HABITAT RELATIONSHIPS OF THE BLACKBRUSH COMMUNITY (*COLEOGYNE RAMOSISSIMA*) OF SOUTHWESTERN UTAH

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Abstract.— Eight general study sites in the blackbrush (*Coleogyne ramosissima*) zone of southwestern Utah were examined. Soils data were gathered and plant cover was estimated. Shrubs were found to be positively correlated with shallow, sandy soil. Nonwoody plants were found to be positively correlated with deeper, silty soils. Cryptogamic soil crusts were positively correlated with silt and nitrogen in the soil and therefore may play a role in elevating soil fertility. Shrubs and grasses were negatively correlated. Management implications are discussed.

The community formed by blackbrush (*Coleogyne ramosissima*) and associated species is an important vegetation type in southern Utah. Kuchler (1964) estimated that the blackbrush community covers 2.5 million acres in Utah alone. It also occupies large acreages in Arizona, California, and Nevada. However, little has been written about blackbrush either as a species or a community type. Bowns (1973) studied the autecology of blackbrush in southern Utah. Other investigations deal with specialized aspects of the ecology of the blackbrush community (Beatley 1966; Loope 1978). Several government reports refer to the blackbrush community in an oblique manner (Little 1978; USDI BLM 1979). Most of these studies included field observations and contain valuable comments on relationships in the blackbrush community but offer little quantitative information about the blackbrush community of Utah. The purpose of our study was threefold. We have provided a quantitative analysis of the blackbrush community, compared our analysis to previously observed relationships, and postulated new relationships.

Site Description

Our study sites were located in the Dixie Corridor between the Beaver Dam Wash and the Beaver Dam Mountains in southwestern Utah. This area is a transition zone between the hot desert of the Mojave and the cold desert of the Great Basin. The soils are shallow, well drained, and have from 2% to 7% slopes. One site was on a sandstone bench overlooking Manganese Wash. The other sites were on the alluvial plain west of the Beaver Dam Mountains, with the furthest site being 20 miles from Manganese Wash. All sites had been grazed in the past, though some were not being grazed at the time of the study. There was no evidence of burning on any of the sites. Parent materials are mixed alluvium formed from limestone, gneiss, schist, sandstone, and basalt (Bowns 1973). Altitude at the study plots ranged from 1070 m (3511 ft) to 1400 m (4593 ft). The average annual precipitation, recorded over a 30-year period at the nearby Gunlock powerhouse was 296 mm (11.65 in). The average annual temperature, from the same location, was 16.1 C (61 F) (Hodges and Reichelderfer 1962). Eubank and Brough (1979) list extremes of temperature from 46.7 C (116 F) to -23.9 C (-11 F) at St. George, which is on the edge of the blackbrush range.

Methods

Eight general study sites were selected. Five 10 × 10 m sampling plots were randomly placed at each site. All plots were placed on sites of uniform topography, with ravines and rock outcroppings being avoided. Each plot was subsampled with fifteen 1 m^2 quadrats. The quadrats were distributed uniformly in three rows of five quadrats each within the study plots. Vascular plant cover was estimated for each species (Daubenmire 1959) at each quadrat. In addition, cover

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TABLE 1. Prevalent species in the blackbrush zone. The number of prevalent species is equal to the average number of species on the 10 × 10 m study plots.

Species	Mean cover	Standard deviation	Mean frequency	Standard deviation
Coleogyne ramosissima	37.8	8.3	96.7	5.4
Bromus rubens	3.4	3.1	66.3	30.0
Bromus tectorum	2.8	2.7	63.2	39.7
Ephedra nevadensis	1.2	1.9	7.3	8.3
Thamnosma montana	0.8	2.3	6.2	12.3
Prunus fasciculata	.5	1.1	3.2	5.0
Xanthocephalum microcephela	.4	1.2	2.1	5.6
Yucca brevifolia	.4	1.1	2.4	4.9
Yucca baccata	.4	0.9	4.1	5.4

contributed by rock, litter, and cryptogamic crusts was estimated. Soil depth was measured with a penetrometer (Greenwood and Brotherson 1978) at each corner and center of each plot (the five readings were averaged to give a single estimate for each plot). Percent slope and exposure were obtained for each plot using an Abney level and compass, respectively. Elevation at each plot was taken from USGS 1:24,000 topographic maps.

