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Cryptogamic soil crusts: recovery from grazing near Camp Floyd State Park, Utah, USA

Jeffrey R. Johansen
SERI, Golden, Colorado

Larry L. St. Clair
Brigham Young University

CRYPTOGAMIC SOIL CRUSTS: RECOVERY FROM GRAZING NEAR CAMP FLOYD STATE PARK, UTAH, USA

Jeffrey R. Johansen[1] and Larry L. St. Clair[2]

ABSTRACT.—The effects of grazing on the cryptogamic and vascular plant communities at two sites near Camp Floyd State Park, Utah County, Utah, were studied. The grazed site was subject to heavy grazing up until seven years prior to the study. The ungrazed site within the park boundaries had been protected from grazing for 20 years prior to the study and had a well-developed algal-lichen-moss crust. We found that the algae of the grazed site had recovered in terms of degree of crusting. There were no significant differences in the algal communities of the two sites when prevalent species were used as blocks in the ANOVAR analysis. However, when major algal groups were used as blocks, the analysis was significant, with the more recently grazed site having lower algal frequency. This difference, together with a few compositional differences, indicates that, although the algal community seven years following grazing is very similar to the algal community free of grazing for 20 years, the seven-year site is still in the process of recovery and community development. The diatom collections had a higher density in the grazed site, though the difference was not significant. Recovery of the lichen and moss community was not complete. The lichen *Collema tenax* and the mosses *Bryum pallescens* and *Tortula ruralis* were all significantly more abundant in the ungrazed area. Total cover of the lichen and moss components of the soil crusts was significantly lower in the more recently grazed area. Vascular cover was also lower.

Cryptogamic soil crusts are an important component of many arid rangeland ecosystems in the western United States. Such crusts have been found to be important in nitrogen fixation (Snyder and Wullstein 1973, Rychert and Skujins 1974) and enhancement of seedling establishment (St. Clair et al. 1984). The greatest benefit of cryptogamic crusts, however, is probably reduction of soil erosion. Soil aggregation, particularly by blue-green algae, reduces detachment of soil particles by wind and rain (Bailey et al. 1973, Anantani and Marathe 1974). Improved water penetration in crusted soils reduces runoff and subsequent erosion (Brotherson and Rushforth 1983). Sedimentation is also reduced by the increased tortuosity of surface water pathways due to the characteristic hummocking of desert crusts.

The effects of both burning and grazing on soil cryptogams have recently been investigated. Range fires can severely damage all components of the soil crust (Johansen, Javakul, and Rushforth 1982, Johansen et al. 1984, Callison et al. 1985). Several workers have noted that moderate to heavy grazing can seriously damage soil cryptogams because the crusts are trampled by livestock. Rogers and Lange (1971) noted that stocking pressure was negatively correlated with lichen cover and that soil mobility and erosion was increased in areas of reduced lichen cover. Kleiner and Harper (1972) found that the effects of grazing were more notable on the soil cryptogams than on the vascular plant communities in Canyonlands National Park. They also noted that soil erosion was higher in areas with lower cryptogam cover and observed changes in organic matter, available phosphorus, and calcium in eroded soils (Kleiner and Harper 1977). The effects of long-term moderate to heavy grazing near Navajo National Monument also showed that grazing has a more pronounced effect on the cryptogamic cover and diversity than on vascular plant cover and diversity (Brotherson et al. 1983). Burros in the Grand Canyon are currently causing erosion through destruction of *Tortula* (bryophyte) and lichen crusts (Phillips et al. 1977).

Several factors influence the development of cryptogamic crusts. Cryptogamic growth is best in soils of high electrical conductivity, high phosphorus, and high silt content (Anderson et al. *Factors*, 1982). Crust buildup is also positively correlated with soil alkalinity. The crusts of gypsiferous soils of southern

[1]SERI, 1617 Cole Blvd., Golden, Colorado 80401.
[2]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

Utah are particularly well developed, having high lichen and algal diversity (Anderson and Rushforth 1976). Recovery of crusts from disturbance follows several trends. Algae are the most resistant component to disturbance (Anderson et al. *Recovery*, 1982) and are also the quickest to recover (Johansen et al. 1984). Lichens and mosses are slower to recover. Anderson et al. *Recovery*, (1982) found that lichens and mosses had become fairly well established after a 14–17-year period of protection from grazing. Exclosures protected for 37–38 years showed little change in the moss flora, though lichen diversity was greater than in the 14–17-year-old exclosures. This paper also indicated a need for studies examining recovery in the first 15 years following protection from disturbance.

