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Long-term effects of brush management on vegetation diversity in ephemeral drainages

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Abstract

There has been recent concern regarding the effects of range management practices on biodiversity. Our objective was to determine the long-term (>30 years) effects of chaining, and chaining followed by root plowing, on vegetation diversity in an ephemeral drainage system. Plant species richness and diversity were estimated in 2 chained (ca. 1950) areas, 2 chained (ca. 1950) and root-plowed (ca. 1960) areas, and 2 untreated areas during April 1993. Beta diversity within treatments was estimated with mean dissimilarity (1-mean similarity). Mean similarity was quantified with Jaccard's index. Spatial gradient analysis in which pairwise similarities were regressed against the distance between each pair of samples within a site was used to describe similarity within a site. Species richness and diversity were similar among treatments for both herbaceous and woody species. Similarity (Jaccard's index) among transects within a site increased with increasing degree of disturbance. Chained and root plowed sites had lower beta diversity than chained or untreated sites. Similarity in the chained and root plowed sites varied randomly, not spatially, while the control (untreated) and chained sites had negative spatial gradients, indicating spatial heterogeneity within these sites. Although root plowing did not reduce species richness and diversity as reported on upland sites in previous studies, beta diversity and habitat heterogeneity were lower on chained and root plowed sites than on chained or untreated sites.

Keywords: browse, chaining, drainage, root plowing, similarity, wildlife habitat.

Many landscapes have been impacted by human land uses resulting in landscape mosaics of natural and human-disturbed patches. Human-induced alterations of arid and semiarid areas have dramatically altered the size, shape and arrangement of landscape mosaics within these ecosystems (Rappole et al. 1986). Such alterations are typified by the brush management applied during the last 50 years. In Texas, landowners chemically and mechanically treated more than 579,000 ha of rangeland annually from 1940-1981 to increase forage for livestock (Welch 1982). Maintenance of biotic diversity is one of the critical issues facing range managers. With large-scale brush management still in practice, concern about the long-term effects of such practices on community diversity is increasing (Lewis et al. 1988).

Severe alterations such as root plowing generally result in a long-term reduction in density and diversity of browse plants preferred by white-tailed deer (*Odocoileus virginianus* Raf.) (Fulbright and Beasom 1987, Ruthven et al. 1993). In the western South Texas Plains, mesquite (*Prosopis glandulosa* Torr.) and twisted acacia (*Acacia schaffneri* (Wats.) Herm.) dominate plant communities in root plowed sites (Fulbright and Beasom 1987), whereas huisache (*A. farnesiana* (L.) Willd.) often dominates root-plowed sites in the eastern South Texas Plains (Mutz et al. 1978, Ruthven et al. 1993). Ruthven et al. (1993) reported that brush diversity in the eastern South Texas Plains was greater in untreated areas than in areas root plowed 17-18 years prior. In contrast, brush species richness and diversity on 2 upland sites in the western South Texas Plains were similar 15-16 years following offset disking (Montemayor et al. 1991).

Long-term effects of mechanical brush management on herbaceous composition and diversity have received little attention. Mutz et al. (1978) determined that herbage scores (a relative index based on range condition class and carrying capacity) changed little from 1963-1977 on shredded, roller chopped, or untreated plots. Ruthven et al. (1993) found herbaceous diversity and richness similar between untreated and root-plowed areas. Our objective was to determine long-term effects of chaining and chaining and root plowing on herbaceous and woody composition and diversity in an ephemeral drainage in the western South Texas Plains.

