Great Basin Naturalist

Volume 41 | Number 3 Article 11

9-30-1981

Grazing impacts on sagebrush communities of central Utah

Jack D. Brotherson
Brigham Young University

W. Todd Brotherson
Brigham Young University

GRAZING IMPACTS ON THE SAGEBRUSH COMMUNITIES OF CENTRAL UTAH

Jack D. Brotherson[1] and W. Todd Brotherson[1]

Abstract.— Twenty-three study sites were established in the sagebrush communities bordering Utah Lake. Relic (ungrazed) and grazed stands were represented in the sample. Differences in species composition, vegetation, and soil characteristics were assessed. Major differences in species composition and vegetative characteristics were due to the influence of grazing. Major changes were loss of native perennial grass cover, and increases in cover from introduced annual species. Differences in the soil characteristics were due to habitat rather than grazing influences.

When the pioneers first came into Utah Valley in 1847, they found a vast area of beauty and plenty in which they could successfully build homes, establish farms, and run large herds of sheep, cattle, and horses. Following settlement, grazing and its effects were seen throughout Utah and the West. Through the journals and records of early pioneers and explorers, we are able to confirm the fact that there has been a great deal of vegetation change in the last century and a half, resulting in widespread changes in the communities of sagebrush and other desert vegetation. The lands in which the first pioneers settled contained great quantities of palatable grasses and other forage plants (Cottam 1961, Wakefield 1936). Many settlers owned large herds, and native forage supplies became depleted from the constant grazing and regrazing of the land. This depletion opened the way for increases in such woody plants as sagebrush and juniper, along with other unpalatable species.

In 1877, John D. Lee was taken back to be executed at Mountain Meadows in southern Utah, a once beautiful green valley and favorite resting area for travelers on the Spanish Trail; he was asked to identify the spot on which he had led the dreadful massacre some twenty years before. He could not do it. He was hardly able to recognize the valley at all, describing it as being "God-forsaken" (Birney 1931).

Overgrazing also left its effect on Utah Valley and other valleys in the area. Orson Hyde lamented these occurrences in a General Conference talk 7 October 1865:

> I find the longer we live in these valleys that the range is becoming more and more destitute of grass; the grass is not only eaten up by the great amount of stock that feed upon it, but they tramp it out by the very roots; and where grass once grew luxuriantly, there is now nothing but the desert weed, and hardly a spear of grass is seen.
>
> Between here, Temple Square and the mouth of Emigration Kanyon, when our brethren, the Pioneers, first landed here in '47, there was an abundance of grass all over these benches; they were covered with it like a meadow. There is now nothing but the desert weed, the sage, the rabbit-bush and such like plants, that make very poor feed for stock (Roberts 1930).

A grazing animal does not eat everything in its path, but it grazes selectively, concentrating on the most palatable and desirable species. This observation of animal behavior and the response of certain plant species to such behavior has led to a classification of plant species with respect to their degree of desirability and degree of value in a grazing community. The first group is classified as decreasers. These are the more palatable species that diminish under prolonged grazing pressure. The second group are increasers, and generally increase under similar use, and are often the less palatable plants in the community. The third group is composed of invaders, plants present only marginally or not at all in native vegetation (e.g., introduced or exotic species); they are usually unpalatable. Under constant grazing use the vegetative composition of the native communities shifts, becoming less and less desirable. As grazing intensity is allowed to increase, the composition may become totally dominated by unpalatable invaders. This condition steadily

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

decreases the condition class or value rating of the land (Stoddart 1975).

Even though Utah Valley and its environs are in many localities well studied from the natural history and ecological points of view, little has been reported in the literature with regard to (1) man's impact on the plant communities since settlement, (2) the influence and changes wrought by introduced exotic plants, (3) species composition for the major community types, (4) environmental factors typical of the major community types, and (5) community diversity.

