Effects of Contour Furrowing on Soils, Vegetation, and Grassland Breeding Birds in North Dakota[1]

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Abstract

On certain soil types in the Northern Great Plains, mechanical treatment such as contour furrowing is used to break up "claypan" soils and increase grass production. The effect of this treatment on breeding bird communities has not been documented. I compared soil characteristics, vegetation, and the breeding bird community on two sites over three years in southwestern North Dakota. One site was contour furrowed in 1968 and the other, adjacent site, was not treated. The chemical makeup of the soil on the two sites was similar 20 years following treatment but vegetation cover differed. The treated site had greater cover of wheatgrass (*Agropyron* spp.) and non-persistent litter, and a lower cover of buffalo grass (*Buchloe dactyloides*), Wyoming big sagebrush (*Artemisia tridentata wyomingensis*), spikemoss (*Selagenella densa*), and an unidentified lichen than the untreated site. Breeding bird densities did not differ between the treated and untreated site in any of the three years, but the relative abundance of Chestnut-collared Longspurs (*Calcarius ornatus*) and Vesper Sparrows (*Pooecetes gramineus*) was greater on the treated site. Horned Larks (*Eremophila alpestris*) were the most common species on both sites, and there was little difference in the occurrence of Brewer's Sparrow (*Spizella breweri*), Lark Buntings (*Calamospiza melanocorys*), and Western Meadowlarks (*Sturnella neglecta*). Thus, mechanical treatment did not change the density of breeding birds but rather shifted the composition of the avian community. Sage grouse (*Centrocercus urophasianus*) apparently used the untreated site more than the treated site and may be adversely affected by this treatment.

Key words: Chestnut-collared Longspur, contour furrowing, grassland birds, grasslands, Horned Lark, land treatment, livestock forage, North Dakota, Vesper Sparrow.

Introduction

Land treatments such as chaining, plowing, disking, and seeding frequently are used to alter vegetation cover of western rangelands (Young and Evans 1978, Keller 1979, Urness 1979, Evans and Young 1987, Herbel 1987, McKenzie 1987, Wiedemann 1987). The objective, typically, is to decrease the cover of woody vegetation such as sagebrush (*Artemisia* spp.) (Parker 1979, Wiens and Rotenberry 1985) or juniper (*Juniperus* spp.) (Winegar and Elmore 1978, Martin 1978) and increase grass cover for livestock. While the impacts of such vegetation conversions on native wildlife may be positive or negative, depending on the species (Braun et al. 1976, Saab and Rich 1997, Wisdom et al. 2000), too often no monitoring is conducted to assess the effects and thereby provide scientific information for future land-management decisions.

In this study, I assessed the effect of contour furrowing, or deep plowing (Sandoval 1978), on soil characteristics, vegetative cover, and the breeding bird community for three years in southwestern North Dakota. Soils were in the Rhoades-Absher complex (USDA 1975) and have patches known as "pan spots" or "claypan" interspersed with patches of vegetation called "grassed highs" (*fig. 1*). Pan spots are devoid of vegetation because they are nearly impermeable to water and to the exchange of gasses, such as O_2 and CO_2, between the atmosphere and plant roots. These soils also may have salt content high enough to limit plant growth even if water is available (Roundy 1987, Seelig and Richardson 1991).

Contour furrowing consists of plowing the soil to a depth of about 0.3 m. Plowing breaks up the restrictive claypan and, depending on the depth of the water table and the amount of soluble salts beneath the surface, may improve the productivity of the soil (Sandoval and Reichman 1971, Sandoval 1978, Seelig and Richardson 1991). This practice also converts a level soil surface into a series of parallel ridges and furrows (*fig. 1*) along the contours of the landscape, hence the technique's name. The distance between adjacent ridges or furrows is about 2 m.