Materials and Methods

Data were collected during April 1993 on the Chaparral Wildlife Management Area 12 km west of Artesia Wells in Dimmit and LaSalle counties, Texas. The Chaparral Wildlife Management Area is composed of 6,150 ha of scrub-brush rangeland typical of South Texas and is within the South Texas Plains ecological region (Hatch et al. 1990). The Chaparral Wildlife Management Area receives an average of 75 cm of precipitation annually with peaks in April-June and August-October. Precipitation amounts and patterns are highly

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variable from year to year. Soils are sandy loams, and topography consists of gently rolling hills interspersed with ephemeral drainage systems. Woody vegetation on the Chaparral Wildlife Management Area is dominated by mesquite, whitebrush (*Aloysia gratissima* Gill. & Hook.), blackbrush acacia (*A. rigidula* Benth.), guayacan (*Guaiacum angustifolium* Engelm.), and prickly pear (*Opuntia lindheimeri* Engelm.).

The Chaparral Wildlife Management Area was purchased in 1969 at which time cattle were grazed continuously. From 1974-84 a 1-herd, 4-pasture rotation grazing system was initiated. Cattle were removed in 1984 and reintroduced in 1990. From 1990 to the present, a 1-herd, 6-pasture rotation grazing system has been used with 7 months of grazing followed by 5 months of deferment. The stocking rate has been 6.2 ha/animal unit.

We used a completely random experimental design with 3 treatments and 2 replications. Treatments were chained (ca. 1950), chained (ca. 1950) then root plowed (ca. 1960), and untreated (no record of treatment within the past 50 years). Treatments located within ephemeral drainages varying from 500 to 4,000 m apart were identified using aerial photographs. The soil in the drainage areas was classified as Duval fine sandy loam (0-3%); a fine-loamy, mixed, hyperthermic Aridic Haplustalf (Stevens and Arriaga 1985).

A 500-m-long baseline following the center of the drainage channel was delineated within each of the 6 sites. Nine randomly located, 25-m lines were centered on, and placed perpendicular to, each baseline by a stratified random method (Chambers and Brown 1983). Presence/absence of woody species intersecting the line was recorded, and herbaceous species presence/absence was recorded along the center 10 m of each line. Sample size adequacy to estimate species richness was determined with the Stein 2-staged sample test (Steel and Torrie 1980).

Herbaceous and woody plant alpha diversity was quantified with Shannon's Index (Pielou 1975). Frequency data were used to calculate Shannon indices. Species richness data were square root transformed and percentage data (similarities) were arcsine square-root transformed before analysis. Woody and herbaceous data were analyzed with 1-way analysis of variance and Duncan's multiple range test (SAS Institute, Inc. 1988).

Pairwise similarities among all lines within a site were calculated and the mean dissimilarities (1-mean similarity) for each site (beta diversity) were determined (Scheiner 1992). Jaccard's similarity index was used because it is a consistent measure of similarity when using presence/absence data (Janson and Vegelius 1981).

The GLM procedure (SAS Institute, Inc. 1988) was used for analysis of variance and to test for a linear trend of similarities among disturbance regimes, since disturbances could be ranked by severity. Spatial gradients of similarities were calculated for each treatment by least-squared regression. Similarity between each pair of lines within a treatment (dependent variable) was regressed against the distance between that pair (independent variable). Gradients (slopes) among treatments were compared with dummy variables.

Results and Discussion

Herbaceous species richness and Shannon's index were similar among treatments (P = 0.570 and 0.662, respectively) (Table 1). Woody species richness and diversity were also similar among treatments (P = 0.347 and 0.307, respectively) (Table 1). In previous studies, many browse plants of high value to white-tailed deer were absent from root-plowed rangeland (Mutz et al. 1978, Fulbright and Beasom 1987, Ruthven et al. 1993). We observed no absence of high-value browse species following root plowing on the Chaparral Wildlife Management Area (Table 2). Chained and root plowed sites had smaller (P = 0.028) values for beta diversity (0.59 + 0.01)($\bar{x}$+ SE) than the other sites (untreated 0.70 + 0.01; chained 0.66 + 0.01). Beta diversity of untreated sites was similar ($P > 0.05$) to that of chained sites

Similarities among lines within a site were linearly and positively correlated (P = 0.006)(r^2 = 0.87) (n=6) with level of disturbance, indicating similarity within a site increased with increasing disturbance. Biondini et al. (1989) suggested that large-scale disturbances can obscure the consequences of small-scale disturbances (e.g., gopher activity, feral hog rooting) on a site. This would lead to greater similarity within a site that had been drastically disturbed, as in the chained and root plowed treatment even after >30 years.

