Pasture Soil and Vegetation Response to Renovation Tillage

M.L. Self-Davis, M.S. Miller*, R.L. Raper, and D.W. Reeves

Abstract: Information is needed to determine if renovation tillage improves soil quality and forage productivity in Southeastern pastures. A study was conducted at Crossville AL on a Hartsells fine sandy loam (tine-loamy, siliceous thermic, Typic Hapludult) to determine soil and vegetation responses to renovation tillage in grazed and ungrazed pastures. A I.6-ha endophyte-infected tall fescue *(Festuca arundinacea,* Schreb.)-bermudagrass *(Cynodon dactylon* (L.) Pers.) pasture was subdivided into 18 7.3-m x 30.5-m plots: one-half of the plots were continuously grazed, and one-half cut for hay in May and September 1994-1995. Renovation tillage treatments *(Aer-way* pasture renovatort. Paraplow@.and no-tillage) were applied in March 1994 and 1995. Although changes in bulk density related to tillage treatment were detected one year after initial treatment. well-defined trends were not observed. The Paraplow effectively lowered soil strength to 32 cm in both grazed and ungrazed plots. However, Paraplow tillage of ungrazed plots resulted in a 26% decrease in root length density at 0-5 cm. *Aer-Way* treatment of grazed plots resulted in an 19% higher root biomass at 0-5 cm one year after initial treatment. Paraplow and *Aer-Way* treatments increased residue and bare ground percentages in grazed plots in 1994. In 1995. residue percentage increased in all Paraplow-treated plots, grazed and ungrazed. Renovation tillage increased dry matter yields compared to no-tillage under dry soil conditions and this increased yield translated into greater removal of herbage N and P. The Paraplow appears to be an effective pasture renovation tillage method for reduction of layers of high strength in the soil studied. Further study is needed to determine if alterations in pasture cover composition and root biomass induced by repeated renovation tillage impact forage yield and quality, pasture hydrologic condition, and water quality.

Introduction

Grazing has both direct and indirect effects on hydrologic processes in pastures (Thurow, 1991). The direct physical effect of an animal's hoof action causes mechanical injury to plants or loss of vegetation. Indirect effects include creation of compacted layers that can result in reduced infiltration rates and increased surface runoff. As pasture infiltration rates decrease, less water is available for forage production (Abdel-Magid et al. 1987) and quality of forage produced is lowered. Little information is available on the impacts of grazing on hydrologic condition of Southeastern pastures, but the impacts may be significant. Renovation tillage has been presented as a management technique that increases infiltration rates and thus, may enhance pasture hydrologic condition. There is currently widespread producer interest in improved hydrologic condition of southem region pastures through the use of renovation tillage. A major reason for this interest in Alabama is the desire to reduce surface runoff and increase nutrient retention on pastures to which poultry waste has been applied. Producers are also interested in pasture productivity responses to various renovation techniques.

High infiltration rates are often associated with large, interconnected macropores that are open to the soil surface (Helalia, 1993). Tillage usually increases infiltration in the short term since breaking the surface soil generally decreases bulk density and increases porosity and potential water storage (Mukhtar et al. 1985). However, in pasture situations where permanent sods exist, tillage is kept at a minimum. Tillage implements used in pasture situations generally concentrate on loosening surface soil while as much vegetation is left intact as possible. Pasture renovators that resemble 'pitting' implements used on rangeland and the Paraplow (Tye Manufacturing, Lockney TX), or the more recently available Paratill (Bigham Brothers, Inc., Lubbock TX), tillage tools that loosen surface soil but do not drastically invert it, are tillage options available for pasture use.

The *Aer-Way* Renovator (Holland Hitch Inc., Wiley TX) is a ground-driven rolling-tined aerator/cultivator being marketed as an implement that can improve pasture conditions relative to surface soil porosity and soil microbial activity. However, there has been no published study of the effectiveness of this practice for enhancement of pasture soil quality or hydrologic condition. Information is also unavailable on the effects of off-set shank deep-tillage in Southeastem pastures. However, limited research in England found that soil loosening by the Paraplow after an initial forage harvest resulted in an annual yield loss of approximately 25

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percent, which was attributed to damage to the grass root system (Douglas, 1994).