The vegetation was classified as wheatgrass-grama-needlegrass (Whitman and Barker 1994). Dominant grasses included wheatgrasses (*Agropyron smithii* and *A. dasystachyum*), needlegrass (*Stipa viridula*), blue grama (*Bouteloua gracilis*), and buffalo grass (*Buchloe dactyloides*). Other major components of the vegetation

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Figure 1— Photographs of the untreated (above) and treated (contour furrowed) sites in Bowman County, North Dakota.

included plains pricklypear (*Opuntia polycantha*), Wyoming big sagebrush (*Artemisia tridentata wyomingensis*), spikemoss (*Selagenella densa*), and an unidentified lichen. Breeding birds in the area included the Horned Lark (*Eremophila alpestris*), Chestnut-collared Longspur (*Calcarius ornatus*), Lark Bunting (*Calamospiza melanocorys*), Western Meadowlark (*Sturnella neglecta*), Vesper Sparrow (*Pooecetes gramineus*), Brewer's Sparrow (*Spizella breweri*), and Sage Grouse (*Centrocercus urophasianus*). The first four species are among a suite of declining grassland birds in the region (Johnson and Schwartz 1993, Johnson and Igl 1995, USDOI 1996). Brewer's Sparrow and Sage Grouse also are declining across the west (Saab and Rich 1997, Connelly and Braun 1997). However, the latter two species are on the periphery of their ranges in southwestern North Dakota whereas the others are widespread in the region (Kantrud 1981).

The null hypotheses tested were that there were no differences between the treated and untreated sites in 1) selected soil characteristics, 2) ground cover, 3) breeding bird density, or 4) relative abundance of breeding birds.

Study Area and Methods

The study took place in the Big Gumbo Planning Unit of the U. S. Bureau of Land Management in Bowman County, in extreme southwestern North Dakota (46°07'N, 103°59'W). This is within the Southwestern Slope, one of four physiographic regions commonly recognized in North Dakota (Kantrud 1981). The treated site was contour furrowed in 1968, is about 200 ha in size, and is adjacent to the untreated site. Both sites are part of the same soil mapping unit (USDA 1975) and were grazed at the same time of year under a rest rotation system as part of the same pasture. Grazing took place after bird and vegetation sampling.

In 1988, soil samples were collected at three depths from three sites in each of the following types of sites: untreated (9 samples in claypan and 9 in grassed highs) and treated (9 samples), for a total of 27 samples. Sample depth depended on the soil horizons at the sample point. Three depth categories were defined: The "top" sample extended from ground surface to 5 to 13 cm down; the "middle" sample extended from the previous depth to 23 to41 cm; and the "bottom" sample extended from the previous depth to 41 to 71 cm. Pan spots were smooth, flat areas devoid of vegetation where water stands following precipitation (*fig. 1*). Grassed highs were sites among the pan spots that were covered with vegetation, typically blue grama, buffalo grass, and pricklypear (*fig. 1*). Samples from the treated site were taken from the top of a ridge, the side of a ridge and the bottom of a furrow. Soils were analyzed for pH, electroconductivity (EC), Ca, Mg, Na, sodium absorption ratio (SAR) and exchangeable sodium. Canopy cover and frequency of occurrence for each plant species were assessed in a 20 x 50 cm frame placed at 1-m intervals (Daubenmire 1959) along a randomly selected transect in the treated and in the untreated sites. A total of 80 samples were taken in each of 1988, 1989 and 1990 from each site. In addition to vegetation, non-persistent litter (non-woody grass and forb material), persistent litter (woody material, pricklypear), and bare ground also were estimated. Values for wheatgrass may have included small amounts of needlegrass (1-2 percent). Although the 80 samples were taken along the same transect, the precise locations of the sample frames likely varied slightly between years.

Bird surveys were conducted along each of three transects on the treated site and three on the untreated site. Each transect was censused once each year—1988, 1989 and 1990—under favorable weather conditions. Transects on the treated site were 700 m long, while those on the untreated site were 500 m long. All transects were 140 m wide. Distance from the centerline to each detected bird was measured perpendicularly to the nearest meter with a rangefinder. Bird densities were calculated according to Burhham et al. (1980). A measure of relative abundance—birds/100 m of transect—also was calculated for each species.

