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DUTCHWOMAN BUTTE REVISITED: EXAMINING PARADIGMS FOR LIVESTOCK GRAZING EXCLUSION

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ABSTRACT: In 2000, a collaborative rangeland monitoring program was established with the University of Arizona, Gila County Cattlegrowers, and the Tonto National Forest. Dutchwoman Butte (DWB) is an isolated, ungrazed 40 ha mesa with relict vegetation. Our objective was to contrast the vegetation of DWB to that of a grazed site, Whiskey tank (WT), across multiple years (2001, 2003, 2004, and 2005). Data were collected for plant frequency, botanical composition (dry weight rank procedure), ground cover, and distance to the nearest perennial plant base (fetch). In 2001, DWB had 42% composition from perennial grasses. In 2003, the total species composition from perennial grasses was 2.0% and in 2004 and 2005, 6.5% and 2.1%, respectively. On WT, the composition from perennial grasses was 57% in 2001, 19% in 2003, 45% in 2004, and 37% in 2005. The dominant grass species present on DWB in 2001 was green sprangletop (*Leptochloa dubia*; 24% frequency) and sideoats grama (*Bouteloua curtipendula*; 22% frequency). The dominant grass species present on WT in 2001 was curly mesquite (*Hilaria belangeri*; 37% frequency) and sideoats grama (20% frequency). Hairy grama frequency (*Bouteloua hirsuta*) in 2001 was similar ($P > 0.05$) on both sites (14% on DWB and 13% on WT), decreased ($P < 0.05$) at both sites in 2003, but recovered ($P < 0.05$) at WT in 2004 to 19% while remaining less than 1% at DWB. In 2005, hairy grama frequency was still greater ($P < 0.05$) at WT than at DWB (10 vs. 1%). Sideoats grama was similar on both sites in 2001 ($P > 0.05$) but decreased ($P < 0.05$) at both sites in 2003 and never increased above 6% during the trial. Curly mesquite frequency at WT in 2005 was similar ($P > 0.05$) to that observed in 2001, being 40% in 2005 and 37% in 2001. Green sprangletop on DWB was less ($P < 0.05$) in 2005 than in 2001 (3 vs. 24%). Fetch was less ($P < 0.05$) on DWB than on WT in 2001 (10.9 ± 0.71 vs. 13.0 ± 0.89 cm), but was greater ($P < 0.05$) than at WT from 2002 to 2005. The WT site appeared more resilient to drought than DWB and the greater presence of low growing sod forming species like curly mesquite could have aided in drought recovery at WT.

Key Words: Cooperative Extension, Rangeland Monitoring, Grazing

Introduction

In 2000, a collaborative range monitoring program was established with the University of Arizona Cooperative Extension in Gila County, the Gila County Cattle Growers, and the Tonto National Forest. The Dutchwoman Allotment was selected as one of four ranches in Gila County to participate in the "Reading the Range" program.

Dutchwoman Butte (DWB) is an isolated land form supporting relict vegetation on the 40 ha on top of the butte. As reported previously (Ambos et al., 2000), elevations at the top of DWB range from approximately 1,441 m at lower levels to just over 1,527 m at the extremity, tilting to the southeast on a 20% slope. The top of the butte has never been grazed by domestic livestock, though deer and bear ascend its heights periodically. The Butte is located at the southern extremity of the Sierra Ancha Mountains just north of Roosevelt Lake in central Gila County, Arizona. One of the key areas selected for the allotment was located on DWB (1,479 m) paired with a grazed companion site immediately across the canyon. The Whiskey Tank Companion Site (WT) is situated approximately 182 m lower (1,287 m) than DWB on a mesa with a 10% slope and a similar southeastern aspect. Over geologic time, it is theorized that DWB separated from the Companion Site across the canyon.

Materials and Methods

The 726 ha pasture enclosing WT was grazed lightly (less than 40%) from September 15, 2000 to May 1, 2001 the first year of data collection by 150 cows (70% of the permitted livestock numbers). In 2002, a severe drought occurred and cattle were removed from the allotment in July 2002. The cattle removal continued until May 2004. Lower cattle numbers (30% of permitted numbers) returned to the Whiskey Pasture on September 15, 2005 and grazed this pasture until April 1, 2006. At the time of monitoring in 2005 (November 8), utilization at WT was 15%.