Study Area

Twenty-three study sites were established in plant communities bordering Utah Lake, Utah County, Utah, at approximately 40° 10′ N, 11°50′ W (Fig. 1). Elevations ranged from 1370 m (4500 ft) to 1400 m (4900 ft) above sea level. Study sites were established in grazed and ungrazed areas of the sagebrush community. Study sites were chosen to represent relatively homogeneous vegetation types.

Weather data for Provo, Utah, is representative of the study area. The average annual precipitation is 340 mm (14 inches), with 60 percent of the total falling in the winter and spring months. The hottest month of the year is July, averaging 33 C; the coldest month is January, averaging 3 C. The majority of its runoff water reaches Utah Lake from tributary streams arising in the Uinta and Wasatch mountain ranges directly east of Utah Lake. Precipitation in these mountains ranges from 760 to 1270 mm (30 to 50 inches) annually (Swenson 1972).

Materials and Methods

The study sites were selected to depict the range of variation within the sagebrush community in the central Utah area. A 10 × 10 m study plot (0.01 ha) was established at each site. Study plots were delineated by a cord 40 m long with loops every 10 m for corners. The corners were secured by steel stakes. Each plot was subsampled with twenty 0.25 m² quadrats distributed uniformly across the surface of the plot in five rows of four quadrats each.

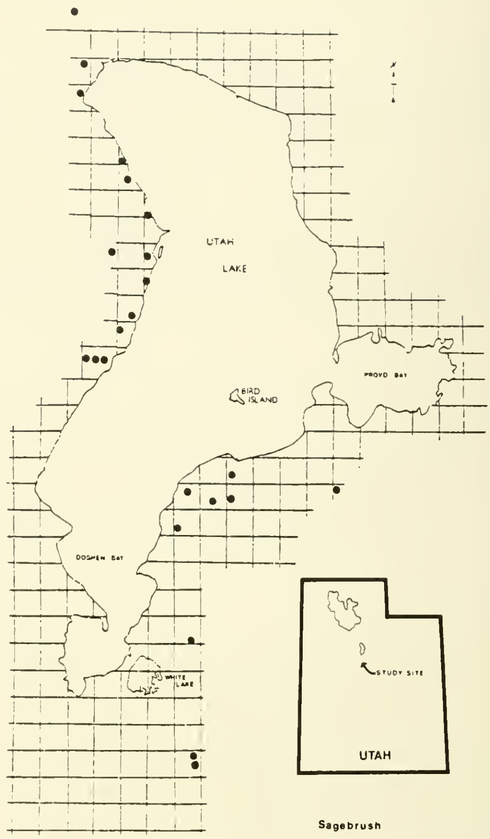

Fig. 1. Map of study site locations in the sagebrush zone in central Utah.

Total living plant cover, plant cover by life form (i.e., shrubs, subshrubs, perennial forbs, perennial grasses, annual grasses, annual forbs, cryptogams), litter, exposed rock, and bare soil were ocularly estimated. Cover for all plant species encountered was also estimated, using the cover class categories (1 = 0 – 5 percent; 2 = 5 – 25 percent; 3 = 25 – 50 percent; 4 = 50 – 75 percent; 5 = 75 – 95 percent; 6 = 95 – 100 percent) suggested by Daubenmire (1959). In addition, all species occurring within the study plot but not encountered in the quadrat subsamples were listed and given a percent cover value of 0.01 so they could be included in the overall data analyses. All species were classified as to life form (see above), longevity (perennial, biennial, annual), and according to whether they are native or introduced.

Three soil samples were taken in each plot (from opposite corners and the center) from the top 20 cm of soil and later combined for laboratory analysis. This depth was considered adequate because Ludwig (1969), in a study of the different foothill communities in Utah, showed that the surface decimeter of soil when sampled with reference to mineral concentrations yields 80 percent of the information useful in correlations with plant data. Holmgren and Brewster (1972) also showed in a study of desert shrub communities that greater than 50 percent of the fine roots (those most likely to absorb soil minerals) were found concentrated in the upper 15 cm of the soil profile. With respect to grasslands, Christie (1979) found that the top layer of soil is the region of most active mineral uptake.