Three samples of the surface 20 cm of soil were taken in each plot (from opposite corners and the center). Subsamples were later pooled for laboratory analyses. Dependence on surface samples alone seemed justified, since Ludwig (1969) has shown that the surface decimeter of soil from Utah foothill communities provided over 80% of the information useful in correlation analyses relating soil mineral content with plant parameters. Holmgren and Brewster (1972) also showed that over 50% of the fine roots (those most likely to absorb soil minerals) were found concentrated in the upper 15 cm of soil profile of Utah cold desert shrub communities. With respect to grasslands, Christie (1979) likewise found that the top layer of soil supplies most of the minerals taken up by plant roots.

Soil samples were analyzed for texture (Bouyoucos 1951), pH, mineral composition, and organic matter. Soil reaction was taken with a glass electrode pH meter on a 1:1 soil-water paste (Russell 1948). Soils were extracted with 1.0 normal neutral ammonium acetate for exchangeable calcium, magnesium, potassium, and sodium (Jackson 1958, Hesse 1971, Jones 1973). Zinc and copper were extracted from the soils by use of DPTA (diethylenetriamine-penta-acetic acid) extracting agent (Lindsay and Norvell 1969). Individual ion concentrations were determined by using a Perkin-Elmer Model 403 atomic absorption spectrophotometer (Isaac and Kerber 1971). Soil phosphorus was extracted using sodium bicarbonate (Olsen et al. 1954). Total nitrogen was determined by macro-Kjeldahl procedures (Jackson 1958). Organic matter was determined by loss on ignition of 10 grams of soil at 950 C in a LECO medium temperature resistance furnace (Allison 1965).

Prevalent species (those most frequently encountered during sampling) were selected using the procedure of Warner and Harper (1972). Prevalent species were selected on the basis of both cover and frequency values. Niche overlap values (Colwell and Futuyma 1971) were calculated. Although niche overlap values can measure various aspects of interspecific association, in this study we used them to measure the degree to which various species pairs coexist in specific geographical compartments. A dendrogram of interspecific association (Sneath and Sokal 1973) was developed from the niche overlap values. The degree to which pairs of environmental variables were positively correlated in the 40 study plots was analyzed with correlation coefficients. Clustering procedures followed the weighted-pair group method (Sneath and Sokal 1973). Means and standard deviations are reported for biotic and abiotic variables across the 40 sampling plots.

RESULTS AND DISCUSSION

Table 1 lists the prevalent species, their average cover and frequency. The most

TABLE 2. Environmental factors in the blackbrush zone.

Environmental factor	Mean	Standard deviation
Biotic factors		
Total living cover (%)	55.5	9.0
Percent composition		
Shrubs	42.7 (76.9)*	7.5
Forbs	1.2 (2.2)	1.8
Grass	6.3 (11.4)	4.3
Cryptogams	5.3 (9.5)	5.2
Spp./stand	7.7	2.3
General site factors		
Elevation (m)	1271.3	94.5
Slope (%)	9.6	9.7
Litter (%)	7.9	3.8
Rock (%)	38.7	10.3
General soil factors		
Clay (%)	12.9	3.7
Silt (%)	26.2	6.9
Sand (%)	60.9	9.2
OM (%)	.5	.5
Soil depth (dm)	1.3	.7
pH	8.5	.2
EC (mmhos/cm)	.6	.2
Soil mineral nutrients		
Nitrogen %	.05	.02
Phosphorus (ppm)	15	5
Calcium (ppm)	9639	5335
Magnesium (ppm)	800	400
Sodium (ppm)	2709	149
Potassium (ppm)	211	78
Zinc (ppm)	1	1
Copper (ppm)	1	1

*Numbers in parenthesis indicate relative cover values.

abundant species is blackbrush, which contributes 75% of all vascular plant cover. Annual grasses (*Bromus rubens* and *Bromus tectorum*) account for 12% of the total cover. The remaining species on the prevalent species list are shrubs. Combined, they make up 7% of the total vascular plant cover. Although no forbs appear as prevalent species, 28 forbs were encountered in the study. However, all were uncommon and together they contributed only 2% of the total vascular plant cover.

