhat steeper than those with the species. Steeper slopes could adversely affect the ability of the plant to remain stable where sand is likely to shift more.

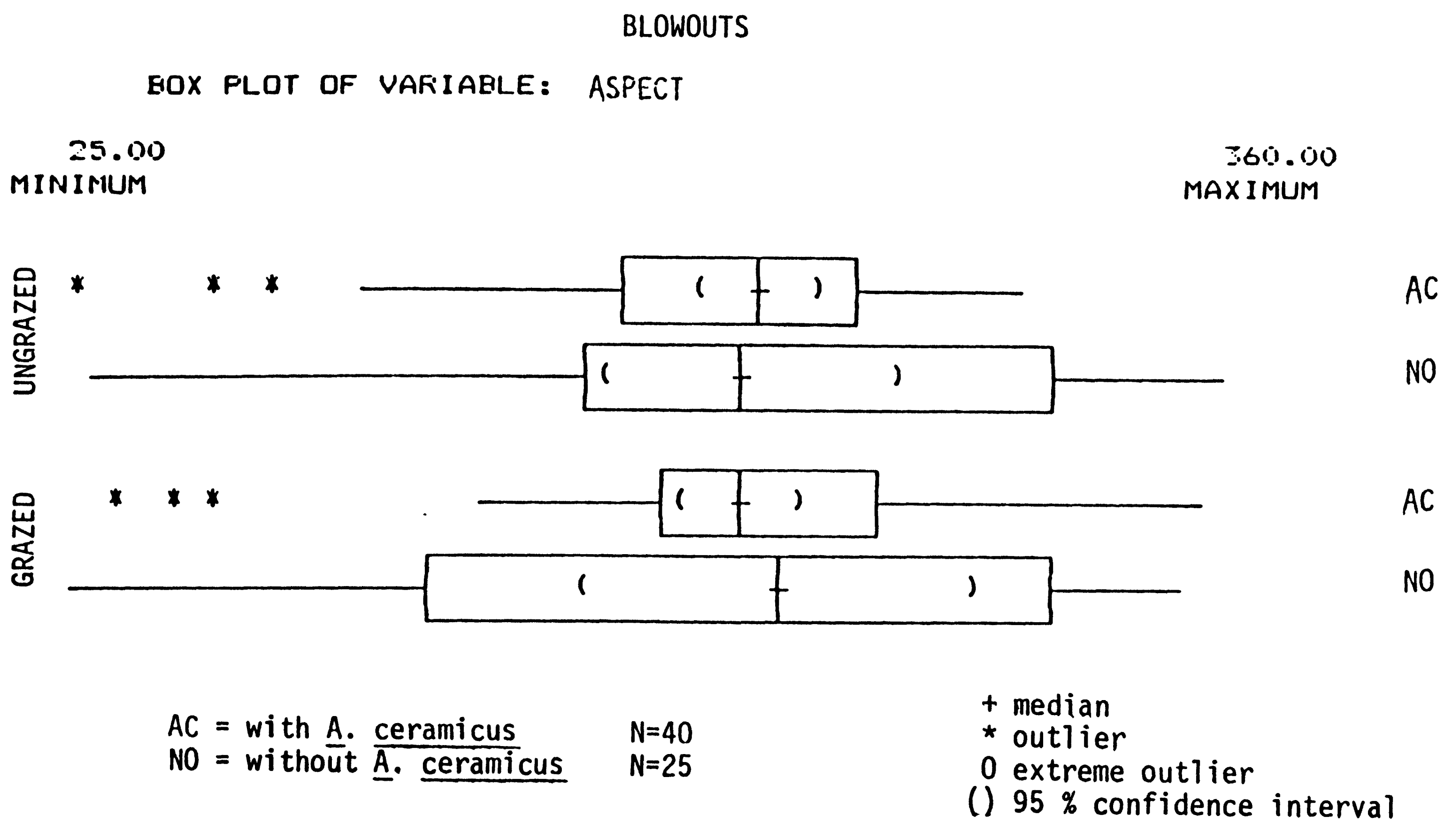


Figure 13. Box-plots of aspect in degrees for blowouts with and without *Astragalus ceramicus* on ungrazed and grazed allotments.

BLOWOUT ASPECTS

UNGRAZED ALLOTMENT

WITH AC

N OF CASES	40
MINIMUM	30.000
MAXIMUM	300.000
MEAN	212.625
STANDARD DEV	62.101

WITHOUT AC

N OF CASES	25
MINIMUM	40.000
MAXIMUM	360.000
MEAN	225.600
STANDARD DEV	96.591

GRAZED ALLOTMENT

WITH AC

N OF CASES	40
MINIMUM	45.000
MAXIMUM	350.000
MEAN	222.675
STANDARD DEV	62.198

WITHOUT AC

N OF CASES	25
MINIMUM	25.000
MAXIMUM	345.000
MEAN	220.600
STANDARD DEV	96.688

Table 7. Summary statistics for aspect for blowouts with and without *Astragalus ceramicus* (AC) on the grazed and ungrazed allotments.

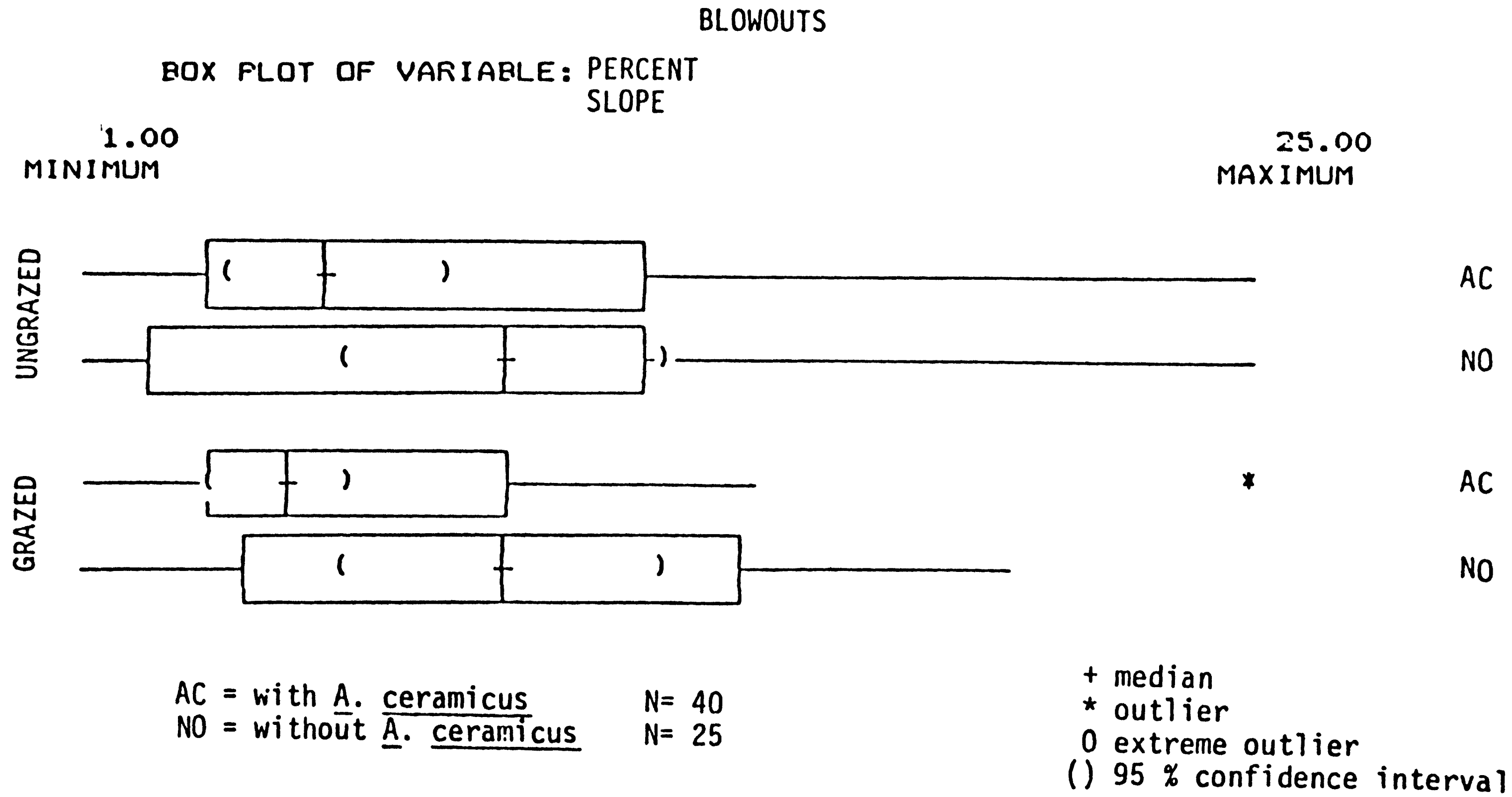


Figure 14. Box-plots of percent slope for blowouts with and without Astragalus ceramicus on the ungrazed and grazed allotments.