The following characteristics were recorded for each study plot: elevation (taken from published U.S. Dept. of Interior Geological Survey 7.5 minute series topographic maps); percent slope; slope position (1 = ridgetop, 2 = midslope, 3 = drainage accumulation area); erosion (0 = none, 1 = light, 2 = moderate, 3 = heavy); grazing impact (0 = none, 1 = light, 2 = moderate, 3 = heavy).

Soil samples were analyzed for texture (Bouyoucos 1951), pH, soluble salts, mineral composition, and organic matter. Soil reaction was taken with a glass electrode pH meter. Total soluble salts were determined with a Beckman electrical conductivity bridge. A 1:1 soil-water paste (Russell 1948) was used to determine pH and total soluble salts. Soils were extracted with 1.0 neutral normal ammonium acetate for calcium, magnesium, potassium, and sodium ions (Jackson 1958, Hesse 1971, Jones 1973). Zinc, manganese, iron, and copper were extracted from the soils by use of DTPA (diethylenetriaminepentaaceticacid) extracting agent (Lindsay and Norvell 1969). Individual ion concentrations were determined using a Perkin-Elmer Model 403 atomic absorption spectrophotometer (Isaac and Kerber 1971). Soil phosphorus was extracted by sodium bicarbonate (Olsen et al. 1954). Total nitrogen analysis was made using macro-Kjeldahl procedures (Jackson 1958). Soil organic matter was determined by loss on ignition at 950 C, using a 10-gram sample in a LECO medium temperature resistance furnace following methods described by Allison (1965).

Plant nomenclature follows Welsh and Moore (1973) for the dicotyledons (trees, shrubs, forbs, etc.) and Cronquist et al. (1977) for the monocotyledons (grasses, sedges, rushes, etc.). Prevalent species (those most frequently encountered during sampling) of the various plant communities are reported, with the number being considered equal to the average number of species per 0.01 ha sampling area (Warner and Harper 1972). Diversity values were computed using the formula

$$H^1 = -\sum_i pi \log pi,$$

where H^1 is the diversity index and pi is a measure of the relative abundance of a species in a given habitat (Pielou 1977).

Data taken on the biotic and abiotic factors of the different sites within the study area (one data set per study plot) were lumped by grazing category and summarized. A great deal of variation in the data was observed both within and between categories.

Results and Discussion

The grazed and ungrazed study sites in the sagebrush communities of central Utah were chosen from established stands surrounding Utah Lake. The grazed sites were chosen from widely spaced areas to represent as nearly as possible the present state of the sagebrush community. The ungrazed sites were chosen to represent stands of the sagebrush community that had not been grazed for the past 35–40 years. Such stands (often classed as "relict areas") were very difficult to locate.

To successfully assess the effects of grazing on the sagebrush community, prevalent species lists (Table 1) were made for the grazed and ungrazed communities. The number of species considered to be prevalent for each type was calculated by dividing the average number of species per stand by the total number of stands studied. The ungrazed community had 8 prevalent species; the grazed had 10 (Table 2). The greater number of species in the grazed area probably reflected more intense sampling in those areas.

As shown in Table 1, grazing impacts are easily seen in community composition. Decreasers have essentially been eliminated, and the invaders (*Bromus tectorum, Ranunculus* *testiculatus, Poa bulbosa*) have increased in cover from 10 to 59 percent. These are also accompanied by an 18 percent increase in the cover of the woody species *Artemisia tridentata* and *Chrysothamnus nauseosus*. These increases are associated with a reduction in cover (48 percent) of the palatable species (*Agropyron spicatum, Poa nevadensis, Stipa comata, Oryzopsis hymenoides*).

In looking at cover differences in lifeform classes (Table 2), the depletion of grazable vegetation is also evident. The change in shrub cover is due mainly to increases of *Artemisia tridentata*. The corresponding loss of grass cover is due mostly to *Agropyron spicatum*. In addition, the increases in annual forbs and grasses reflect the competitive advantages of unpalatable exotic species (55 percent composition in the grazed area) as palatable species diminish under grazing.