Soils at most sites were strongly skeletal and often had shallow $CaCO_3$ pans. As a result, penetrometer readings were also shallow, averaging only 1.3 dm (5.1 in.) in depth (Table 2). Shallowness of soil is an important characteristic of the blackbrush community and may partially determine the abundance and/or distribution of blackbrush. Thatcher

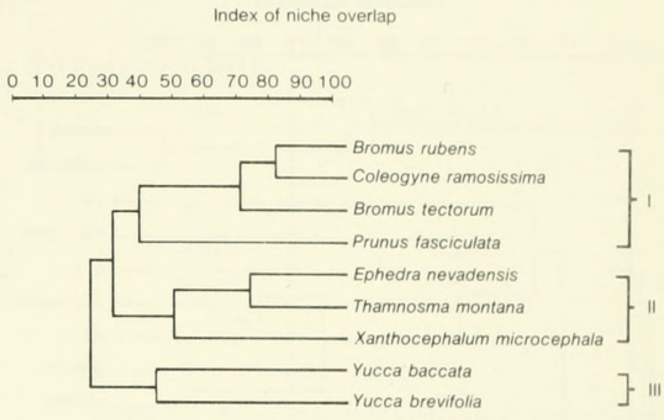

Fig. 1. Cluster diagram based on niche overlap values for the prevalent species in the blackbrush community.

(1975) and Doughty et al. (1976) concluded that edaphic factors were highly influential in the distribution of blackbrush. In addition to being shallow, soils that support blackbrush have abundant exposed rock (38.7%) and a high sand content (60.9%). The soils had an average pH of 8.5. Such high pH values are undoubtedly related to elevated levels of calcium (9639 ppm) and sodium (2710 ppm) in the soils. Soils analyzed by Bowns (1973) in the same vegetation zone showed patterns similar to those reported here.

Relative cover of shrubs, grasses, and forbs is in about the same proportions as the representation of those life form groups on the prevalent species list. Nearly 10% of the total plant cover was contributed by cryptogamic crusts. Although the role of cryptogamic crusts is not completely understood, their abundance indicates that they should not be ignored in the ecology of the blackbrush community.

Figure 1 depicts a cluster of species based on niche overlap values. For purposes of discussion, the nine species have been divided into three groups. In group I, blackbrush, red brome (*Bromus rubens*), and cheatgrass (*Bromus tectorum*) are closely associated. This occurs because red brome and cheatgrass often take advantage of the microhabitat provided by blackbrush individuals by living directly underneath the canopy of the blackbrush. Even though red brome and cheatgrass have a high niche overlap value with blackbrush, there is a negative correlation between grasses and shrubs. This is because niche overlap and correlation analyses measure different aspects of plant distribution. Desert almond (*Prunus fasciculata*)

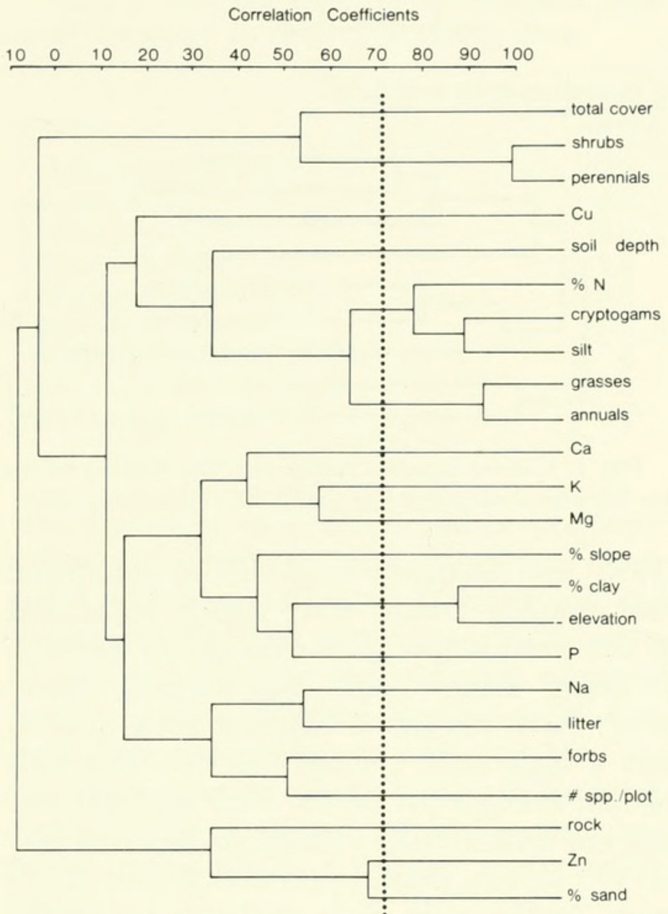

Fig. 2. Cluster diagram based on correlation coefficients for pairs of variables on all plots in the blackbrush community. Associations to the right of the dotted line are significant at the 0.01 level. Associations to the left of the dotted line are not significant.

occurs somewhat randomly on our study sites but tends to be more closely associated with blackbrush than other species. The species in group II are all hardy and relatively unpalatable shrubs that predominate on southern exposures where soils are shallow and conditions less favorable than surrounding areas. The distribution of the two *Yucca* species in group III is enigmatic. *Yucca baccata* and *Yucca brevifolia* occur intermixed in stands only occasionally and on the fringes of their respective ranges. Because neither *Yucca* species is in its preferred habitat in the blackbrush zone, their association may only be coincidental.