PERCENT SLOPES OF BLOWOUTS

UNGRAZED ALLOTMENT		GRAZED ALLOTMENT	
WITH AC		WITH AC	
N OF CASES	40	N OF CASES	40
MINIMUM	1.000	MINIMUM	1.000
MAXIMUM	25.000	MAXIMUM	25.000
MEAN	8.425	MEAN	7.175
STANDARD DEV	6.089	STANDARD DEV	5.012
WITHOUT AC		WITHOUT AC	
N OF CASES	25	N OF CASES	25
MINIMUM	1.000	MINIMUM	1.000
MAXIMUM	25.000	MAXIMUM	20.000
MEAN	9.520	MEAN	10.120
STANDARD DEV	6.820	STANDARD DEV	5.223

Table 8. Summary statistics of percent slope in blowouts with and without *Astragalus ceramicus* (AC) on ungrazed and grazed allotments.

Blowout Vegetation Cover

Comparisons were made between allotments of blowouts that contained *A. ceramicus*. Mean percent cover measures for the variables shrub, grass, forb and total were not strongly statistically significant (P = 0.162, 0.120, 0.506, 0.189) (See Tables 5, p.44 and 6, p.46). As noted in other parts of the study mean percent bare ground was found to be significantly different (P = 0.000). Box-plot results were similar to the results of transect data (Figure 15). Higher bare ground and lower shrub, grass and total percent cover were observed on the grazed allotment with the exception that forb averages were somewhat higher than on the ungrazed allotment.

Soil Moisture Capacity

Texture and organic matter are major determinants of soil moisture availability (Ball, 1964). The results of the mechanical analysis for sand, silt and clay showed little variation between the means of blowouts with and without *A. ceramicus* (Table 9). A trend was observed toward higher silt, clay and organic matter in blowouts without *A. ceramicus*. This could be a result of higher vegetation cover, which in turn stills the air, allowing lighter soil particles to remain in and on the soil. From a textural chart, the soil would be classified as sandy due to high percentages of sand and low percentages of silt and clay.

BLOWOUTS WITH A. ceramicus

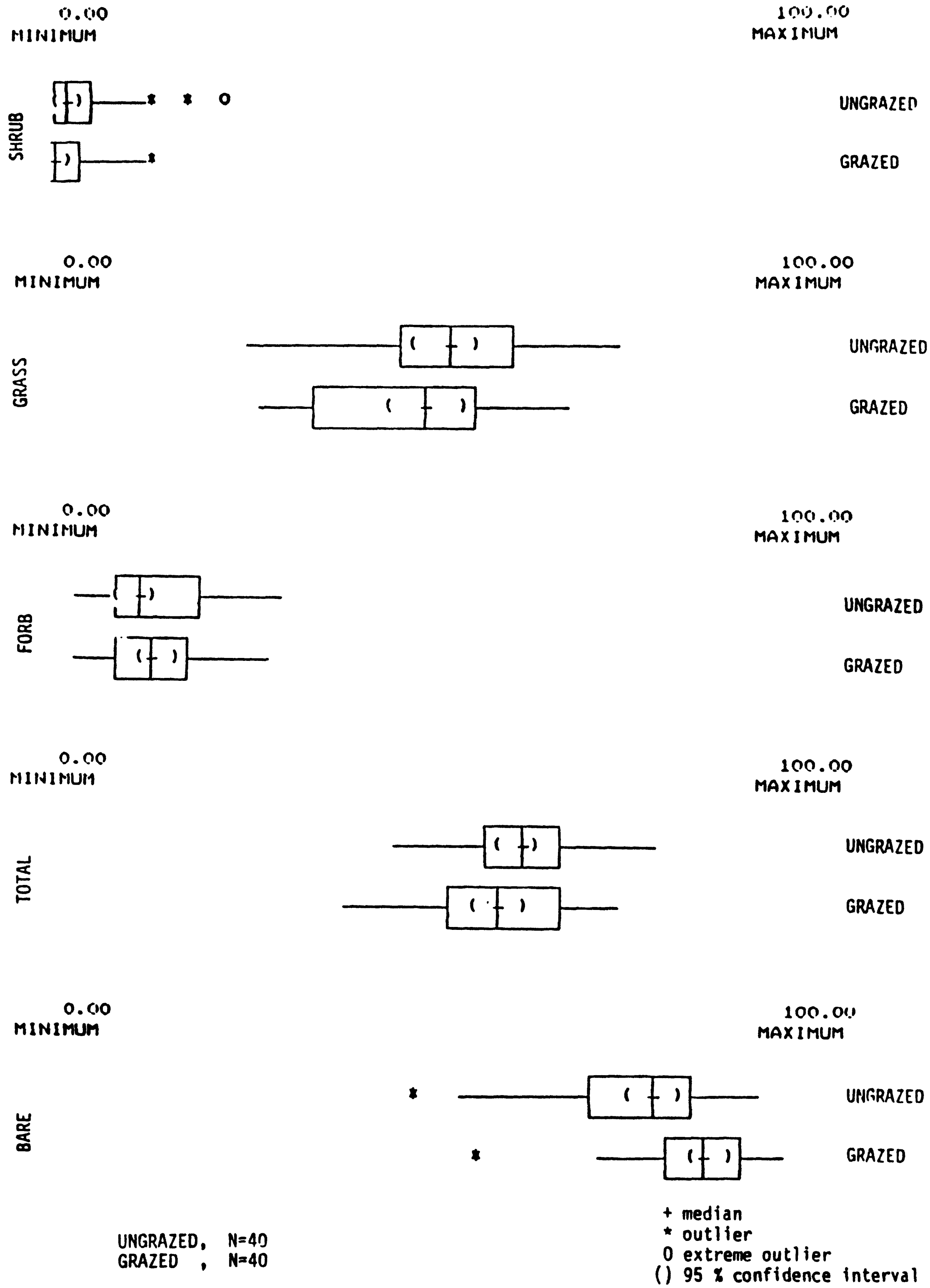


Figure 15. Box-plots of cover for blowouts with *Astragalus ceramicus* on the ungrazed and grazed allotments.

BLOWOUT SOIL TEXTURES

UNGRAZED ALLOTMENT

	SAND	SILT	CLAY	ORGANIC
N OF CASES	22	22	22	22
MINIMUM	91.200	0.000	1.000	0.045
MAXIMUM	97.000	3.600	7.400	0.147
MEAN	94.323	1.350	4.327	0.086
STANDARD DEV	1.906	1.069	1.835	0.031

GRAZED ALLOTMENT

	SAND	SILT	CLAY	ORGANIC
N OF CASES	12	12	12	12
MINIMUM	80.200	0.400	2.200	0.055
MAXIMUM	96.400	10.800	9.000	0.329
MEAN	92.233	2.467	5.300	0.134
STANDARD DEV	4.371	2.780	2.280	0.076

Table 9. Summary statistics of percent sand, silt and clay and mg/20 gm soil organic matter for blowouts with and without Astragalus ceramicus.

The box-plots for texture and organic matter show extensive overlap for blowouts with and without A. ceramicus (Figure 16). Differences between blowouts are statistically significant for organic matter and less so for sand, silt, and clay (P = 0.023, 0.108, 0.169, 0.279, respectively.). However, the mean organic contents are exceptionally low (0.0045 mg/gm and 0.007 mg/gm, for blowouts with and without A. ceramicus, respectively) and it is not known if it is ecologically important for water relations. The greater amounts of organic matter in blowouts without A. ceramicus is a likely result of the greater overall cover observed for these blowouts. Such a relationship has been described for other dune systems (Olson, 1958).

Stem Number and Species Area

The mean number of stems, density of stems per square meter of species area occupied, and the density of stems per square meter of blowout area are all significantly higher for the ungrazed allotment (P = 0.00, 0.00, 0.00, respectively). The box-plots and summary statistics confirm these results (Figures 17 and 18, Table 10). However, the ratio of the species area (total area covered by A. ceramicus) to the area of the blowout, does not appear different for the two allotments (Table 10 and Figure 19) (P = 0.155). Using the means of the blowout area and the total number of blowouts observed for each