To assess use of the area by Sage Grouse, seven parallel 100-m belt transects across the treated area and another 7 across the untreated area were conducted in 1988. The number of grouse pellet groups encountered in a 2-m wide belt was counted. Single pellets were not counted.

Differences in soil characteristics were tested with a two-factor ANOVA (Manugistics 1997), with depth category and treatment as the factors. I then ran a discriminant function analysis to see if the treated and untreated sites could be differentiated by any combination of soil characteristics. Differences in vegetation cover between the treated and untreated sites were tested with a nonparametric repeated measures ANOVA (Zar 1996). A nonparametric test was necessary because the data were not distributed normally and could not be brought adequately near normality through data transformations. A repeated measures test was chosen because the vegetation measurements on each site, although conducted in three different years, were not independent. Bird densities were calculated according to the program TRANSECT (Burnham et al. 1980) for each site for each year. Within-year comparisons between densities on the treated and untreated sites were made with t-tests, using the density and standard error estimates provided by TRANSECT.

Results

Soils

Values of all measured soil variables generally increased with depth (*Table 1*). A series of two-factor ANOVA's (*Table 2*) showed that there was an effect of depth category for pH, electroconductivity, Mg, Na, sodium absorption ratio (SAR) and exchangeable

Table 1— *Soil characteristics ($\bar{x}$ ± sd) at different soil depths. Units are in Milli-Equivalents/Liter unless otherwise noted.*

Characteristic	Depth Category[a]			F	P
	Top	Middle	Bottom		
pH	6.89 (0.80) a	7.34(0.33) b	7.79 (0.37) c	6.05	<0.05
EC[b]	2.70 (1.39) a	5.44 (2.41) b	8.04 (3.63) c	18.99	<0.001
Ca	11.71 (9.19) a	19.62 (7.22) b	19.02 (6.67) b	2.82	<0.10
Mg	4.91 (4.05) a	11.72 (6.69) a	25.48 (14.92) b	31.28	<0.001
Na	14.44 (11.79) a	35.93 (21.72) b	59.62 (32.42) c	15.68	<0.001
SAR[c]	6.22 (4.70) a	9.62 (4.57) b	12.96 (4.71) c	6.14	<0.05
Ex. Na (%)[d]	6.99 (5.92) a	11.15 (5.47) b	14.89 (5.11) c	6.51	<0.05

[a] Means with the same letter within a characteristic are not significantly different across depth categories (df = 2, 18).
[b] Electroconductivity in deciSiemens/meter.
[c] Sodium absorption ratio.
[d] Exchangeable sodium.

Table 2— *Soil characteristics ($\bar{x}$ ± sd) in the treated and in the untreated areas. Units are in Milli-Equivalents/Liter unless otherwise noted.*

	Treatment [a]				
		Untreated			
Characteristic	Treated	Claypan	Grassed High	F	P
pH	7.23 (0.57) a	7.60 (0.41) a	7.19 (0.86) a	1.52	<0.50
EC [b]	7.01 (3.95) a	6.11 (3.05) a	3.06 (1.55) b	11.42	<0.005
Ca	18.93 (5.93) a	15.36 (8.39) a	16.06 (10.53) a	0.52	<0.50
Mg	19.69 (14.19) a	6.15 (14.20) a	6.27 (4.37) b	13.77	<0.001
Na	49.78 (37.02) a	44.91 (22.87) a	15.31 (11.58) b	10.68	<0.005
SAR [c]	10.71 (6.39) a	11.83 (1.91) a	6.25 (5.16) b	4.68	<0.05
Ex. Na (%) [d]	12.16 (7.29) a	13.89 (2.07) a	6.98 (6.29) b	5.65	<0.05

[a] Means with the same letter within a characteristic are not significantly different across treatments (df = 2, 18).
[b] Electroconductivity in deciSiemens/meter.
[c] Sodium absorption ratio.
[d] Exchangeable sodium.

sodium (EC). There was no effect of depth for Ca. There also was an effect of treatment for EC, Mg, Na, SAR and exchangeable sodium. There was no effect of treatment for pH or Ca. Discriminant function analysis of these data by depth category resulted in a single significant function (P = 0.0023) that explained 79.85% of the variance and classified 23 of the 27 samples correctly. However, discriminant analysis of these data by treatment did not yield a significant function. Thus, soil characteristics are not useful in distinguishing the treated from the untreated site.