Although one generally expects a reduction of total plant cover after prolonged heavy grazing, in our case the opposite actually proved true. As the way is opened for annuals to invade an area, they spread rapidly and fill in the spaces between and under the shrubs. Thus, in this study, the total living cover increased from 70 to 83 percent under grazing (Table 2). These increases in cover are due to the fact that measurements on total cover were taken in the spring and early summer, when the annuals were at peak growth. By summer and fall they have finished their life cycles and died back, leaving large bare areas of uncovered soil.

The soil studies indicate that grazing had essentially no impact upon the soil texture, hydrogen ion concentration (pH), and chemical nutrients. The higher levels of phosphorus, calcium, sodium, and potassium in the grazed site soils can be accounted for by the fact that the slopes of the two areas were different (ungrazed = 19 percent; grazed = 8 percent); these nutrients are fairly mobile in high calcium content soils and, therefore, as it rains, they tend to be dissolved in runoff water or be carried downhill as absorbed ions on eroded colloidal material.

In addition to results showing modification of vegetation under grazing, another factor affects the chances for the native plants to return. *Ranunculus testiculatus*, a species suspected of allelopathy (Buchanan et al. 1978), deposits harmful chemicals into the soils, causing a retardation of seed germination or complete quelling of the growth of other species. Should these plants cover enough of an area, the native vegetation may never recover.

Grazing has been practiced on most of the plant communities of Utah Valley for many years. As discussed above, its effects can greatly change the structure of the dominant vegetation. The effects documented in the sagebrush communities can also be observed in the shadscale and greasewood communities. Although data are unavailable, the effects are highly similar and in some areas large stands of these types have been denuded of perennial vegetation and are now classified as mixed weed communities.

TABLE 1. Means and standard deviations (SD) of plant species cover on grazed and ungrazed sites around Utah Lake.

	Grazed		Ungrazed	
Prevalent species	Mean	SD	Mean	SD
Artemisia tridentata	31.2	9.3	18.3	9.4
Bromus tectorum	30.9	18.9	9.9	12.3
Agropyron spicatum	0.1	0.5	29.9	24.0
Ranunculus testiculatus	26.2	15.6	0.3	0.6
Poa nevadensis	4.8	7.5	15.4	15.4
Xanthocephalum sarothrae	1.1	1.7	6.8	10.4
Stipa comata	—	—	5.4	13.2
Alyssum alyssoides	1.3	2.2	4.2	6.8
Phlox longifolia	3.4	13.6	0.9	2.1
Chrysothamnus nauseosus	2.8	8.5	1.0	2.3
Sitanion hystrix	2.3	3.3	—	—
Sphaeralcea coccinea	2.2	4.0	0.5	1.2
Poa bulbosa	2.0	8.4	—	—
Poa sandbergii	1.8	5.1	—	—
Oryzopsis hymenoides	—	—	1.8	4.3

TABLE 2. Means and standard deviations of environmental factors and significance levels for the difference of the means for grazed and ungrazed sites around Utah Lake. Significance levels were computed using the student t-statistic.