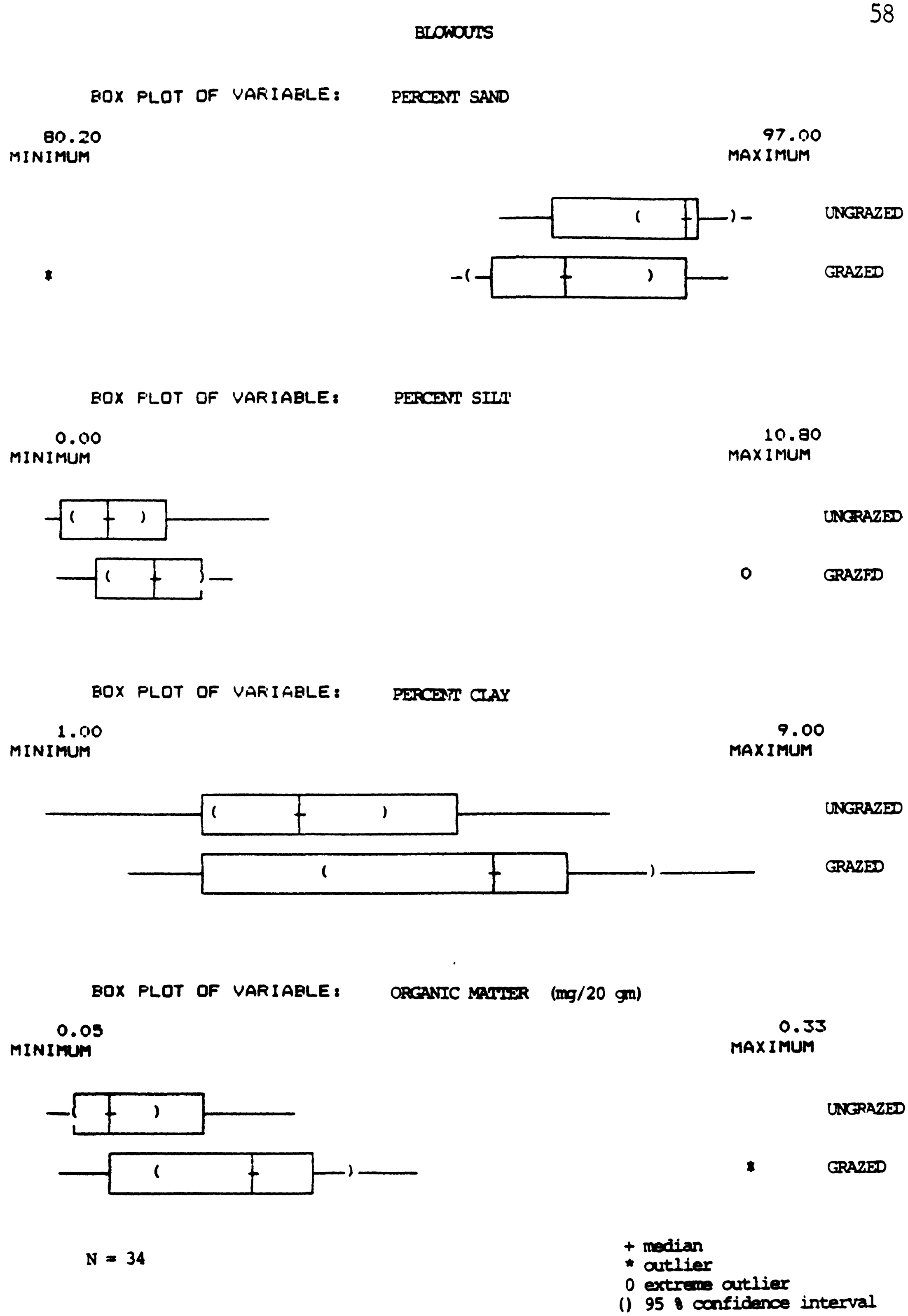


Figure 16. Box-plots of percentages of sand, silt and clay and amounts of organic matter in blowouts.

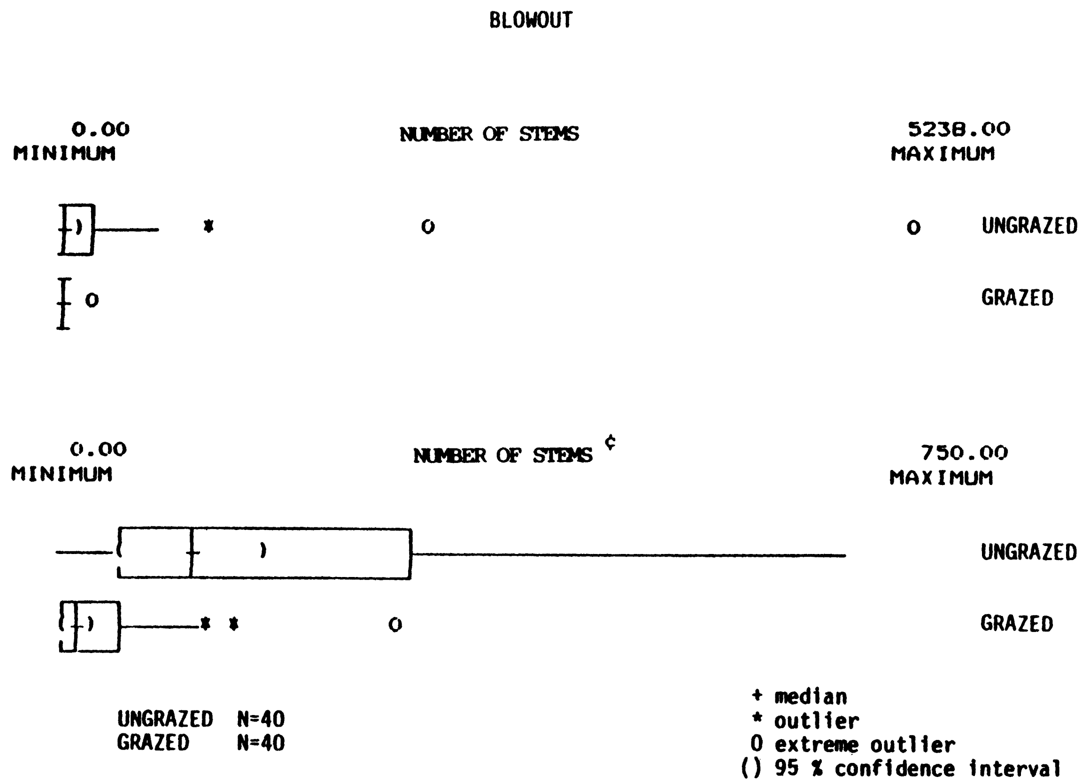


Figure 17. Box- plots of stem numbers in blowouts on the ungrazed and grazed allotments.

¢ = Scale reduced for better presentation, 3 outliers on ungrazed allotment dropped.

BLOWOUTS

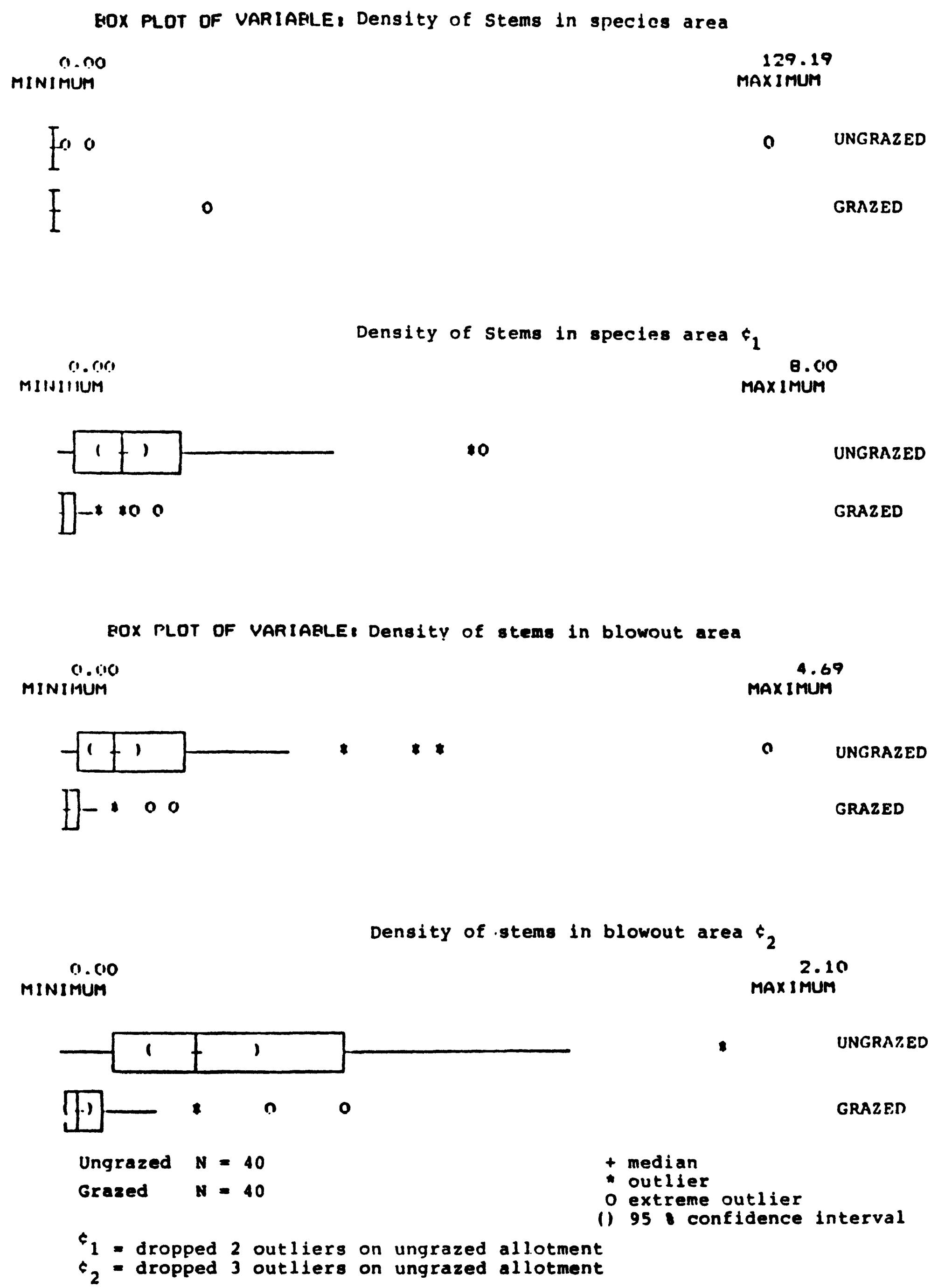


Figure 18. Box-plots of density of stems in the species area and density of stems in the blowout area for the ungrazed and grazed allotments.