Spatial gradients (slopes) of similarity were used to assess within-treatment spatial variability (Fig. 1). All treatments had intercepts different from zero ($P < 0.001$). The control and chained treatments had negative slopes (P = 0.003 and $P < 0.001$, respectively), while the chained and root plowed slope was not significant (P = 0.692) (i.e., slope = 0). Regression lines and slopes (spatial gradients) were

Table 1. Species richness and Shannon's index for herbaceous (H), woody and cacti (W), and total (T) vegetation on untreated (n=2), chained (n=2), and chained/root-plowed (C/RP) sites (n=2) in ephemeral drainages on the Chaparral Wildlife Management Area, Dimmit and LaSalle counties, Texas, April 1993.

		Richness			Shannon's Index		
		H	W	T	H	W	T
Untreated	$\bar{x}$	27.5	9.0	36.5	3.11	1.84	3.34
	SE	1.5	2.0	0.5	0.34	0.26	0.04
Chained	$\bar{x}$	30.0	13.5	43.5	3.15	2.35	3.52
	SE	5.0	1.5	6.5	0.15	0.11	0.14
C/RP	$\bar{x}$	32.5	12.0	44.5	3.24	2.24	3.55
	SE	0.5	2.0	1.5	0.05	0.21	0.02
P-value		0.57	0.35	0.38	0.66	0.31	0.52

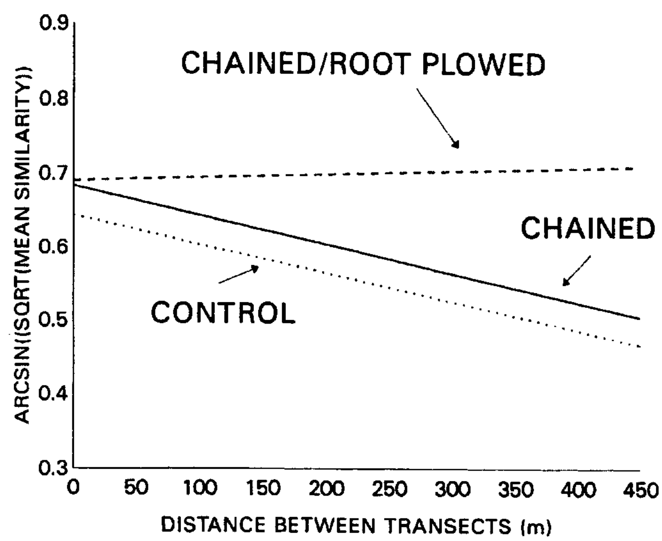

Fig 1. Spatial similarity gradients of chained (ca. 1950), chained (ca. 1950) and root-plowed (ca. 1960), and untreated (control) sites on a drainage system on the Chaparral Wildlife Management Area in Dimmit and LaSalle counties, Texas (April 1993). Regression equations and correlation coefficients for control, chained, and chained/rootplowed treatments were SIM = -0.0196 (DIST) + 0.644 (r = 0.44), SIM = -0.0199(DIST) + 0.684 (r = 0.40),and SIM = 0.0021(DIST) + 0.692 (r = 0.19), respectively.

Table 2. Scientific names of common woody and herbaceous species by presence or absence within untreated, chained, and chained and root plowed (C/RP) sites (Hatch et al. 1990).