The primary purpose of our study was to determine the degree of recovery of the cryptogamic crust community in a soil that has been protected from grazing for seven years near Camp Floyd State Park. This study differs from past studies in that the grazed area is compared with an adjacent area that has been protected for 20 years rather than with an area still under grazing pressure.

SITE DESCRIPTION

The study was conducted near and within the boundaries of Camp Floyd State Park, Utah County, Utah. The park is located 0.4 km southwest of Fairfield, Utah, along State Highway 73 in central Utah and is relatively small (16.2 hectares). It was established in 1962 with the principal point of interest being an inactive military cemetery which occupies only a small portion of the total area of the park. The balance of the park has not been developed and is dominated by an *Atriplex confertifolia–Sarcobatus vermiculatus* desert shrub community. A well-developed cryptogamic soil crust flora consisting of various species of lichens, mosses, and algae is present. The soils at Camp Floyd belong to the Woodrow silt loam with an average water-holding capacity of 28–30 cm of water for the 1.5 m (5 ft) profile. This soil type has a slow permeability and is classified as a mixed (calcareous) mesic, xeric torifluvent. The mean annual rainfail in this area is 35 cm.

From 1935 until the establishment and subsequent fencing of the park area, the 1,600 hectares of shrubland immediately around the cemetery were heavily grazed by sheep and cattle during winter months (October to May). Fencing of the park property has effectively eliminated grazing in the park since 1962. This has permitted the establishment of a diverse and well-developed algal-lichen-moss community. The area outside the park continued to be heavily grazed until 1975, at which time livestock were removed from this range.

METHODS

Two permanent transects with points placed every 2 m were established in the vicinity of Camp Floyd State Park. The ungrazed area transect consisted of 6 points within the park boundaries. Data from this transect were compared with similar data collected from burned sites, and that comparison is the basis of a previous paper (Johansen et al., 1984). The grazed area transect consisted of 8 points one mile south of the park. Fieldwork was conducted from September to Novemeber, 1982.

Two crust samples were collected from each transect point at opposite compass points 0.25 m from the center of the point on 23 September 1982. Each sample was prepared for culturing by gently crushing soil clods to a maximum diameter of 5 mm. Twenty cm^3 of soil from each sample were placed in a sterilized petri dish and saturated with 20 ml of distilled water. Samples were then incubated under continous cool-white fluorescent light at room temperature (24 C) for 10 days. Percent visible algal cover in each petri dish was estimated at the end of the culture period. Frequency and relative abundance of living algal species were also estimated at that time by subsampling the center of each petri dish and examining this subsample under the light microscope. A total of 25 microscope fields were examined for each subsample, and presence and absence of each species in each field were noted. Permanent diatom mounts were prepared using standard acid oxidation procedures and Hyrax diatom mountant. Slides were prepared using quantitative dilutions for quantitative comparisons of soil diatoms (Johansen et al. 1982).

Visual estimates of total cryptogamic and vascular plant cover were made in the field

TABLE 1. Average percent frequencies of living algal species in grazed and ungrazed areas. Each species was tested using the Mann-Whitney test to determine if significant differences existed between treatments (* indicates p<.05, ** indicates p<.01). Estimated visible algal cover in culture dishes is also given.