COUNTS AND DENSITIES OF *Astragalus ceramicus* IN BLOWOUTS

UNGRAZED ALLOTMENT

	No. stems	Species area density	Blowout area density	Species area / Blowout area
N OF CASES	40	40	40	40
MINIMUM	7.000	0.023	0.023	0.001
MAXIMUM	5238.000	129.185	4.694	1.000
MEAN	381.475	4.515	0.717	0.680
STANDARD DEV	882.259	20.296	0.890	0.343

GRAZED ALLOTMENT

	No. stems	Species area density	Blowout area density	Species area / Blowout area
N OF CASES	40	40	40	40
MINIMUM	3.000	0.021	0.011	0.000
MAXIMUM	312.000	30.562	0.855	1.000
MEAN	54.350	1.032	0.134	0.568
STANDARD DEV	59.217	4.797	0.173	0.357

Table 10. Summary statistics for stem number, density of stems in the species area, density of stems in the blowout area, and species area per blowout area for the ungrazed and grazed allotments.

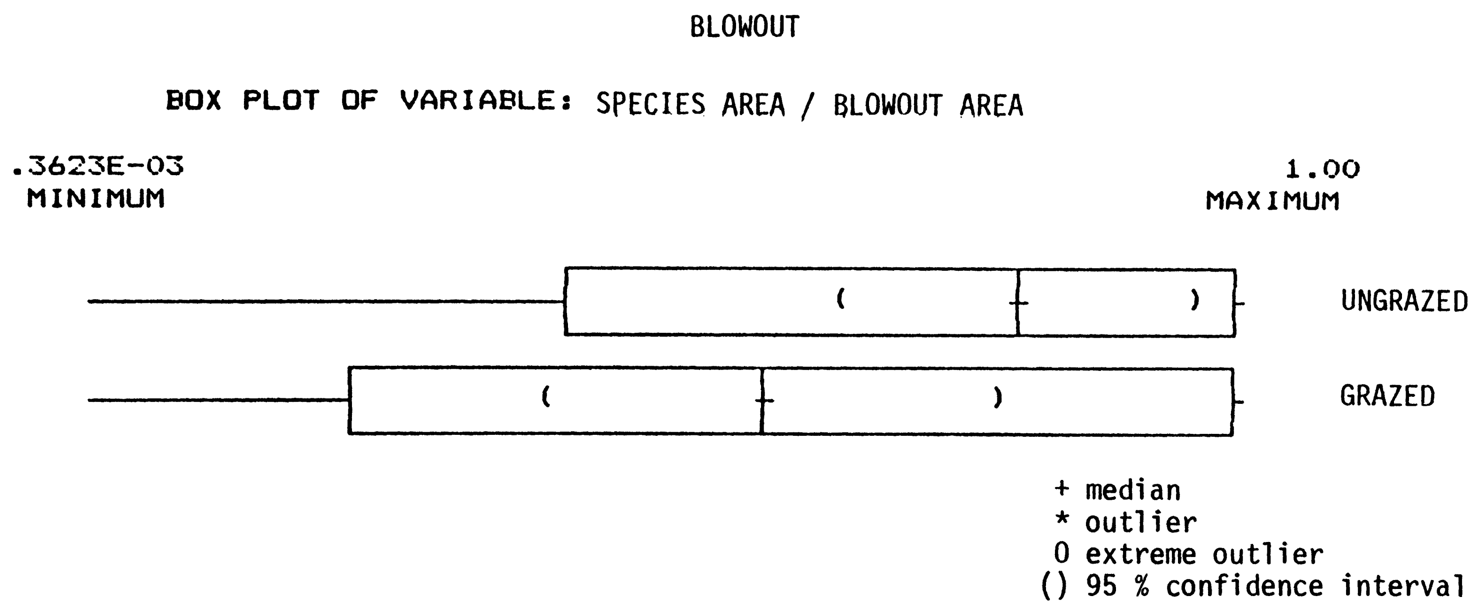


Figure 19. Box-plots of species area per blowout area for the ungrazed and grazed allotments.

allotment, I estimated the area in blowouts to be 47,164.5 m^2 and 66,785.4 m^2 for the ungrazed and grazed allotments, respectively. Comparing this to the total area of each allotment, 3.031 km^2 and 2.461 km^2, I estimated the percentage of area in blowouts to be 1.56 percent and 2.71 percent for the ungrazed and grazed allotments, respectively. Although there is more area in blowouts on the grazed allotment and the species areas per blowout are similar, the density of A. ceramicus and the total number of stems is lower on the grazed allotment.

If there is more available habitat on the grazed allotment, why is the density of A. ceramicus stems in the blowouts lower? Transect results, show lower vegetation cover overall on the grazed allotment. I suggest, that the lower number of A. ceramicus stems may be due to the trampling and soil disturbance that occurs with grazing. Such conclusions have been drawn in other studies (Van der Maarel, 1976; Collins and Barber, 1985). Grazing disturbance may be severe enough to be detrimental to A. ceramicus populations, although it is also likely to be the mechanism that currently maintains the habitat necessary to maintain the population.

Historical Disturbance Mechanisms

Since A. ceramicus seems well established on the site, the question arises as to what mechanisms may have contributed to the maintenance of the open habitat in the past. Records from the B.L.M. (Beaverhead District, Dillon, Montana) show that both allotments have been grazed consistently since 1939. A series of aerial photographs dated 1942, 1955, 1965, and 1976 were studied to determine vegetational changes that may have occurred in relation to meteorological records. Unfortunately, the vegetation type, sagebrush grassland, and the photographs were not distinct enough to enable me to draw any detailed conclusions. The 1955 photo did appear to show lower vegetation cover overall on the currently ungrazed (B.L.M.) allotment, whereas the grazing records show no change in grazing status. At that time, few checks were made on grazing permits, and it is possible that year had heavier use than normal (Lou Hagener, pers. comm.). In general, the numbers of blowouts do not appear to have changed much during this time period.

Precipitation and temperature data from this period (Appendix D) also show no outstanding trends. It is likely that an extended drought could maintain and enlarge blowouts as has been described for sand prairie areas in Nebraska and Colorado (Pool, 1914; Albertson et al., 1957; Stubbendieck, 1986). Interviews with long-time area ranchers revealed that herds were moved from the east into the Centennial Valley, during the dust-bowl years in the 30's. The valley was also dry, but still maintained better available forage than in southern and eastern Montana (Duke Gilbert, Les Staudenmeyer pers. com.).

Grazing

Grazing by domestic herds, first sheep (until WW II) and later cattle began in the late 1800's and could likely have maintained the blowouts in the sandhills. During the early 1900's until about 1936, there were numerous permanent ranches in the valley and grazing impacts were likely higher then at present (Lincoln Miller, pers. com.).

It is impossible to know when A. ceramicus became established at the sandhills site. Previous to this time bison, elk, deer and antelope may have played a part in maintaining this open habitat. Bison remains have been discovered at indian sites on the Upper Snake River Plain that date to 10,000 YBP (Swanson and Sneed 1966; Butler, 1971). The Centennial Valley may have been a likely summering area for bison herds as has been found in Alberta (Reeves, 1978). Currently a small herd of antelope are permanent residents of the dunes; however, it was rare to come across areas where their grazing was discernable on the ungrazed allotment.

Fire

Another possible natural disturbance mechanism is fire. From 1700 to 1900 the fire frequency for the forests at mid to high elevations in the Centennial

Mountains was found to be 58 years (Bakeman and Nimlos, 1985). Arno and Gruell (1983) report a fire frequency of 49 years for the sage-brush grassland timber interphase located near Henry's Lake twenty-five air miles to the east.

It is possible that this frequency might maintain the open habitat required for A. ceramicus as has been shown in other sandhill communities (Bragg, 1978; Abrahmson, 1984; Morrison et al., 1986). It is not known, how this species would react to the heating of soils that occurs with fire, although the root-stock is deeply buried and likely to be protected.

The Artemesias are generally killed by fire, and it is likely that grasses would increase after a fire (Blaisdell, 1953). Since grasses were found to be one of the major contributers to total cover, it is possible that this might have a negative effect on the colonies of A. ceramicus. However, other studies on post-fire recovery for a sandhills site in Florida found recovery to be 1-2 years longer for the drier ridge sites over the moist swale sites, which were fully recovered in 2 years (Abrahmson, 1984).