Range Monitoring Data Collection. Range monitoring data reported here were collected from 2001 to 2005, excluding 2002. Data were not collected in 2002 due to drought and livestock removal. Range monitoring data were collected annually in October or November, except for 2001, when data were collected in February. Data collection (Sampling Vegetation Attributes: Interagency Technical Reference, 1996) on the top of DWB consisted of six transects encompassing three hundred 0.16 m^2 quadrats for plant frequency and dry weight rank for plant species composition. Cover point data for litter, gravel (2 mm to 1.9 cm), rock (> 1.9 cm), live perennial basal vegetation, litter, persistent litter (> 1.27 cm deep and persistent), and bare ground were collected at two points on each quadrat. From the center point

in a 360° arc, the distance to the nearest perennial plant base (fetch) was measured for each quadrat.

Data collection at WT was identical to that collected on DWB, except that we only collected frequency, cover, fetch, and dry weight rank data from 200 quadrats placed along four transects. Fewer transects were used due to space limitations.

Statistical Analyses. Treatment means for cover and fetch data were separated using paired t-tests with pooled variance for the two means. Frequency data means were separated using 95% confidence intervals for binomial populations (Owen, 1962).

Results and Discussion

Climate During the Period of this Study. Precipitation in central Arizona typically occurs in a bimodal fashion, with a very dry May and June. Winter moisture is influenced by Pacific oceanic temperatures and air streams and summer moisture is influenced by the North American monsoon. Summer moisture generally occurs from July through September. It should be recognized that summer rainstorms exhibit considerable variability in their location and intensity. For the purpose of this study, winter moisture is defined as that occurring from November through June and summer moisture from July through October.

Winter and summer precipitation at the Roosevelt weather station (Arizona Climate Summaries, 2006) is shown in Table 1. Average annual precipitation is 40.34 cm. Precipitation recorded in 2002 was the driest in Arizona recorded history (since 1905). The *total* 2002 precipitation was less than Southwestern tree ring estimated (Ni et al., 2002) *cool season* (November to April) precipitation for all years since A. D. 1000 except possibly 1904, 1773, 1685, 1664, and 1150.

Table 1. Precipitation data at Roosevelt [1], cm

Year	Winter (Nov. to July)	Summer (July to Nov.)	Total
Nov. 2000 to Nov. 2001	21.34	17.93	39.27
Nov. 2001 to Nov. 2002	5.00	4.78	9.78
Nov. 2002 to Nov. 2003	21.26	14.25	35.51
Nov. 2003 to Nov. 2004	19.46	10.80	30.26
Nov. 2004 to Nov. 2005	45.34	11.35	56.69
Long Term Average	**25.48**	**14.86**	**40.34**

[1]Arizona Climate Summaries, Available at: http://www.wrcc.dri.edu/

Species Composition. Figure 1 shows the total composition of perennial grasses at each site preceding and through the drought. Due to the drought, the perennial grasses on DWB were mostly replaced by annuals. Though perennial grasses dropped precipitously at WT, they were not reduced to the same levels as they were on DWB. Recovery of perennial grasses following the brief respite from the ongoing drought occurred at WT in 2004, but not at DWB.

Cover Data. Cover data for the two key areas preceding and following the brief respite from drought showed some changes (Table 2). Due to the much larger

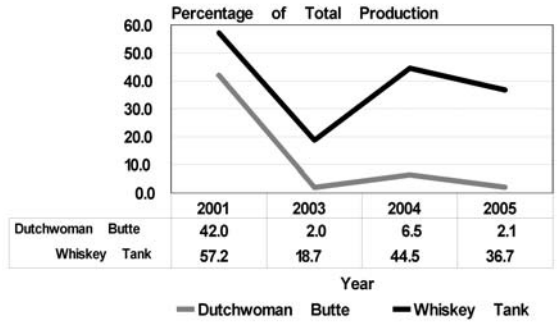

Figure 1. Percentage of total production from perennial grasses as estimated by dry weight rank. Grasses included in totals are listed in Table 3.

sample size for the fetch data compared to the bare ground and live vegetation cover data (200 to 300 individual measurements vs. 4 to 6 transects), only the fetch data changed in a statistically significant way during the trial. At the beginning of the trial, plants were closer together on the top of DWB. Through the drought, plants were closer together at WT. By the fall of 2004, WT had recovered sufficiently to have plant spacings comparable to what was observed at the onset of the trial. However, due to the poor monsoon moisture received at WT in 2005, plant spacings increased again in 2005.