Species	Grazed	Ungrazed
CYANOPHYTA		
Anabaena variabilis Kuetzing	.3	4.0
Aphanothece castagnei (Breb.) Rabh.	1.0	.3
Chroococcus minor (Kuetz.) Naegeli	1.0	.3
Chroococcus turgidus (Kuetz.) Naegeli		2.0
Gloeothece linearis var. *composita* G. M. Smith		.3
Microcoleus vaginatus (Vauch.) Gomont	55.0	57.0
Nostoc commune Vaucher	.5	10.0 *
Nostoc muscorum C. A. Agardh	.3	
Nostoc cf. *paludosum* Kuetzing	.8	1.7
Nostoc species	5.5	7.7
Phormidium minnesotense (Tild.) Drouet	27.8	15.3
Synechococcus aeruginosus Naegeli	.3	
Tolypothrix tenuis (Kuetz.) Schmidt	1.8	3.7
Unknown Chroococcaceae	1.5	4.0
CHLOROPHYTA		
Ulothrix tenerrima Kuetzing	.3	3.0
Unknown coccoids	16.3	23.0
BACILLARIOPHYTA		
Hantzschia amphioxys (Ehr.) Grunow	18.5	26.0
Navicula mutica Kuetzing	5.0	12.3
Navicula paramutica Bock	1.0	.3
Pinnularia borealis Ehr.	.8	.7
FLAGELLATES	.3	1.7
TOTAL SUM FREQUENCY	137.0	173.3
VISIBLE ALGAL COVER	16.6	36.5 **
SHANNON-WIENER DIVERSITY INDEX	2.35	2.75**

using a 1/4 m^2 circular quadrat placed at each permanent transect point. In addition to the 1/4 m^2 circular quadrats, a smaller 2 × 50 cm rectangular quadrat consisting of ten 2 × 5 cm subquadrats was placed perpendicular to the transect at each point and percent cover of algal crust and lichen and moss species was estimated. Cover was measured in November in the ungrazed area and in September in the more recently grazed area.

Soils were analyzed by the Soil Analysis Laboratory, Department of Agronomy and Horticulture, Brigham Young University, for pH, phosphorus, nitrate, Kjeldahl nitrogen, potassium, calcium, magnesium, zinc, iron, manganese, sodium, copper, organic matter, electrical conductivity, and sodium adsorption ratio. All samples were taken from the top 17.5 cm of soil for these analyses.

Mann-Whitney tests (Ryan et al. 1976) were performed for each species to determine significance levels of differences between grazed and ungrazed areas. This test was used in preference to the Students t-test (Snedecor and Cochran 1980) because some of our data were not normal. Shannon-Wiener diversity indices were calculated for the living algae and diatom communities for each transect point (Patten 1962, Shannon and Weaver 1949). Similarity indices for all 14 stands were calculated following the methods of Ruzicka (1958). Four different sets of similarity indices were calculated using lichen and moss cover, living algal density, diatom density, and vascular plant cover. These four sets of indices were then clustered following Sneath and Sokal (1973) to illustrate the degree of similarity between grazed and ungrazed stands in the four different plant communities. Importance values for species of living algae and diatoms were determined by multiplying average percent relative density times presence (Warner and Harper 1972). Species with importance values above 1.00 were used in the subsequent ANOVAR analyses.

Multivariate analysis of variance adapted in preference to the Students t-test (Snedecor for a fixed effects, unbalanced design following the methods of Bryce et al. (1980) was used to analyze differences between blocks (lichens mosses, algae, vascular plants) and treatments (time since grazing). Several separate ANOVAR tests were run, including tests using the vascular plant cover data, lichen and moss cover data, living algal data, and subfossil diatom data. In some data sets the variance of each species and group was related to the mean. To satisfy the homogeneity of variance assumption of analysis of variance for these data sets, a log (x+1) transformation was used (Bartlett 1947). With each analysis of variance, the standardized residuals were plotted against the normal scores to give a measure of normality. In all cases the probability plot thus generated was subjectively judged as being normal or close to normal. Our use of transects satisfied the requirements of systematic sampling as described by Cochran (1977). The Duncan multiple range test was used to determine significance of differences between species means when analysis of variance showed significance for this factor (Duncan 1955). Unless otherwise stated, the alpha level used for this test was 0.01.