Chapter 6

Summary

Astragalus ceramicus var. *apus* is a rare plant found to be associated with the early successional habitat of the sandhill blowouts. A study was undertaken to determine the habitat of *A. ceramicus* and the mechanisms that maintain its habitat.

The physiography was found to be similar across the study site allowing for valid vegetative comparisons to be made between the two allotments.

With the help of discriminant analysis and box-plots, I discerned that bare ground and total cover were the variables that best delineated blowouts with and without *A. ceramicus*. A scatter plot of the data revealed that bare ground was equal to or greater than 50% and total vegetation cover between 40% and 80% in blowouts containing this species.

Transect data revealed that the two allotments were physiographically similar and that the pattern of vegetative cover across landforms was the same; however, percent cover measures were lower and percent bare ground higher on the grazed allotment. These differences are most likely attributable to the cessation of grazing on the B.L.M. (ungrazed) allotment.

Although the grazed allotment had more available habitat (blowouts), the density of stems of *A. ceramicus* was lower. One possible reason for the reduction in numbers of stems is the increased disturbance caused through trampling of soils by domestic herds.

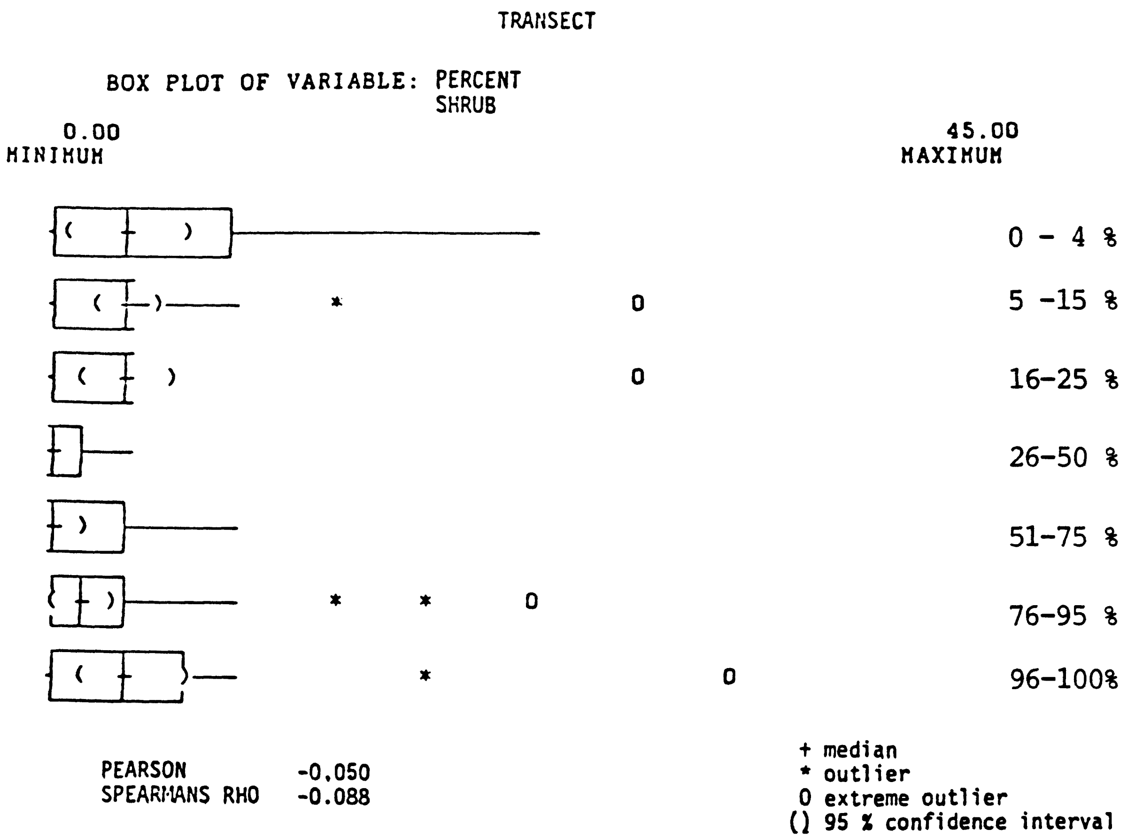
Grazing disturbance at high intensities may be detrimental to the colonies of A. ceramicus; however, it is also one mechanism which currently maintains the early successional habitat. Climatic factors may also aid in maintaining this open habitat.

Preservation of rare species usually entails protecting their habitat. In the case of early successional species, such as Astragalus ceramicus var. apus, this may include maintaining a disturbance regime to establish and maintain the open habitat with which the plants are associated, while keeping trampling at an acceptable level. For management purposes, alternating a year of grazing and a year of rest while monitoring colonies might be appropriate. Manual removal of vegetation would maintain open habitats but would be somewhat labor intensive. The use of fire management techniques has the advantage of not introducing exotic weed species; nonetheless, it should be tested to ensure that the entire population is not lost should the species not be fire tolerant.

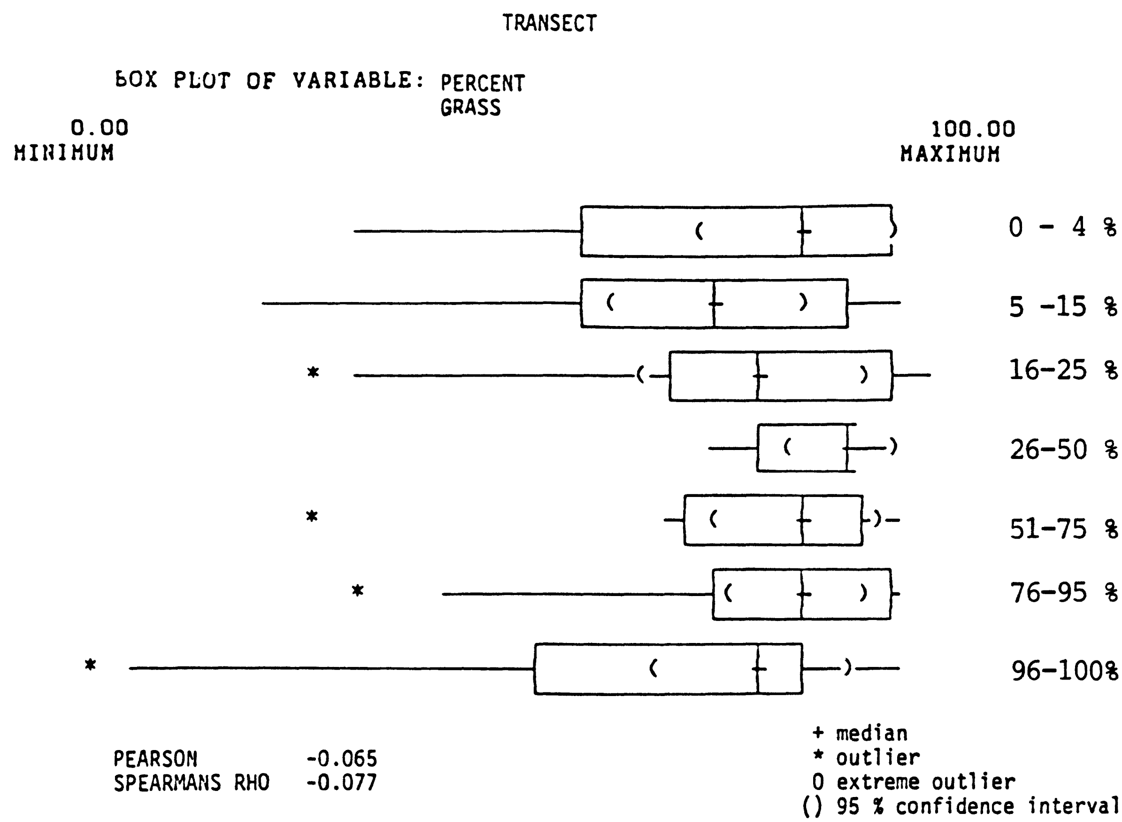
APPENDICES

GRAZED ALLOTMENT	UNGRAZED ALLOTMENT	YEAR
8/3-10/21 300 yearlings	No grazing	1987
8/12-11/2 300 yearlings	5/1-5/25 150 /trespass * no fence north end	1986
7/25-10/10 395 yearlings	6/1-8/15 400-500 cattle *no fence north end	1985
8/21-10/14 425 yearlings	No grazing	1984
7/20-10/1 400 yearlings	6/1-7-15 200 cattle * no fence north end	1983
8/10-11/14 347 yearlings	No grazing	1982