Ground Cover

Cover of western wheatgrass and non-persistent litter were significantly greater on the treated site while cover of buffalo grass, sagebrush, the lichen, and spikemoss were significantly greater on the untreated site (*Table 3*). The latter two species were nearly absent from the treated site, even after 20 years. Cover of blue grama, pricklypear, persistent litter and bare ground did not differ significantly between the treated and untreated site.

Bird Densities and Relative Abundances

Horned Larks, Chestnut-collared Longspurs and Western Meadlowlarks occurred on both sites in all three years. Vesper Sparrows, Lark Buntings and Brewer's Sparrows occurred on the treated site in all years but on the untreated site in only two of three, two of three, and one of three years, respectively. Sample sizes were sufficient for calculating densities only for Horned Larks and for all species combined. A few additional species were detected on the transects but they were all classified as flyovers.

There was no significant difference between the density of Horned Larks on the treated and untreated site in any year, with the possible exception of 1990 (*Table 4*). However, the sample size for Horned Larks on the treated site (N = 21) was substantially below the minimum number of detections (N = 40) recommended for accurate density estimation (Burnham et al. 1980). For all species combined, there also was no difference in density between sites in any year (*Table 4*).

Although it is not possible to calculate densities for the other species, their relative abundance showed that Vesper Sparrows and Chestnut-collared Longspurs occurred more frequently on the treated site (*Fig. 2*). Western Meadowlarks and Lark Buntings occurred at about the same rate on both sites while Brewer's Sparrows were rare on both sites.

Sage Grouse pellet groups occurred at a rate of 0.5 ± 0.5 (se) per 100 m on the treated sites and 3.0 ± 2.9 per 100 m on the untreated site. These means are significantly different (t = 2.76, P < 0.05).

Table 3— *Percent ground cover ($\bar{x}$ ± sd) on treated (T) and untreated (U) sites, chi-squared values and significance of the difference between treated and untreated sites.*

Variable	Site	Percent cover	χ^2_r	P
Blue grama	U	3.0 (5.9)	10.12	NS
	T	2.2 (5.9)		
Buffalo grass	U	7.0 (17.0)	24.62	<0.001
	T	2.3 (9.5)		
Western wheatgrass	U	4.5 (7.6)	182.60	<0.001
	T	27.4 (23.0)		
Big sagebrush	U	5.5 (13.3)	11.58	<0.05
	T	1.7(5.7)		
Pricklypear	U	4.6 (12.6)	0.28	NS
	T	2.8 (8.3)		
Lichen	U	2.8 (4.1)	100.96	<0.001
	T	0.1 (0.4)		
Spikemoss	U	8.4 (22.7)	15.02	<0.05
	T	0.0 (0.2)		
Persistent litter	U	2.9 (7.2)	8.29	NS
	T	1.7 (5.1)		
Non-persistent litter	U	3.9 (5.9)	134.63	<0.001
	T	15.2 (13.1)		
Bare ground	U	55.0 (39.0)	0.06	NS
	T	55.8 (32.1)		

Table 4— *Breeding bird density (birds/ha) on treated (T) and untreated (U) sites by year.*

		1988 [a]		1989		1990	
Variable	**Site**	**N**	**x̄ ± SE**	**N**	**x̄ ± SE**	**N**	**x̄ ± SE**
Horned Lark	U	67	8.0 (1.2)	64	4.2 (1.6)	44	4.3 (0.6)
	T	74	7.0 (9.0)	44	4.2 (0.7)	21	1.6 (0.4)
All species combined	U	90	13.9 (2.4)	96	9.8 (1.8)	62	6.5 (1.3)
	T	134	13.8 (1.7)	111	9.5 (1.1)	73	6.2 (1.0)

[a] There were no significant differences between the treated and untreated sites for a given year
[b] Sample size (N = 21) is below the minimum recommended - no tests were run with this cell.