RESULTS

Living Algae

The seven most important living algal species were *Microcoleus vaginatus* (importance value=55.86), *Phormidium minnesotense* (20.83), unknown green coccoid (18.46), *Hantzschia amphioxys* (17.06), *Nostoc* species (4.59), *Navicula mutica* (4.07), and *Nostoc commune* (1.42). Average percent frequencies for all algal species are given in Table 1. Multivariate analysis of variance based on the above seven prevalent species showed that the algal communities of the two areas were not significantly different. The Mann-Whitney test on the visual algal cover estimated in the field supported this conclusion (Table 3). The multivariate analysis did show that the species had significantly different frequencies. Duncan's test showed that *Microcoleus vaginatus* was significantly more abundant than all other algal species. *Phormidium minnesotense*, unknown coccoid green algae, and *Hantzschia amphioxys* were significantly more abundant than all less common algal species. The interaction between treatment and species was significant (p=.023). This was likely due to the

Fig. 1

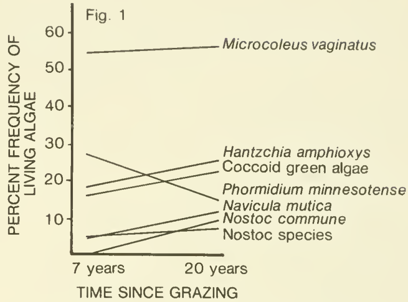

Fig. 1. Interaction between living algal species and treatment, significant at p=.023, using multivariate analysis of variance.

fact that *Hantzschia amphioxys*, *Navicula mutica*, *Nostoc commune*, and coccoid green algae were all more abundant in the park area, whereas *Phormidium minnesotense* was more numerous in the more recently grazed stands (Fig. 1). *Microcoleus vaginatus* and *Nostoc* species showed only minor differences in frequency between the two sites.

A separate analysis of variance was conducted to compare major algal groups. When using this data set, the difference between treatments was significant (p=.041), the more recently grazed plots having lower values. The groups were also significantly different (p<.001). Duncan's test showed that Cyanophyta were significantly more abundant than the other three algal groups. Bacillariophyceae and Chlorophyta were significantly more abundant than unidentified flagellates.

Nostoc commune had a significantly greater population in the 20-years-since-grazing area (p=.024) according to the Mann-Whitney test. No other living algal species or groups were significantly different at the two sites according to this test.

Subfossil Diatoms

The nine most important subfossil diatom species, including chrysophyte cysts observed in diatom mounts, were *Hantzschia amphioxys* (importance value 69.93), *Navicula mutica* (54.96), chrysophyte cysts (46.43), *Pinnularia borealis* (18.91), *Navicula mutica* var. *cohnii* (6.06), *Navicula paramutica* (3.65), *Navicula mutica* var. *nivalis* (2.42), *Navicula contenta* f. *parallela* (2.39), and *Cy-*

TABLE 2. Average densities (1,000 cells/cm) of diatom species in grazed and ungrazed areas. Each species was tested using the Mann-Whitney test to determine if significant differences existed between treatments (* indicates p<.05, ** indicates p<.01). Density of chrysophyte cysts is also given.

Species	Grazed	Ungrazed
Achanthes lanceolata Breb.	1	
Anomoeneis species	1	
Cocconeis placentula var. *lineata* (Ehr.) Cleve	5	1
Cyclotella kutzingiana Thwaites	39	11*
Denticula elegana f. *valida* Pedic.	2	1
Diploneis oblongella (Naeg. *ex* Kuetz.) Ross	1	
Epithemia adnata var. *minor* (P. & H.) Patr.		2
Epithemia turgida (Ehr.) Kuetzing	10	1**
Fragilaria brevistriata Grunow	3	
Fragilaria construens var. *venter* (Ehr.) Grunow	9	4
Fragilaria pinnata Ehr.		3
Hantzschia amphioxys (Ehr.) Grunow	1,250	562**
Melosira dendroteres (Ehr.) Ross		2
Melosira granulata (Ehr.) Ralfs	3	2
Melosira species	2	
Navicula contenta f. *parallela* Petersen	43	24
Navicula cuspidata (Kuetz.) Kuetzing	1	
Navicula elginensis var. *rostrata* (Mayer) Patr.		1
Navicula excelsa Krasske	3	2
Navicula mutica Kuetzing	698	728
Navicula mutica var. *cohnii* (Hilse) Grunow	85	78
Navicula mutica var. *nivalis* (Ehr.) Hust.	46	21
Navicula paramutica Bock	82	19**
Nitzschia paleacea		1
Pinnularia appendiculata (Ag.) Cleve		1
Pinnularia borealis Ehr.	404	105**
Pinnularia species	1	
Rhopalodia gibba (Ehr.) Mueller		1
Rhopalodia gibberula (Ehr.) Mueller		3
Stephanodiscus carconensis (Eul.) Grunow	1	
Stephanodiscus hantzschii Grunow	1	
Stephanodiscus species		2
TOTAL DIATOMS	2,690	1,570
TOTAL CHRYSOPHYTE CYSTS	675	530
SHANNON-WIENER DIVERSITY INDEX	1.94	2.14*