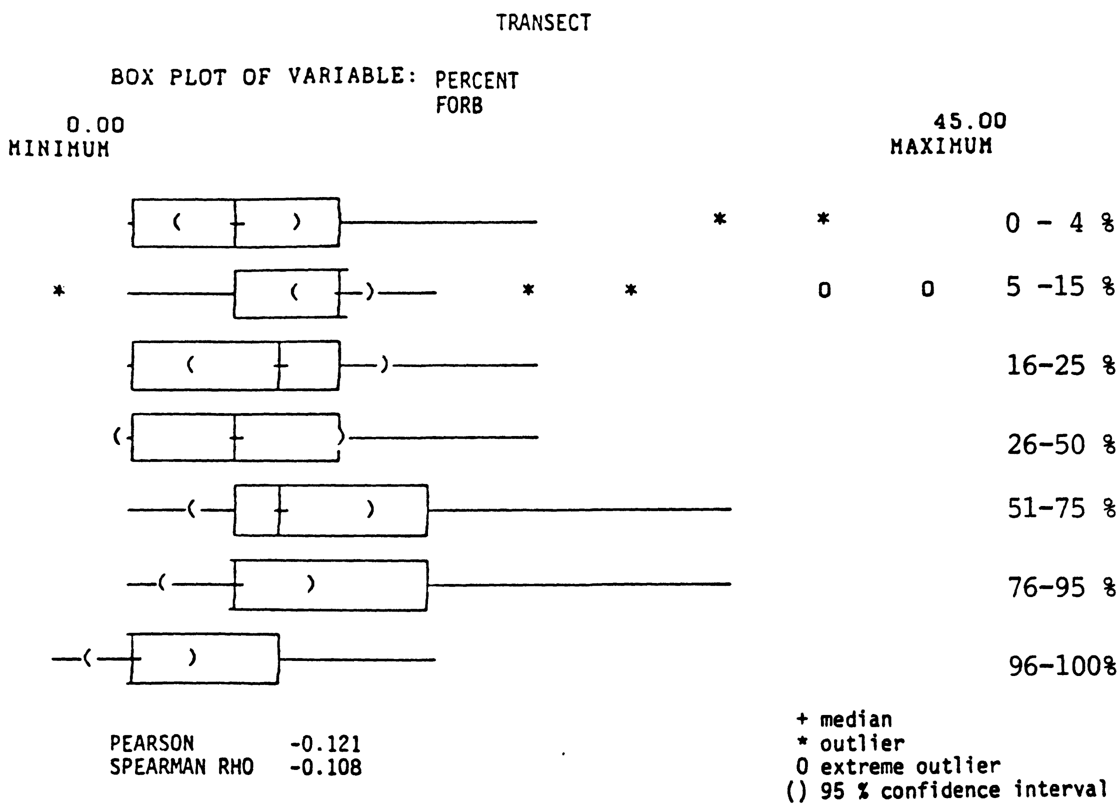
Appendix A. Grazing use and permit figures 1982-1987.



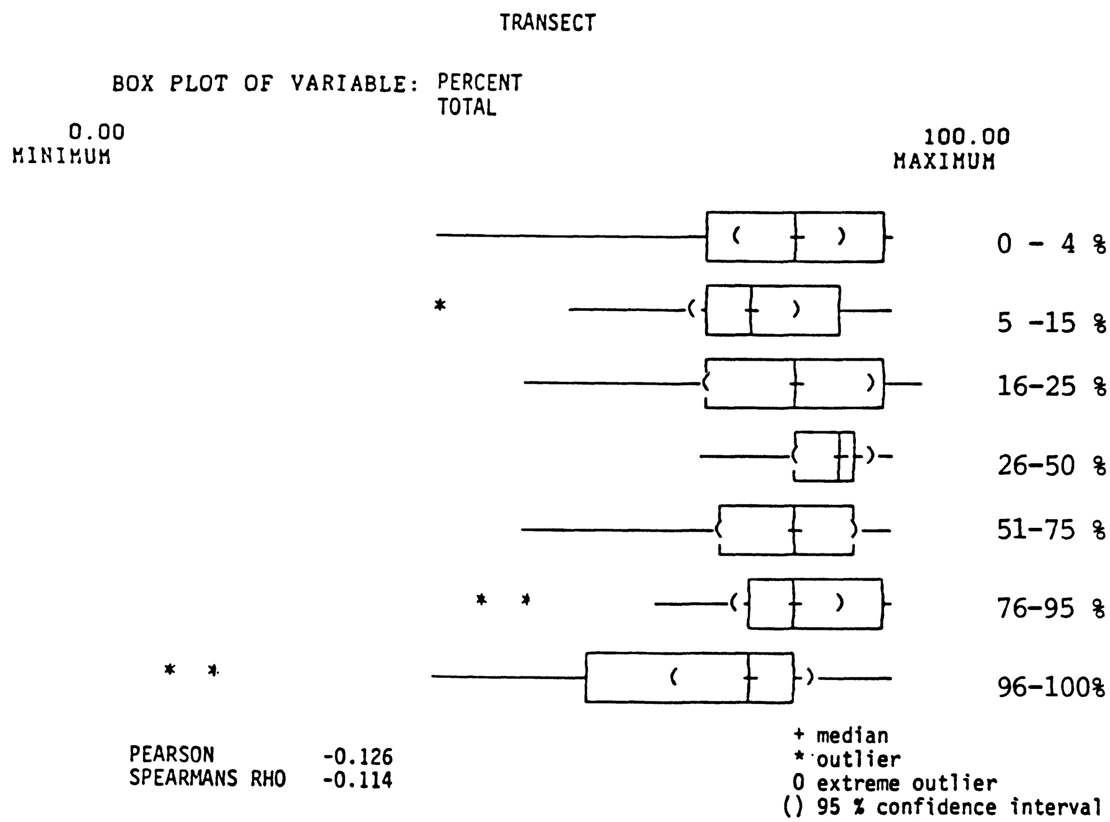
Appendix B. Box-plot of percent shrub cover by the percentage of grazing on the grazed allotment.



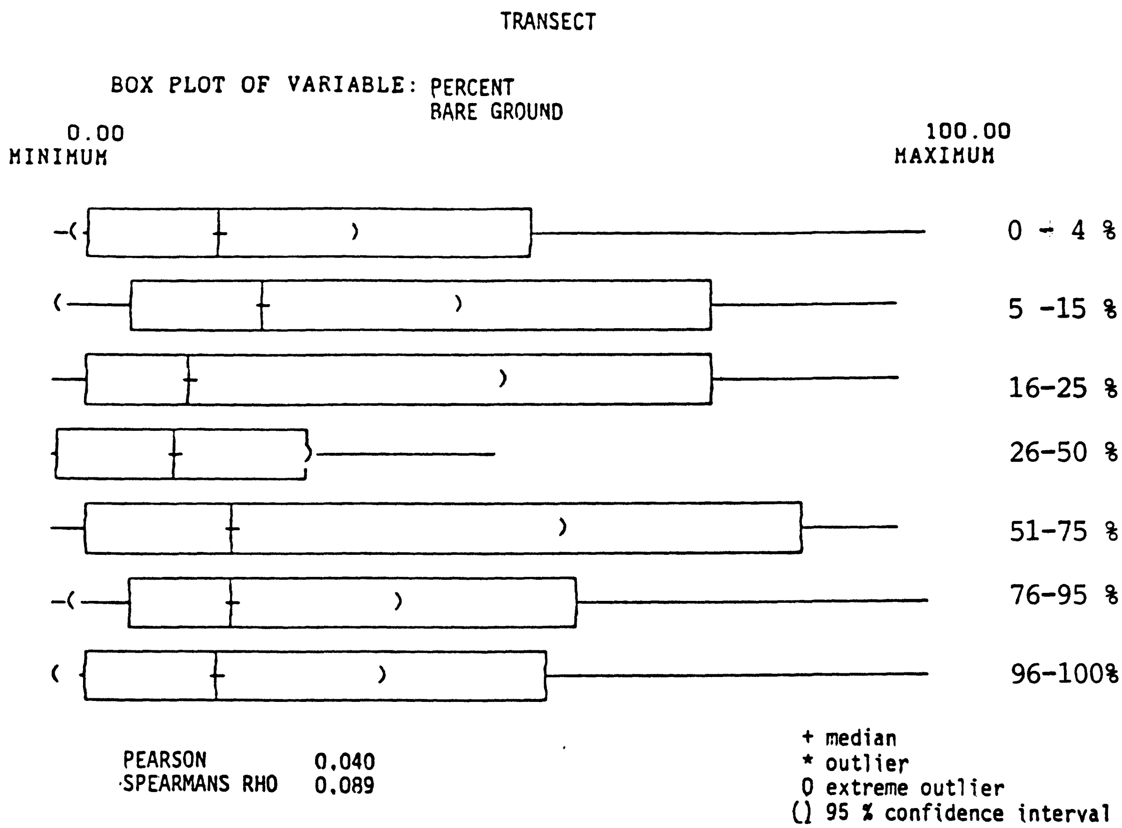
Appendix B. Box-plot of percent grass cover by the percentage of grazing on the grazed allotment.



Appendix B. Box-plot of percent forb cover by the percentage of grazing on the grazed allotment.



Appendix B. Box-plot of percent total cover by the percentage of grazing on the grazed allotment.



Appendix B. Box-plots of percent bare cover by the percentage of grazing on the grazed allotment.