Frequency Data. Perennial grass frequency varied prior to and through the drought at both monitoring sites (Table 3). Prior to the drought, DWB had a much greater abundance of green sprangletop (*Leptochloa dubia* [H. B. K.] Nees) and WT had a much greater abundance of curly mesquite (*Hilaria belangeri* [Steud.] Nash). The sites were comparable with respect to sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.), hairy grama (*Bouteloua hirsuta* Lag.), and threeawn (*Aristida* spp.). The Companion Site also had a greater frequency of cane beardgrass (*Bothriochloa barbinodis* [Lag.] Herter) than did DWB at the beginning of the trial.

Surprisedly, the grass species most impacted on both sites was sideoats grama. At the end of the study, sideoats grama had not recovered on either site. It would be expected for the more shallow rooted hairy grama species to suffer more plant mortality during the drought, but on WT this species had recovered to pre-drought levels by the end of the study. Curly mesquite, a shallow rooted, sod forming grass, rebounded fairly quickly from the effects of the drought on WT. Given the proper moisture and temperature regime, curly mesquite has the ability to anchor new plants from stolons. The frequency of curly mesquite on DWB did not demonstrate such a recovery.

Much has been written and said about the influence of livestock grazing upon the increased presence of more grazing resistant plants like curly mesquite in the Southwest.

While it is true that livestock grazing may increase the competitive advantage of curly mesquite to other bunch grasses, in this study curly mesquite may have actually aided in the drought recovery for WT.

Why did the perennial grass population decline on DWB and not on WT? Soils were taxonomically the same with nearly identical diagnostic attributes and vegetation was similar. Several possibilities exist: 1) The same mechanisms or genetic mutations which make plants resistant to grazing may also make them more resistant to drought (Cheplick et al., 2000; Cheplick and Chui, 2001; Smith, 1998); 2) Grazing may result in a more diverse age classification of plants due to seed dispersal and seed implantation by grazing herbivores, thus making grazed plant communities more resistant to environmental stress than more even-aged plant communities (Holechek, 1981); 3) Grazing removes senescent plant material, and if not extreme, helps open up the basal plant community for photosynthesis and rainfall interception (Holechek, 1981); 4) Beneficial mychorrizae for plant health may be contributed into ecological sites by grazing herbivores (in this case, cattle) in a truly symbiotic relationship; 5) Shading and rainfall infiltration could have been greater at WT due to the greater abundance of the sod forming grass, curly mesquite; and/or 6) The Sites in question are examples of state and transition models (Briske et al., 2005), wherein each site is independently different from the other following different trajectories (grazed vs. ungrazed) from a common original state.

Additional possibilities in comparing grazed vs. excluded sites are suggested by Holechek et al. (2006). In their study, they reported that livestock grazing at light to moderate intensities can have positive impacts for plant survival on rangelands in the Southwest (Arizona and New Mexico). Courtois et al. (2004) found similar results between grazed and excluded sites in Nevada. Two paradigms that have become dogma need to be reexamined. First, grazing tolerant native grasses should not be viewed only as an indication of degraded ecological systems. They may in fact be part of an ecological site that is functioning effectively and contributing to a healthy ecosystem under adverse climatic conditions. The second paradigm that needs to be reevaluated is that removing livestock from ecological systems will always lead us to “Nirvana”.

Climate is the biggest influence of ecological systems, followed distantly by management. Poor management can exacerbate the effects of drought, while effective management can help temper and ease drought recovery. On WT, effective management has been practiced for over 25 years.

The timing of this study was especially fortuitous since it preceded and followed the 2002 drought. Will DWB recover? The authors of this study are divided on this question. Some feel that Arizona may be entering an extended period of drought and when moisture comes to DWB, it may be exploited by the presence of invasive and native annuals, preventing extensive establishment of perennial grasses. The other authors feel that the seed source is present on the Butte and if several seasons of favorable summer moisture and temperatures occur in succession, perennial grasses could begin to establish again.