Environmental factor	Grazed		Ungrazed		Significance level
	Mean	SD	Mean	SD	
GENERAL SITE FACTORS					
Elevation (feet)	4624.0	108.2	5472.0	894.7	.05
Percent slope	8.3	8.2	19.2	14.3	NS
Slope position[a]	2.1	0.8	2.2	0.8	NS
Moisture index[b]	1.1	0.6	1.2	0.4	NS
Erosion index[c]	0.2	0.4	0.0	0.0	.05
Percent litter cover	6.9	4.8	5.6	3.0	NS
Percent exposed rock	2.7	2.7	13.7	14.1	NS
Percent exposed bareground	9.1	5.2	11.2	5.1	NS
GENERAL SOIL FACTORS					
Percent sand	40.7	10.2	32.0	6.7	.05
Percent silt	37.4	6.6	44.0	5.4	.05
Percent clay	22.2	4.4	24.0	2.8	NS
Percent fines	56.6	9.8	68.0	6.7	.05
Percent organic matter	2.3	0.8	3.0	0.5	0.05
pH	7.4	0.2	7.5	0.1	NS
Soluble salts (ppm)	293.7	38.3	275.2	36.8	NS
SOIL MINERAL NUTRIENTS					
Nitrogen (percent)	0.1	0.1	0.2	0.1	NS
Phosphorus (ppm)	11.2	3.9	6.1	2.0	.05
Calcium (ppm)	7500.2	2139.4	6258.3	2960.6	NS
Magnesium (ppm)	227.3	69.1	229.7	100.1	NS
Sodium (ppm)	176.9	53.9	62.6	7.6	.05
Potassium (ppm)	566.6	225.7	305.3	78.4	.05
Iron (ppm)	5.2	2.5	6.2	1.5	NS
Manganese (ppm)	9.4	3.5	9.7	3.8	NS
Zinc (ppm)	1.5	0.7	1.5	1.3	NS
Copper (ppm)	1.9	0.6	1.7	0.7	NS
BIOTIC FACTORS					
Total living cover	83.1	6.6	69.9	10.9	NS
Percent shrub cover	29.1	8.2	26.6	10.5	NS
Percent forb cover	3.8	7.6	1.5	2.9	NS
Percent grass cover	9.9	9.8	51.3	11.6	.05
Percent annual cover	43.0	27.1	11.3	14.6	.05
Percent annual grass cover	22.2	15.3	8.4	10.6	.05
Percent annual forb cover	20.8	11.8	2.9	3.9	.05
Percent cryptogam cover	14.9	12.2	9.4	8.4	NS
Diversity[d]	2.2	0.3	2.0	0.5	NS
Mean no. of species/stand	10.0	3.1	7.8	3.3	NS
Mean no. of native species/stand	6.3	2.7	6.5	2.6	NS
Mean no. of introduced species/stand	3.8	0.8	1.3	1.0	.05
Native species (percent of total)	60.8	8.8	83.5	9.5	.05
Introduced species (percent of total)	39.3	8.8	16.5	9.5	.05
Total cover of native species	43.2	14.5	87.2	13.4	.05
Total cover of introduced species	56.8	14.5	12.8	13.4	.05
Grazing impact[e]	2.2	1.2	0.5	0.6	.05

[a]Slope position is defined as 1 = top of slope, 2 = midslope, 3 = bottom of slope.
[b]The moisture index runs from 1 to 5 with 1 indicating xeric conditions and 5 indicating standing water.
[c]The erosion index runs from 0 to 3 with 0 indicating no erosion and 3 indicating heavy erosion.
[d]Diversity was computed using Shannon-Weiner's index.
[e]Grazing impact is defined as 1 = light, 2 = moderate, and 3 = heavy grazing.

Grazing effects in the meadows have been less dramatic because of more favorable moisture conditions and because of the general capacity of the dominant life forms (i.e., grasses and sedges) to withstand grazing pressure. Changes due to grazing pressures in the native vegetation of these areas most often take the form of shifts in the dominance of species over long periods (i.e., as more palatable species are grazed in preference to others, the competitive ability of grazed species is reduced, thus allowing the less palatable species to increase in dominance). Such changes are difficult to document because of the long time periods needed to make the shifts and because of the lack of "relict" meadows for comparison purposes.

Literature Cited

Allison, L. E. 1965. Organic Carbon. Pages 1320–1345 *in* C. A. Black, D. D. Evans, J. L. White, L. E. Ensminger, F. E. Clark, and R. C. Dinauer, eds. Agronomy Series No. 9 Part 2. Methods of soil analysis—chemical and microbiological properties. American Society of Agronomy, Inc., Madison, Wisconsin.