BLOWOUTS

BLOWOUT AREA UNGRAZED ALLOTMENT

with A. ceramicus

N OF CASES	40
MINIMUM	23.559
MAXIMUM	1602.012
MEAN	471.809
STANDARD DEV	365.489

without A. ceramicus

N OF CASES	25
MINIMUM	77.745
MAXIMUM	1700.960
MEAN	589.352
STANDARD DEV	443.079

BLOWOUT AREA GRAZED ALLOTMENT

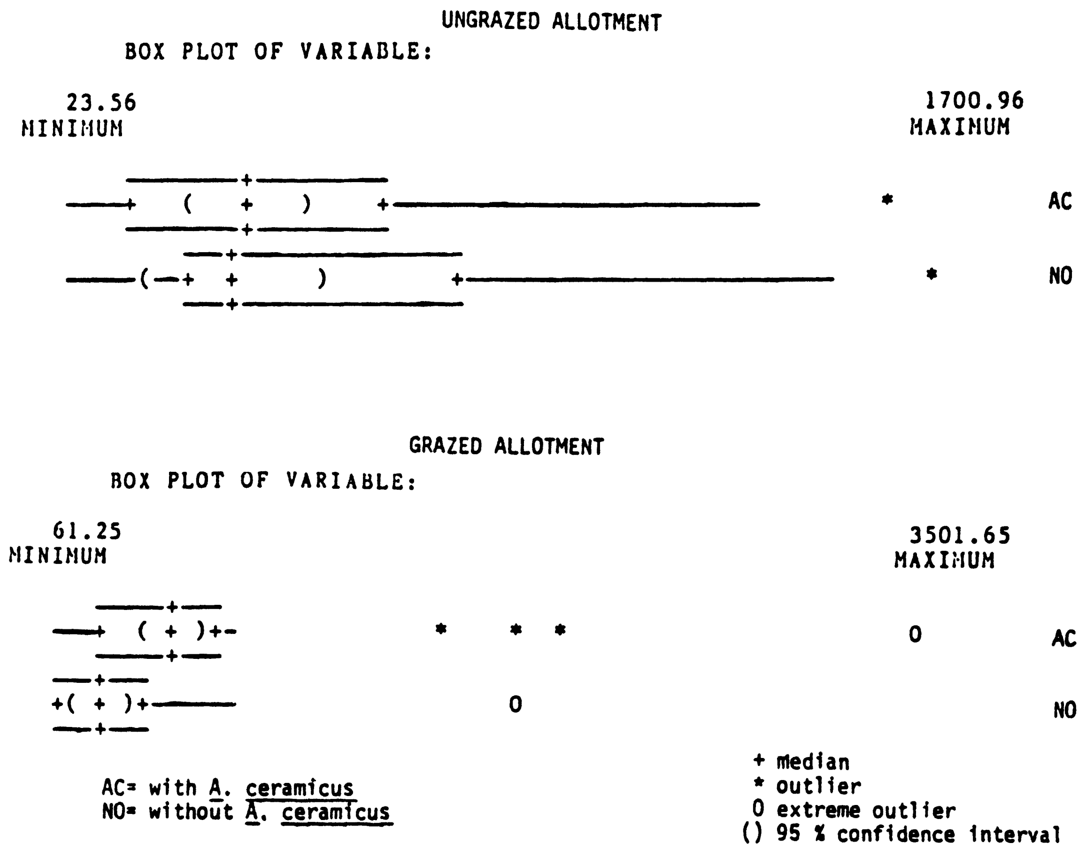
with A. ceramicus

N OF CASES	40
MINIMUM	61.253
MAXIMUM	3501.653
MEAN	669.586
STANDARD DEV	637.016

without A. ceramicus

N OF CASES	25
MINIMUM	65.965
MAXIMUM	1949.115
MEAN	395.210
STANDARD DEV	376.015

Appendix C. Table of blowout areas with and without A. ceramicus on the grazed and ungrazed allotments.



Appendix C. Box-plots of blowout areas with and without <u>A. ceramicus</u> on the ungrazed and grazed allotments.

	TEMPERATURE		PRECIPITATION	
YEAR	AVG.	DEPARTURE	AVG.	DEPARTURE
1943	--	--	15.70	--
1944	33.4	--	19.20	--
1945	34.2	--	20.78	--
1946	35.2	--	25.79	--
1947	34.3	--	19.76	--
1948	33.4	--	18.75	--
1949	33.2	--	20.48	--
1950	35.4	--	22.69	--
1951	33.5	--	21.30	--
1952	34.8	--	21.51	--
1953	37.1	--	14.66	--
1954	36.5	--	19.00	--
1955	33.0	--	26.80	--
1956	34.4	--	15.35	--
1957	34.2	--	21.94	--
1958	--	--	22.65	--
1959	34.7	--	19.65	--
1960	41.2	--	14.43	--
1961	35.6	--	21.19	--
1962	34.7	--	20.73	--
1963	36.2	--	23.00	--
1964	34.0	--	22.12	--
1965	34.9	--	20.96	--
1966	36.1	--	13.45	--
1967	36.0	--	24.37	--
1968	34.1	--	20.18	--
1969	35.5	--	20.15	--
1970	34.2	--	27.20	--
1971	34.1	--	26.32	--
1972	35.2	--	21.22	--
1973	34.6	--	25.56	--
1974	36.1	--	14.47	- 6.05
1975	33.0	--	19.92	- 0.60
1976	35.3	--	20.40	- 0.12
1977	36.1	--	23.00	2.48
1978	34.7	--	15.67	- 4.85
1979	34.5	--	13.28	- 7.24
1980	36.1	--	25.29	4.77
1981	37.6	--	18.81	- 1.71
1982	33.6	--	23.70	3.18
1983	35.1	0.1	23.83	3.31
1984	33.2	- 1.8	25.07	--
1985	31.5	- 3.5	14.95	- 5.57
1986	36.7	+ 1.7	20.65	.13

Appendix D. Climatalogical data from 1943-1986 for Lake View, 5 miles south of the study site.

Literature Cited

Abrahmson, W.G. 1984. Post-fire recovery of Florida Lake Wales Ridge vegetation. Am. J. Bot. 71(1): 9-21.

Abugov, R. 1982. Phased disturbance and species diversity. Ecology 63(2): 289-293.

Albertson, F.W., G.W. Tomavek, and A. Riegel. 1957. Ecology of drought cycles and grazing intensity on grasslands of the great-central plains. Ecol. Mono. 27: 27-44.

Arno, S.F. and G.E. Gruell. 1983. Fire history at the forest-grassland ecotone in southwestern Montana. J. RangeMgt. 36(3): 332-336.

Bakeman, M.E. and Thomas J. Nimlos. 1985. The genesis of mollisols under Douglas fir. Soil Sci. 140(6): 449-452.

Ball, D.F. 1964. Loss-on-ignition as an estimate of organic matter and organic carbon in non-calcareous soils. J. Soil Sci. 15(1): 84-92.

Barneby, R.C. 1964. Atlas of North American Astragalus. Memoirs N.Y. Bot. Gardens 13: 1-1188.

Barnes, P.W., and A.T. Harrison. 1982. Species distribution and community organization in a Nebraska sandhills mixed prairie as influenced by plant/soil-water relationships. Oecologia 52: 192-201.

Barnes, P.W., A.T. Harrison, and S.P. Heinisch. 1984. Vegetation patterns in relation to topography and edaphic variation in Nebraska sandhills prairie. Prairie Nat. 16(4): 145-158.

Blaisdell, J.P. 1953. Ecological effects of planned burning of sagebrush-grass range on the Upper Snake River Plains. U.S.D.A. Tech. Bull. No 1075.

Bragg, T.B. 1978. Effects of burning, cattle grazing, and topography on vegetation of the Choppy Sands range site in the Nebraska sandhills prairie in Proc. First Int. Rangeland Congress. D.N. Hyder ed., pp 248-253.

Bratton, S.P. and P.S. White. 1980. Rare Plant Management: After preservation what? Rhodora 82: 49-75.

Bray, J.R. 1956. Gap phase replacement in a maple-basswood forest. Ecology 37: 598-600.

Burzlaff, D.F. 1962. A soil and vegetation inventory and analysis of three Nebraska sandhills range sites. Nebraska Agricultural Exp. Sta. Rsch. Bull. 206, 32 pp.

Butler, B.R. 1971. The origin of the Upper Snake country buffalo. TEBIWA J. of Idaho St. Museum 14(2): 1-20.

Chambers, J. 1963. Dillon district watershed plan. May 3, 1963.

Collins, S.L. and S.C. Barber. 1985. Effects of disturbance on diversity in mixed-grass prairie. Vegetatio 64: 87-94.

Cooper, W.S. 1958. Coastal sand dunes of Oregon and Washington. Memoirs Geol. Soc. America 72, 169pp.

Cowles, H. C. 1899. The ecological relations of the vegetation on the sand dunes of Lake Michigan. Part I. Geographical relations of the dune floras. Bot. Gaz. 27:361-391.

Daubenmire,R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33(1): 43-64.

Dring, M.J., and L.C. Frost. 1972. Studies of Ranunculus ophioglossifolius in relation to its conservation at Badgeworth Nature Preserve, Gloucestershire, England. Biol. Conservation 4: 48-56.