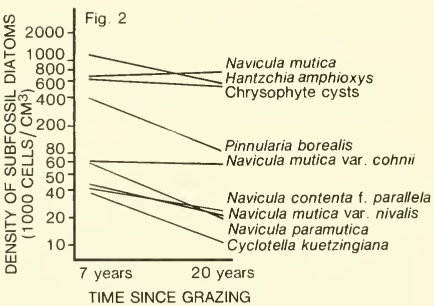

Fig. 2. Interaction between subfossil diatoms and treatment, significant at p<.001, using multivariate analysis of variance.

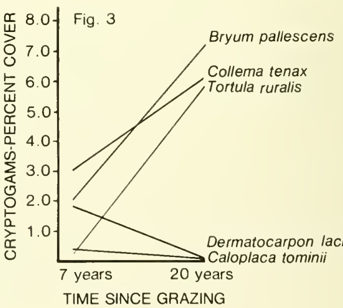

Fig. 3. Interaction between cryptogam species and treatment, significant at p<.001, using multivariate analysis of variance.

TABLE 3. Average percent cover values in grazed and ungrazed areas. Each species and cover class was tested using the Mann-Whitney test to determine if significant differences existed between treatments (* indicates p<.05, ** indicates p<.01).

Species	Grazed	Ungrazed
Cover based on 100 cm^2 rectangular quadrats		
LICHENS		
Caloplaca tominii Sav.	.4	.1**
Collema tenax (Sw.) Ach.	3.0	6.2**
Dermatocarpon lachneum (Ach.) A. L. Sm.	1.8	.1**
Lecidea decipiens (Hedw.) Ach.		P
TOTAL LICHEN COVER	5.1	6.4
MOSSES		
Bryum pallescens Schwaeg.	2.0	7.3**
Pterygoneurum lamellatum (Lindb.) Jur.		P
Tortula ruralis (Hedw.) Gaertn., Meyer & Scherb.	.3	6.1**
TOTAL MOSS COVER	2.3	13.4**
TOTAL ALGAL COVER	21.0	22.6
TOTAL CRYPTOGAMIC CRUST COVER	28.4	42.4

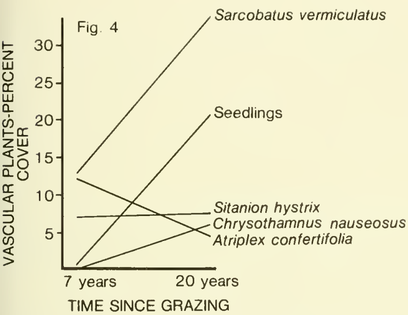

Fig. 4. Interaction between vascular plant species and treatment, significant at p=.001, using multivariate analysis of variance.

clotella kuetzingiana (1.52). Average densities of all diatom species are given in Table 2. Multivariate analysis based on the data for these nine taxa showed that diatoms were significantly more abundant in the recently grazed area (p<.001). Species were also significantly (p<.001) different. According to Duncan's test, *Hantzschia amphioxys*, *Navicula mutica*, and chrysophyte cysts were all significantly higher than the other diatom taxa. *Pinnularia borealis* was significantly more abundant than all less abundant species. *Navicula mutica* var. *cohnii* was more abundant than the other three prevalent species used in the analysis. The interaction between species and treatment (p<.001) is illustrated in Figure 2.

Lichens and Mosses

Multivariate analyses demonstrated several important differences among treatments, blocks, and interactions in the lichen and moss communities. Total lichen and moss cover was substantially greater in the park area (p<.001). Species of cryptogams had significantly (p<.001) different cover. Duncan's test showed that *Collema tenax* and *Bryum pallescens* were significantly more abundant than the other taxa. *Tortula ruralis* cover was significantly greater than *Caloplaca tominii* cover. The interaction between species and treatment was significant (p<.001). This was due to the fact the *Bryum pallescens*, *Tortula ruralis*, and *Collema tenax* had higher cover in the park area, whereas *Caloplaca tominii* and *Dermatocarpon lachneum* were most abundant in the more recently grazed area (Fig. 3).