Implications

We collected range monitoring data on an ungrazed relict area and compared that to data collected from a similar grazed site under good management. In this study, we captured ecological changes that may only occur once in a millennium. The data we collected does not support the supposition that areas protected from livestock grazing are better equipped to handle the effects of drought. On the contrary, the grazed site was more resilient than the ungrazed site and maintained a more diverse perennial grass population that was sustained through the drought.

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Table 2. Cover data

Type of data	Year	Dutchwoman Butte	Whiskey Tank Companion Site
Distance to closest perennial plant, cm	2005	26.7 ± 1.35[a] *	17.3 ± 1.12[c] *
	2004	30.5 ± 1.52[a] *	13.7 ± 0.84[a] *
	2003	36.6 ± 1.80[b] *	28.1 ± 2.01[b] *
	2001	10.9 ± 0.71[c] *	13.0 ± 0.89[a] *
Bare ground, %	2005	14.3[a]	14.7[a]
	2004	17.6[a]	16.0[a]
	2003	25.9[a]	21.5[a]
	2001	11.6[a]	16.1[a]
Live basal vegetation, %	2005	6.7[a]	12.4[a]
	2004	13.4[a]	18.0[a]
	2003	9.4[a]	8.9[a]

Live basal vegetation cover in 2001 included annuals, so that data is not included here. Within key area, by cover classification, reported values with differing letters following them are different ($P < 0.05$). Reported values for Dutchwoman Butte vs. Whiskey Tank followed by "*" are different ($P < 0.05$) for that year within the cover classification.

Table 3. Frequency data - Perennial Grasses

Plant Species	Scientific Name	Year	Dutchwoman Butte	Whiskey Tank Companion Site
Green Sprangletop	*Leptochloa dubia* (H. B. K.) Nees	2005	3.1[a]	0.5[a]
		2004	4.4[a] *	0.0[a] *
		2003	1.3[a]	0.0[a]
		2001	23.5[b] *	0.5[a] *
Curly Mesquite	*Hilaria belangeri* [Steud.] Nash	2005	0.7[c] *	40.0[c] *
		2004	5.0[ab] *	48.3[a] *
		2003	2.0[b] *	29.8[b] *
		2001	6.5[a] *	36.7[bc] *
Sideoats Grama	*Bouteloua curtipendula* [Michx.] Torr.	2005	2.1[a]	3.5[a]
		2004	5.0[a]	5.2[a]
		2003	2.7[a]	5.7[a]
		2001	21.5[b]	20.3[b]
Hairy Grama	*Bouteloua hirsuta* Lag.	2005	1.0[a] *	9.9[c] *
		2004	0.3[a] *	18.7[b] *
		2003	1.7[a]	3.6[a]
		2001	14.3[b]	12.9[c]
Spidergrass Threeawn	*Aristida ternipes*	2005	0.7[b] *	4.9[b] *
		2004	1.0[b] *	14.0[a] *
		2003	0.0[b] *	4.6[b] *
Threeawn	*Aristida* spp.	2005	0.3[a] *	7.4[b] *
		2004	1.0[a]	3.6[ab]
		2003	0.3[a]	0.5[a]
		2001	7.5[b]	7.4[b]
Cane Beardgrass	*Bothriochloa barbinodis* [Lag.] Herter	2005	0.3[a]	1.5[a]
		2004	0.3[a]	3.1[a]
		2003	0.0[a]	2.1[a]
		2001	0.7[a] *	6.9[b] *

Within key area, by species, reported values with differing letters following them are different ($P < 0.05$). Reported values for Dutchwoman Butte vs. Whiskey Tank followed by "*" are different ($P < 0.05$) for that year within the species. Other plant species encountered at both Dutchwoman Butte and Whiskey Tank in trace amounts (less than 3%) included plains lovegrass (*Eragrostis intermedia* Hitchc.). Perennial grasses present only on Dutchwoman Butte (less than 3% frequency) were bottlebrush squirreltail (*Elymus elymoides* [Raf.] Swezey ssp. Elymoides). Perennial grasses present only on Whiskey Tank (less than 3% frequency) were Arizona cottontop (*Digitaria californica* (Benth.) Henr.) and tanglehead (*Heteropogon contortus* (L.) P. Beauv. Ex Roem. & Schult.).