Drury, W.H. and Nisbet, C.T. 1973. Succession. The Arnold Arbor. J. 54(3): 331-368.

Ehrenfeld, J.G. 1980. Understory response to canopy gaps of varying size in a mature oak forest. Bull. Torrey Bot. Club 107: 29-41.

Frankel, O.H., and M.E. Soule'. 1981. Conservation and evolution. N.Y.:Cambridge University Press, 327pp.

Goldberg, D.E. 1987. Seedling colonization of experimental gaps in two old-field communities. Bull.Torrey Bot. Club 114(2): 139-148.

Harper, J.L. 1983. Population biology of plants. 6th ed. N.Y.:Academic Press, 892 pp.

Heinisch, S.P. 1981. Water allocation and rooting morphology of two Bouteloua species in relation to their distributions in the Nebraska sandhills. U. of Nebraska, Masters Thesis.

Heyward, F. 1937. The effect of frequent fires on profile development of longleaf pine forest soils. J. For. 35: 23-27.

Hitchcock, C.L., and A. Cronquist. 1981. Flora of the Pacific Northwest. 5th ed. Seattle:Univ. of Wash. Press, 730 pp.

Idaho Natural Heritage Program. 1987. In-house memo.

Keeler, K.H. 1980. The flora and sandhills prairie communities of Arapaho Prairie, Arthur County, Nebraska. Prairie Nat. 12(3-4): 65-78.

Keeler, K.H. 1987. Survivorship and fecundity of the polycarpic perennial Mentzelia nuda (Loasaceae) in Nebraska sandhills prairie. Amer. J. Bot 74(6): 785-791.

Kruckeberg, A.R., and D. Rabinowitz. 1985. Biological aspects of endemism in higher plants. Ann. Rev. Ecol. Syst. 16: 447-479.

Lemen, C.A., and P.W. Freeman. 1986. Habitat selection and movement patterns in sandhills rodents. Prairie Nat. 18(3): 129-141.

Lesica, P., G. Moore, K.M. Peterson and J.H. Rumely. 1984. Vascular plants of limited distribution in Montana. Mont. Acad. Sci. Vol 43 Mono. 2, 55pp.

Levin, S.A. 1976. Population dynamic models in heterogeneous environments. Ann. Rev. Ecol. 7: 287-310.

Malakouti, M.J., D.T. Lewis, and J. Stubbendieck. 1978. Effect of grasses and soil properties on wind erosion in sand blowouts. J. Range Mgt. 31(6): 417-420.

Moore, P.D. 1971. Computer analysis of sand dune vegetation in Norfolk, England, and its implications for conservation. Vegetatio 23(5-6): 323-338.

Morrison, R.G. and G.A. Yarronton. 1974. Vegetational heterogeneity during a primary sand dune succession. Can. J. of Bot. 52: 387-410.

Morrison, L.C., J.D. DuBois and L.A. Kapustka. 1986. The vegetational response of a Nebraska Sandhills grassland to a naturally occurring fall burn. Prairie Nat. 18(3): 179-184.

Mueller-Dombois, D. 1980. Vegetation dynamics in a coastal grassland of Hawaii. in Vegetation dynamics in grasslands, heathlands and Mediterranean ligneous formations. Pages 131-140, Poissonet, P., F. Romane, M.A. Austin, E. Van der Maarel, and W. Schmidt eds. Dr. W. Junk Pub. Boston.

Neely, E.E., and A.T. Carpenter. 1986. Size, structure, and habitat characteristics of populations of Braya humilis var. humilis (Brassicaceae) an alpine disjunct from Colorado. Great Basin Naturalist 46(4): 728-735.

Olson, J.S. 1958. Rates of succession and soil changes on southern Lake Michigan sanddunes. Bot. Gaz. 119(3): 125-170.

Oosting, H.J. 1954. Ecological processes and vegetation of the maritime strand in the southeastern United States. Bot. Rev. 20: 226-262.

Platt, W.J. 1975. The colonization and formation of equilibrium plant species associations on badger disturbances in a tall-grass prairie. Ecol. Monogr. 45: 285-305.

Pool, R.J. 1914. A study of the vegetation of the sandhills of Nebraska. PhD. Thesis Lincoln, Nebraska.

Potvin, M.A. and A.T. Harrison. 1984. Vegetation and litter changes of a Nebraska sandhills prairie protected from grazing. J. Range Mgt. 37(1): 55-58.

Ramaley, F. 1939. Sandhill vegetation of northeastern Colorado. Ecol. Mono. 9(1): 1-51.

Ranwell, D.S. 1972. Ecology of salt marshes and sand dunes. Chapman and Hall, London 251 pp.

Raup, H.M., and G.W. Argus. 1982. The Lake Athabasca sand dunes of northern Saskatchewan and Alberta Canada. The land and vegetation. National Museum of Nat. Sci. Pub. Botany No. 12 Ottawa.

Reeves B.O.K. 1978. Bison killing in southwestern Alberta Rockies in Bison procurement and utilization: A symposium L.B. Davis and M. Wilson ed. J. of Plains Anthro. Memoir 14: 63-78.

Rydberg, P.A. 1895. Flora of the sandhills of Nebraska. Contrib. U.S. Nat. Herb. III: 133-203.

Salter, P.J., G. Berry, and J.B. Williams. 1966. The influence of texture on the moisture characteristics of soils. III. Quantitative relationships between particle size, composition, and available-water capacity. J. Soil Sci. 17(1): 93-98.

Shelly, J.S. 1987. Plants of Special Concern. Montana Natural Heritage Program 12 p.

Shugart, H.H., D.C. West, and W.R. Emanuel. 1981. Patterns and dynamics of forests: An application of simulatron. pages 74-94 in Forest succession concepts and applications. D.C. West, H.H. Shugart, D.B. Botkin eds. N.Y.:Springer-Verlag.

Sonderegger, J.L., J.D. Schofield, R.B. Berg, and M.L. Mannick. 1982. The upper Centennial Valley, Beaverhead and Madison Counties, Montana. Montana Bureau of Mines and Geology Memoir 50. 97 pp.

Stubbendieck, J., S. Schuckert, R. Engel, and E.K. Kocher. 1983. Ecological study of a sandhills blowout. Research Highlights, Range and Forage Management, Dept. of Agronomy, U. of Nebraska-Lincoln. 1: 56-57.

Stubbendieck, J. 1986. Status, ecology, and propagation of blowout penstemon (Penstemon haydenii S. Watson.) Research Proposal prepared for the Nebraska Game and Parks Commission.

Swanson, E.H. and P. Sneed. 1966. Birch Creek papers No. 3: The archeology of the Shoup Rockshelters in east-central Idaho. Occasional papers of the Idaho St. Univ. Museum. No. 17.

Tippy, D.L., J.P. Hahn, R.M. Tribelhorn, and T.J. Nimlos. 1978. Dillon Resource Area resources inventory: Soil survey, Montana Forest and Conservation Exp. Sta. U. of Montana Missoula, MT.

Van der Maarel, E. 1970. Plant species diversity in relation to management. pages 45-63 in The scientific management of animal and plant communities for conservation. E. Duffey and A.S. Watt eds. Blackwell Sci. Pubs. London.

Van der Maarel, E., N. de Cock and E. de Wildt. 1985. Population dynamics of some major woody species in relation to long-term succession on the dunes of Voorne. Vegetatio 61(2): 209-219.

Veno, P.A. 1976. Successional relationships of five Florida plant communities. Ecology 57: 498-508.

Watkinson, A.R. and A.J. Davey. 1985. Population biology of salt-marsh and sand dune annuals. Vegetatio 62: 487-497.

Watt, A.S. 1957. The effect of excluding rabbits from grassland (Mesobrometum) in Breckland. J. of Ecol. 45: 861-878.

Watt, A.S. 1974. Dynamics of chalk grassland. J. Appl. Ecol. 11: 1157-1172.

Weaver, J.E. 1968. Prairies plants and their environment: A fifty-year study in the midwest. U. of Nebraska Press, Lincoln, Nebraska.

Weins J.A. 1976. Population responses to patchy environments. Ann. Rev. Ecol. & Syst. 7: 81-120.

Westoff, V. 1985. Nature management in coastal areas of western Europe. Vegetatio 62: 523-532.

White, P.S., and S.T.A. Pickett. 1985. Natural disturbance and patch dynamics: an introduction. pages 1-9 in The ecology of natural disturbance and patch dynamics. S.T.A. Pickett and P.S. White eds. N.Y.:Academic Press.

Whittaker, R.H. 1975. Communities and ecosystems. N.Y.:Macmillan Pub. Co. 385pp.

Williamson, G.B. 1975. Pattern and seral composition in old-growth beech-maple forest. Ecology 56: 727-731.

Witkind, I.J., and H.J. Prostka. 1980. Geologic map of the southern part of the Lower Red Rock Lake Quadrangle, Beaverhead and Madison counties, Montana, and Clark County, Idaho. U.S.G.S. Map-1216.

Wolfe, C.W. 1972. Effects of fire on a sand hills grassland environment. Proceedings Tall Timbers Fire Ecology Conference 12:241-255.