Birney, H. 1931. Zealots of Zion. Penn Publishing Co., Philadelphia, Pennsylvania.

Bouyoucos, G. J. 1951. A recalibration of the hydrometer method for making mechanical analysis of soils. J. Agron. 43:434–438.

Buchanan, B. A., K. T. Harper, and N. C. Frischknecht. 1978. Allelopathic effects of bur buttercup tissue on the germination and growth of various grasses and forbs in vitro and in soil. Great Basin Nat. 38:90–96.

Christie, E. K. 1979. Ecosystem processes in semiarid grasslands II: Litter production, decomposition, and nutrient dynamics. Aust. J. Agric. Res. 30:29–42.

Cottam, W. P. 1961. Our renewable wildlands—a challenge. Univ. of Utah Press, Salt Lake City. 182 pp.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1977. Intermountain flora—vascular plants of the Intermountain West, USA. Vol. 6, The monocotyledons. Columbia Univ. Press, New York. 584 pp.

Daubenmire, R. 1959. A canopy coverage method of vegetational analysis. Northwest Science 33:43–66.

Hesse, P. R. 1971. Textbook of soil chemical analysis. William Clowes and Sons, Ltd., London. 520 pp.

Hutchings, S. S., and J. E. Schmautz. 1969. A field test of the relative-weight estimate method for determining herbage production. J. of Range Mangt. 22:408–411.

Holmgren, R. C., and S. F. Brewster. 1972. Distribution of organic matter reserve in a desert shrub community. U.S. Dept. Agr. Forest Serv. Res. Pap. INT-130. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Isaac, R. A., and J. D. Kerber. 1971. Atomic absorption and flame photometry: techniques and uses in soil, plant, and water analysis. Pages 17–38 *in* L. M. Walsh, ed. Instrumental methods for analysis of soils and plant tissue. Soil Sci. Soc. Amer. Wis.

Jackson, M. L. 1958. Soil chemical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Jones, J. B. 1973. Soil testing in the United States. Comm. Soil Sci. Plant Anal. 4:307–322. 498 pp.

Lindsay, W. L., and W. A. Norvell. 1969. Development of a DTPA micronutrient soil test. Page 84 *in* Agron. Abstracts. Equilibrium relationships of Zn^{2+}, Fe^{3+}, Ca^{2+}, and H^{+} with EDTA and DTPA in soil. Soil Sci. Soc. Amer. Proc. 33:62–68.

Ludwig, J. A. 1969. Environmental interpretation of foothill grassland communities of northern Utah. Unpublished dissertation, Univ. of Utah. Salt Lake City. Utah. 100 pp.

Olsen, S. R., C. V. Cole, F. S. Watanabe, and L. A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Agr. Cir. No. 939.

Pielou, E. C. 1977. Mathematical ecology. John Wiley and Sons, New York. 385 pp.

Roberts, B. H. 1930. A comprehensive history of The Church of Jesus Christ of Latter-day Saints. Deseret News Press, Salt Lake City.

Russell, D. A. 1948. A laboratory manual for soil fertility students, 3d ed. Wm. Brown Co., Dubuque. 56 pp.

Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. Range management. 3d ed. McGraw-Hill Book Co., New York. 532 pp.

Swenson, J. L., W. M. Archer, K. M. Donaldson, J. J. Shiozaki, J. H. Broderick, and L. Woodward. 1972. Soil survey of Utah County, Utah. USDA Soil Conservation Service.

Wakefield, H. 1936. A study of the native vegetation of Salt Lake and Utah Valley as determined by historical evidence. Proc. Utah Acad. Sci., Arts and Letters, 13:11–16.

Warner, J. H., and K. T. Harper. 1972. Understory characteristics related to site quality for aspen in Utah. BYU Sci. Bull., Biol. Series 16:1–20.

Welsh, S. L., and G. Moore. 1973. Utah plants—tracheophyta. Brigham Young University Press, Provo, Utah. 474 pp.