A separate analysis of variance was run using total lichen and moss cover data. This test also showed a significant difference between treatment means (p<.001). The interaction between cryptogam class and treatment was significant (p<.001) because lichen cover is only slightly greater in the park area and moss cover is markedly greater in the park area. The Mann-Whitney test supports this conclusion in that the difference in total moss cover between treatments is significant, but the difference between mean lichen cover is not (Table 3).

TABLE 4. Average percent cover values in grazed and ungrazed areas. Each species and cover type was tested using the Mann-Whitney test to determine if significant differences existed between treatments (* indicates $p<.05$, ** indicates $p<.01$).

Cover type	Grazed	Ungrazed
Cover based on 1/4 m^2 circular quadrats		
Bare ground	21.1	4.3*
Litter	26.9	23.3
Cryptogamic crust	28.1	38.3
Total vascular plant cover	32.3	73.2
Atriplex confertifolia (Torr. & Frem.) S. Wats.	12.1	4.3
Chrysothamnus nauseosus (Pall.) Britt.		6.0
Sarcobatus vermiculatus (Hook.) Torrey	12.8	34.2
Sitanion hystrix (Nutt.) J. G. Smith	7.1	7.8
Vascular seedlings	.3	20.8**

TABLE 5. Average nutrient levels and soil characteristics of soil samples taken from grazed and ungrazed areas. Each factor was tested using a two-tailed t-test to determine if significant differences existed between treatments (* indicates $p<.05$).

Soil factor	Grazed	Ungrazed
pH	7.98	7.67
Phosphorus (ppm)	20.8	20.2
Nitrate-N (ppm)	6.03	6.30
Potassium (ppm)	944	743*
Calcium (ppm)	56.2	72.8
Magnesium (ppm)	8.4	13.5
Copper (ppm)	1.14	1.15
Zinc (ppm)	0.68	0.79*
Iron (ppm)	2.03	2.94*
Manganese (ppm)	2.34	3.33*
Sodium (ppm)	66	209*
Total organic matter (%)	1.30	1.71
Total nitrogen (%)	0.100	0.107
Electrical conductivity × 1000	0.91	1.81
Sodium adsorption ratio	0.41	1.54*

Multivariate analysis of the vascular plant community data showed that cover was significantly greater in the area protected from grazing for 20 years ($p<.001$). Species were also significantly different ($p=.006$), though only the means for *Sarcobatus vermiculatus* and *Chrysothamnus nauseosus* were significantly different according to Duncan's test. The interaction between treatment and species was also significant ($p=.001$) and is illustrated in Figure 4. Average percent cover values for all vascular species are given in Table 4.

The soils of the two sites were similar to each other (Table 5) though cations were generally higher in the park area. Students t-tests showed that the sites were significantly different in ppm K, Zn, Fe, Mn, Na, and sodium adsorption ratio. Except for potassium, the ungrazed site had greater values for all the above.

DISCUSSION

It is apparent from the data that the algal community, in terms of both the living algae and subfossil diatoms, has nearly recovered from the influence of grazing in the more recently grazed area. Visual estimates in the field as well as microscopic examinations in the laboratory support this conclusion. When the similarity indices for the transect points were clustered, all points were similar in regard to both living algae and subfossil diatoms. The greater density of subfossil diatoms in the more recently grazed area is difficult to explain. It may be due to the lower vascular plant density in the grazed area, which in turn results in increased light intensity and lower litter cover. These factors in combination could favor diatom growth.

The dominant lichen and moss species of this area, *Collema tenax*, *Bryum pallescens*, and *Tortula ruralis*, have not fully recovered in the grazed area. An unusual observation was the significantly greater amount of the lichen *Dermatocarpon lachneum* in the more recently grazed area. We hypothesize that this may indicate an intermediate successional stage in the recovery process. Factors contributing to this phenomenon may include compositional differences in both the vascular and nonvascular plant communities as well as biological modifications of local abiotic factors such as light and moisture. This hypothesis will be tested by future monitoring of the lichen and moss community at these two sites.