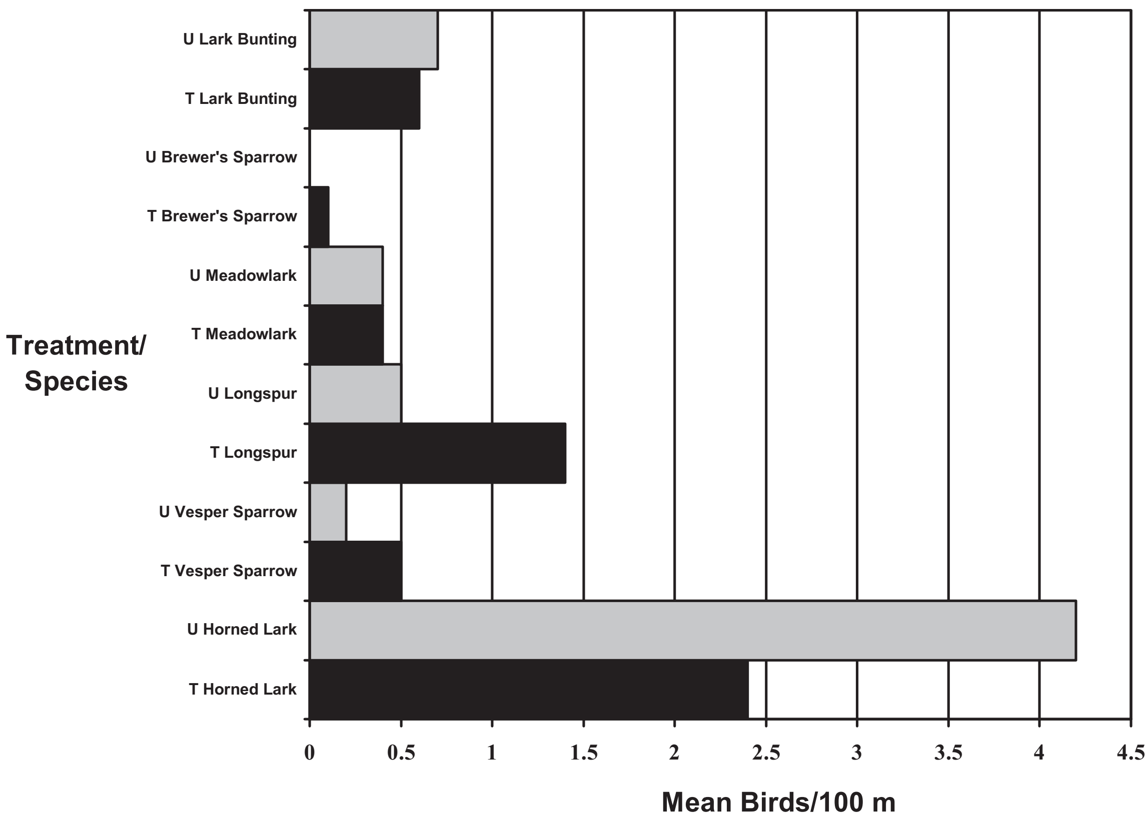

Figure 2—Mean birds/100 m for all breeding species encountered on treated (T) and untreated (U) sites for all years combined.