Figure 2 is a cluster of biotic and abiotic variables based on correlation coefficients. Associations to the right of the dotted line are significant at the 0.01 level. Associations to the left of the dotted line are considered insignificant. The 0.01 level of significance was used because the large number of correlations used to construct the dendrogram might allow too many correlations at the 0.05 level. Several relationships are distinguishable. Cryptogamic crusts, silt, percent soil-nitrogen, grass, and annuals are closely associated. Also positively associated, but less closely, are soil depth, copper, calcium, potassium, magnesium, phosphorus, sodium, clay, litter, and number of species per plot. These patterns suggest that grasses, cryptogamic crusts, and forbs are more common on deeper soils where clay, silt, and mineral nutrients are more abundant. Shrubs, on the other hand, are more common on more shallow, sandy soils. Correlation data for pairs of variables (Table 3) confirm these observations. Shrubs are positively correlated with sand and negatively correlated with clay, silt, and soil depth. Grasses are positively correlated with clay, silt, and soil depth but are negatively correlated with sand. We conclude from these patterns that the relative proportions of shrubs, grasses, forbs, and cryptogamic crusts are controlled by edaphic factors in the blackbrush community. This conclusion corroborates that of Doughty et al. (1976) and Thatcher (1975), who found that presence of blackbrush was related to the presence of certain soil types. Although nonwoody plants often take advantage of the microhabitat provided by the shrubs, they also increase in abundance where soils are deeper, have finer particles, and are more fertile. Deep, silty soils store more soil moisture for nonwoody plants than shallow, sandy soils. Shrubs fill a somewhat different niche by being more abundant on sandy, shallow soils. Shrubs are better able to extract water from shallow, sandy soils than are nonwoody plants. Sandy, shallow soils are more common than deep, silty soils in the study area. Thus, shrubs are the regional dominant in our study.

The relationships between soil nitrogen, silt, and cryptogamic crusts bear comment. The relationship among silt and cryptogamic crusts have been observed earlier by several authors (Loope and Gifford 1972, Kleiner and Harper 1977, Anderson et al. 1982, Brotherson and Rushforth 1983). Kleiner and Harper (1977) argued that, once established, the crusts tend to trap silt at the soil surface. Components of the cryptogamic crusts (i.e., bluegreen algae) have been shown to be nitrogen fixers (MacGregor and Johnson 1971,

TABLE 3. Correlation coefficients for environmental factors.

Environmental factor	Environmental factor				
	Clay	Sand	Silt	Soil depth	Shrubs
Sand	-.755				
Silt	.474	-.935 b			
Soil depth	.152	-.279	.292		
Shrubs	-.504	.907 b	-.946 b	-.229	
Grasses	.681	-.879 b	.813 a	.550	-.870 a

[a]Significant at the .01 level
[b]Significant at the .001 level

Reddy and Gibbons 1975). Anderson and Rushforth (1976), while working on the floristics of the cryptogamic crusts in southwestern Utah, described 11 species of blue-green algae as components of the crusts. The presence of blue-green algae in crusts of the blackbrush community may well explain the significant ($P < .01$) positive correlation between percent nitrogen in the soil and the presence of cryptogamic crusts. This may also indicate the value of cryptogamic crusts in elevating the fertility of associated soils.

Although no data were gathered on blackbrush reproduction, blackbrush seedlings were observed on only one of the eight general study areas. Those seedlings were all approximately 16 years old, but it is difficult to age blackbrush precisely because of stem splitting (Bowns 1973). The scarcity of blackbrush seedlings indicates that blackbrush reproduction occurs infrequently.

The information discussed in this paper does have bearing on current management practices in the blackbrush community of southwestern Utah. Since our data suggest that the sites on which blackbrush occur are predisposed toward dominance by shrubs, the current widespread practice of burning blackbrush sites to convert them to grasslands may be fighting against the natural trends of the sites. Bowns (1973) states that burning of blackbrush stands may give unpredictable or undesirable results. We concur with his statement and suggest that other alternatives to the burning of blackbrush sites be investigated.

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