The greater density of the three dominant lichen and moss taxa in the ungrazed area

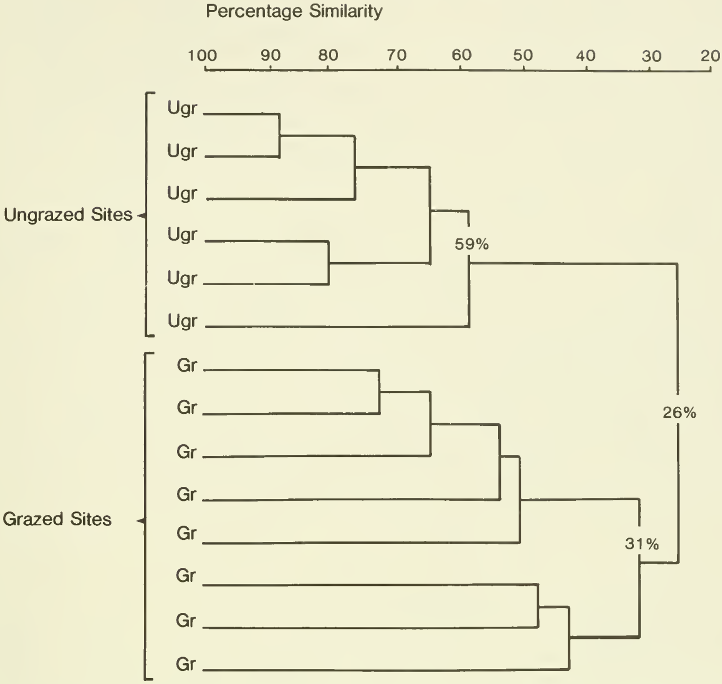

Fig. 5. Fourteen transect points clustered on the basis of Ruzicka's similarity index as computed from lichen and moss data. All stands were similar, yet still clustered into two main groups, i.e., grazed and ungrazed sites.

combined with the significantly greater cover of *D. lachneum* in the more recently grazed area resulted in the formation of discrete site groupings when similarity indices of transect points were clustered (Fig. 5). However, the two clusters based on algal data did not form such discrete clusters, probably because of the high level of similarity between all points. This demonstrates that the algal community has essentially recovered in the seven years following removal of livestock from the range, whereas the lichen and moss communities are still in the process of recovery.

Anderson et al. *Recovery*, (1982) indicate that reestablishment of cryptogamic soil crusts is substantial after 14–18 years. Our study indicates that the recovery rate of the algae is much more rapid than estimated in their study, occurring in fewer than 7 years. The lichens and mosses, on the other hand, fit the predicted recovery patterns and apparently require more than 7 years to fully recover.

An important dimension in the development of soil crusts is frequency and abundance of moisture. The annual precipitation in Utah County has been above normal for the past three years and has undoubtedly played a role in the reestablishment of the soil crusts at the disturbed sites near Camp Floyd. Subjective observations of the grazed site in 1981 indicated that differences between visible cryptogamic cover were evident. Noticeable recovery of the crust in the grazed area occurred during the ensuing moist year before the present study was undertaken. It is possible that in drier areas or drier years development of cryptogamic crusts following grazing disturbance might take longer than the seven-year period observed in the present study.

The greater cover of vascular seedlings observed in the ungrazed area was likely due to temporal differences in sampling. The more recently grazed area was examined in September, whereas the ungrazed area was sampled in November after two months of mild, moist weather. A noteworthy difference in vascular plant community structure was observed. *Atriplex confertifolia* populations were substantially greater in the grazed area (Fig. 4). On the other hand, *Sarcobatus vermiculatus* was most dense in the ungrazed area. Sheep have been known to browse both *Sarcobatus* and *Atriplex*. Thus, over a period of 40 years the abundance of both taxa could have been severely reduced in the grazed area. With the end of grazing pressure, *Sarcobatus vermiculatus*, a vigorous root sprouter, has begun reestablishing itself. In the area protected for 20 years, the development of the *Sarcobatus* population has possibly proceeded to the point that *Atriplex* is being crowded out. In the more recently grazed area the vascular cover is less abundant, and *Atriplex* has not been excluded.

Acknowledgments

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