Common name	Scientific name	Untreated	Chained	C/RP
Bladderpod	*Lesquerella* spp.	P	P	P
Bluewood[1]	*Condalia hookeri* M.C. Johnst	P	P	P
Coreopsis	*Coreopsis* spp.	P	P	P
Cudweed	*Gnaphalium* spp.	P	P	P
Galium	*Galium virgatum* Nutt.	P	P	P
Gaura	*Gaura parviflora* Dougl. ex Lehm.	P	P	P
Groundcherry	*Physallis* spp.	P	A	P
Honey mesquite	*Prosopis glandulosa* Torr.	P	P	P
Indian blanket	*Gailliardia pulchella* Foug.	P	P	P
Lazy daisy	*Aphanostephus riddellii* T. & G.	P	P	P
Monarda	*Monarda* spp.	P	P	P
Old man's beard[1]	*Clematis durmmondii* T. & G.	P	P	P
Oxalis	*Oxalis drummondii* Gray	P	P	P
Ozarkgrass	*Limnodea arkansas* Nutt.	P	P	P
Pellitory	*Parietaria pensylvanica* Muhl.	P	P	P
Pepperweed	*Lepidium austrinum* Small	P	P	P
Pigweed	*Chenopodium* spp.	P	A	P
Plantain	*Plantago hookeriana* Fisch & Mey.	P	P	P
Prickly pear	*Opuntia lindheimeri* Engelm..	A	A	P
Prickly poppy	*Argemone sanquinea* Greene	P	P	P
Rattlesnake weed	*Daucus pusillus* Michx.	P	P	P
Six-weeks fescue	*Vulpia octoflora* (Walt.) Rydb.	P	P	P
Soapberry	*Sapindus saponaria* L.	A	P	A
Spiny hackberry[1]	*Celtis pallida* Torr.	P	P	P
Straggler daisy	*Calyptocarpus vialis* Less.	P	A	A
Sugar hackberry	*Celtis laevigata* Willd.	P	P	P
Tasajillo	*O. leptocaulis* DC.	A	A	P
Texas colubrina	*Colubrina texensis* T. & G.	P	P	P
Texas persimmon	*Diospyros texana* Scheele	P	P	P
Texas thistle	*Cirsium texanum* Buckl.	P	P	P
Texas tridens	*Tridens texanus* (S. Wats.) Nash	P	P	P
Western ragweed	*Ambrosia psilostachya* DC.	P	P	P
White nightshade	*Solanum triquetrum* Cav.	P	P	P
Wolfberry	*Lycium berlandieri* Dunal	P	P	P

[1] Browse plants of high value for white-tailed deer

significantly different ($P < 0.001$ and 0.010, respectively) among treatments. Chained and untreated slopes were similar ($P = 0.972$) but regression lines approached significance ($P = 0.071$) which was likely caused by slight differences between intercepts. Therefore, differences among treatments resulted because the chained and root plowed slope was different from both chained and untreated slopes.

Negative slopes for untreated and chained sites indicated similarity between any 2 points decreased as distance increased within that treatment, i.e., untreated and chained sites had a negative spatial similarity gradient while variation in the chained and root-plowed sites was random and not spatially correlated. This suggests that high-intensity disturbance results in less spatial heterogeneity within a patch. This is similar to Biondini et al. (1989) who stated that large scale disturbances create a more uniform landscape. Similar slopes and lines between untreated and chained treatments suggest that chaining does not affect long-term spatial vegetational patterns within a patch.

The method we used to quantify spatial similarity gradients (heterogeneity) within a site or landscape using presence/absence data can provide additional quantitative information to aid in understanding the spatial variation in vegetation composition of an area. Collection of presence/absence data requires less time than collecting cover, density, or biomass data, thereby reducing man-hours and/or increasing amount of data collected.

Our findings relative to long-term effects of root plowing on species richness and diversity differed from those of other studies. This may be in part because the drainage habitats are more mesic than uplands. Effects of brush management vary with soil moisture and texture, original composition of brush, and timing of treatment (Stoddart et al. 1975). Root plowing after rain is less effective than root plowing during dry seasons because plants will readily reestablish and continue to grow (Vallentine 1989). Favorable moisture relations of drainage areas on the Chaparral Wildlife Management Area may have resulted in lower mortality following treatment, resulting in a rapid recovery to pretreatment condition. This would be especially critical for seedling establishment and resprouting in semi-arid environments by ameliorating the effects of moisture stress. The inferences proposed are not implied to be directly applicable outside of the study area; however, the possibility exists for similar circumstances to occur within other regions.