Discussion

Contour furrowing did not have any obvious effect on the characteristics of the soil measured in this study - pH, EC, Ca, Mg, Na, SAR and exchangeable Na. All generally increased with soil depth on both the treated and untreated sites, but this suite of variables was not useful in discriminating between the treated and untreated sites. This suggests that over the 20-year period between the soil treatment and the sampling, no substantial changes took place in the characteristics of the soil. Furrowing did have a pronounced effect on the vegetation. Western wheatgrass showed the most dramatic change of any type of cover. The 3-year mean for wheatgrass cover was over 27% on the treated site while less than 5% on the untreated site. This apparently was facilitated by mechanically breaking up the claypan to provide improved permeability to water, plant roots (Sandoval 1978) and gasses (Seelig and Richardson 1991), precisely the response that mechanical treatment seeks to produce. A byproduct of this growth of grass was the increase in non-persistent litter. Buffalo grass, big sagebrush, the lichen, and spikemoss all had greater cover on the untreated site. The lichen and spikemoss had not reestablished appreciably on the treated site, even after 20 years. These species tended to occur together in patches on the grassed highs of the untreated site.

A final feature that provided a strong contrast between the treated and untreated sites was the vegetation configuration and physical structure of the sites. The untreated site was very patchy, with dense areas of vegetation interspersed with bare claypan sites. In contrast, the treated site was much more uniform in vegetative cover (*fig. 1*) and had an obvious ridge/furrow structure. I suspect that this mechanical treatment makes it extremely unlikely that the treated site would revert to its former plant composition and physical structure except perhaps over the longest time period.

In each of the three years of the study, densities of Horned Larks were remarkably similar between the treated and untreated site, as were the densities of all species combined. Horned Lark densities on both sites were relatively high and were similar to those reported for shortgrass prairie in Colorado (Beason 1995).

Both Vesper Sparrows and Chestnut-collared Longspurs comprised a greater proportion of the bird community on the treated site. It seems likely that the great increase of wheatgrass on the treated site caused this shift in the composition of the breeding bird community. Horned Larks occupy a great variety of vegetation types across their range (Beason 1995) but a common feature of all of them is substantial amounts of bare ground. Interestingly, the percent cover of bare ground was not different between the two sites. But the configuration of that bare ground was very different, being uniformly distributed on the treated site and patchily so on the untreated site. Chestnut-collared Longspurs (Kantrud 1981, Hill and Gould 1997, Johnson et al. 1998) and Vesper Sparrows (Bent 1968, Kantrud 1981, Rising 1996) also occupy a variety of habitats, preferring more grass cover than Horned Larks.

This distribution of vegetation also had unknown effects on the selection of nest sites, nest success, productivity and return rates of breeding birds. On the untreated site, nests would have to be placed in the grassed highs. The advantage would be that these patches were very dense, with close growing buffalo grass sod, spikemoss, blue grama and pricklypear. The disadvantage would be that predators could perhaps more efficiently search for nests as they could ignore areas of bare ground. On the treated site, predators would have no such obvious clues as to the location of nests. Sage Grouse apparently used the untreated site significantly more than the treated site. As the cover of sagebrush was nearly the same on both sites, one must look to other reasons for this preference. Pellet groups were almost always deposited on the bare soil, immediately adjacent to a grassed high. This suggests that grouse were roosting or loafing where the high grass provided both protection from the wind and visual protection from predators. Constant winds and cold temperatures in a landscape with little topographic relief and little sagebrush cover would place a premium on the microrelief offered by grassed highs. Also, as Sage Grouse are large birds, they are relatively conspicuous when standing in a uniform expanse of wheatgrass (pers. obs.). But when these birds are standing in the untreated habitat, they blend in with the patchy pattern there and can be very difficult to pick out, even when you know where birds have just landed.

Finally, it is worth noting that Brewer's Sparrow, which is showing steep population declines over much of its range (Saab and Rich 1997, Sauer et al. 1997), occurred at low densities despite very low cover of sagebrush. This is consistent with the observations of Igl and Murphy (1996) who found this species in Conservation Reserve Program fields in the area where sagebrush was <0.01 percent of the total vegetative cover. So although this species is considered to be a sagebrush obligate (Braun et al. 1976, Paige and Ritter 2000), it obviously will occupy sites where grass cover far exceeds that of sage (see also Rotenberry et al. 1999).

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