Although plant species richness and diversity were similar on treated and untreated sites, habitat was less heterogeneous in chained and root plowed areas. Increased habitat heterogeneity has been associated with greater animal community diversity (Levin 1974). Therefore, a hypothesis for future research is that intense, large-scale disturbances such as chaining followed by root-plowing may result in a long-term reduction of animal diversity. If management objectives include maintenance of habitat heterogeneity and animal diversity, high intensity disturbances especially within sensitive habitats such as drainage systems, should be avoided.

Literature Cited

Biondini, M.E., A.A. Steuter, and C.E. Grygiel. 1989. Seasonal fire effects on the diversity patterns, spatial distribution and community structure of forbs in the Northern Mixed Prairie, USA. Vegetatio 85:21-31.

Chambers, J.C, and R.W. Brown. 1983. Methods for vegetation sampling and analysis on revegetated mined lands. USDA For. Serv. Gen. Tech. Rep. INT-151.

Fulbright, T.E., and S.L. Beasom. 1987. Long-term effects of mechanical treatments on white-tailed deer browse. Wildl. Soc. Bull. 15:560-564.

Hatch, S.L., K.C. Gandhi, and L.E. Brown. 1990. Checklist of the vascular plants of Texas. Texas Agr. Exp. Sta. Rep. MP-1655. College Station, Tex.

Janson, D., and J. Vegelius. 1981. Measures of ecological association. Oecologia 49:371-376.

Levin, S.A. 1974. Dispersion and population interactions. Amer.. Nat. 108:207-228.

Lewis, C.E., B.F. Swindel, and G.W. Tanner. 1988. Species diversity and diversity profiles: concept, measurement, and application to timber and range management. J. Range Manage. 41:466-469.

Montemayor, E., T.E. Fulbright, L.W. Brothers, B.J. Schat, and D. Cassels. 1991. Long-term effects of rangeland disking on white-tailed deer browse in south Texas. J. Range Manage. 44:246-248.

Mutz, J.L., C.F. Scifres, D.L. Drawe, T.W. Box, and R.E. Whitson. 1978. Changes in range vegetation 14 years after mechanical brush treatment on the coastal prairie. Tex. Agr. Exp. Sta. Bull. 1197. College Station, Tex.

Pielou, E.C. 1975. Ecological diversity. John Wiley & Sons, New York, NY.

Rappole, J.H., C.E. Russell, J.R. Norwine, and T.E. Fulbright. 1986. Anthropogenic pressures and impacts on marginal, neotropical, semiarid ecosystems: the case of South Texas. J. Sci. Total Environ. 55:91-99.

Ruthven, D.C., T.E. Fulbright, S.L. Beasom, and E.C. Hellgren. 1993. Long-term effects of root plowing on vegetation in the eastern South Texas plains. J. Range Manage. 46:351-354.

SAS Institute, Inc. 1988. SAS user's guide, 1988 edition. SAS Institute Inc., Cary, N.C.

Scheiner, S.M. 1992. Measuring pattern diversity. Ecology 73:1860-1867.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics, second edition. McGraw-Hill Book Co., Inc., New York, N.Y.

Stevens, J.W., and D. Arriaga. 1985. Soil survey of Dimmit and Zavala counties, Texas. USDA Soil Conserv. Serv.

Stoddart, L.A., A.K. Smith, and T.W. Box. 1975. Range management. 3rd ed. McGraw-Hill Book Co., New York, N.Y.

Vallentine, J.F. 1989. Range development and improvements, 3rd ed. Academic Press, Inc., San Diego, Calif.

Welch, T.G. 1982. Acres of Texas rangeland treated for brush and weed control. Tex. Agr. Ext. Serv., College Station, Tex.