The objective of this study was to quantify and compare the effects of the *Aer-Way* pasture renovator and Paraplow tillage treatments on soil physical properties and vegetative characteristics of grazed versus ungrazed tall fescue *(Festuca arundinacea* Schreb.)-bermudagrass *(Cynodon dactylon* (L.) Pers.) pastures.

Materials and Methods

The study site was located on a Hartsells fine sandy loam (fine-loamy, siliceous, thermic, Typic Hapludult) at the Sand Mountain Substation of the Alabama Agricultural Experiment Station, DeKalb County AL. One 1.6-ha endophyte-infected tall fescue-bermudagrass pasture was subdivided for the study; the pasture had been used to graze cows and calves continuously since 1981. One-half of the pasture was grazed continuously at a moderate to heavy stocking rate of 26 cow-calf pairs, and one-half of the pasture was excluded from grazing. Experimental design was a randomized complete block with three replications per treatment. Nine 7.3 x 30.5-m plots were located within each pasture. Renovation treatments in both pastures included 1) Paraplow, 2) *Aer-Way* pasture renovator and, 3) no-tillage. Renovation treatments were applied annually on 24 April 1994 and 11 May 1995. Cattle were returned to the grazed pasture upon completion of renovation treatments.

Soil cores were collected using a tractor-mounted soil probe (Giddings Machine Co., Fort Collins, CO) and 5-cm diameter x 92-cm length soil tubes on 21 March 1994 (five locations per plot), and 17 March 1995 (three locations per plot). Bulk density was determined on core sections from 8-13 cm, 18-23 cm, 28-33 cm, 43-48 cm, and 58-63 cm using the core method (Drew and Saker, 1980). Soil strength was measured prior to application of initial renovation treatments (21 March 1994), two months subsequent to initial treatment (6 June 1994), then six months and one year after initial treatment (14 October 1994, and 17 March 1995, respectively). Soil strength was measured to 50 cm using a cone penetrometer (American Society of Agricultural Engineers, 1988, Standard ASAE S313.2).

Soil cores were sampled for root analyses as described for bulk density at five different locations within each plot on 21 March 1994, and 17 March 1995. Cores were separated into seven segments: 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-31 cm, 31-46 cm, 46-61 cm, then roots washed from each segment using a hydroneumatic elutriation system (Smucker et al. 1982 [Gillison's Variety Fabrication Inc., Benzonia MI]), and stored in 150ml L-1 ethyl alcohol. Root length was determined using a Comair Root Length Scanner (Hawker de Havilland, Ltd. Salsibury, SA), and root biomass determined after samples were dried (60°C, 48 h).

Cover composition was determined from five transects (45 points per transect) per plot. Forage yield was determined on ungrazed plots 14 May 1994, 14 September 1994, and 2 May 1995. Forage quality measurements: acid detergent fiber, permanganate lignin, neutral detergent fiber (Goering and Van Soest, 1970) and in vitro dry matter digestibility (Tilley and Terry, 1970), were determined on samples ground to pass a I-mm mesh (Udy Cyclone Mill). Plant P concentrations were determined as molybdovanadophosphoric acid for 0.1 N HCI acid extracts of dry ash from 0.25 g tissue (Hue and Evans, 1986); nitrogen tissue concentrations were determined by the Kjeldahl method.

Data were analyzed using ANOVA (SAS Institute, Inc., 1990). Mean differences were separated using Fisher's protected LSD (Steele and Torrie, 1980). Means for response variables measured in grazed and ungrazed plots were compared using the t-test. Probability level for rejection of the null hypothesis was set at 0.10.

Results and Discussion

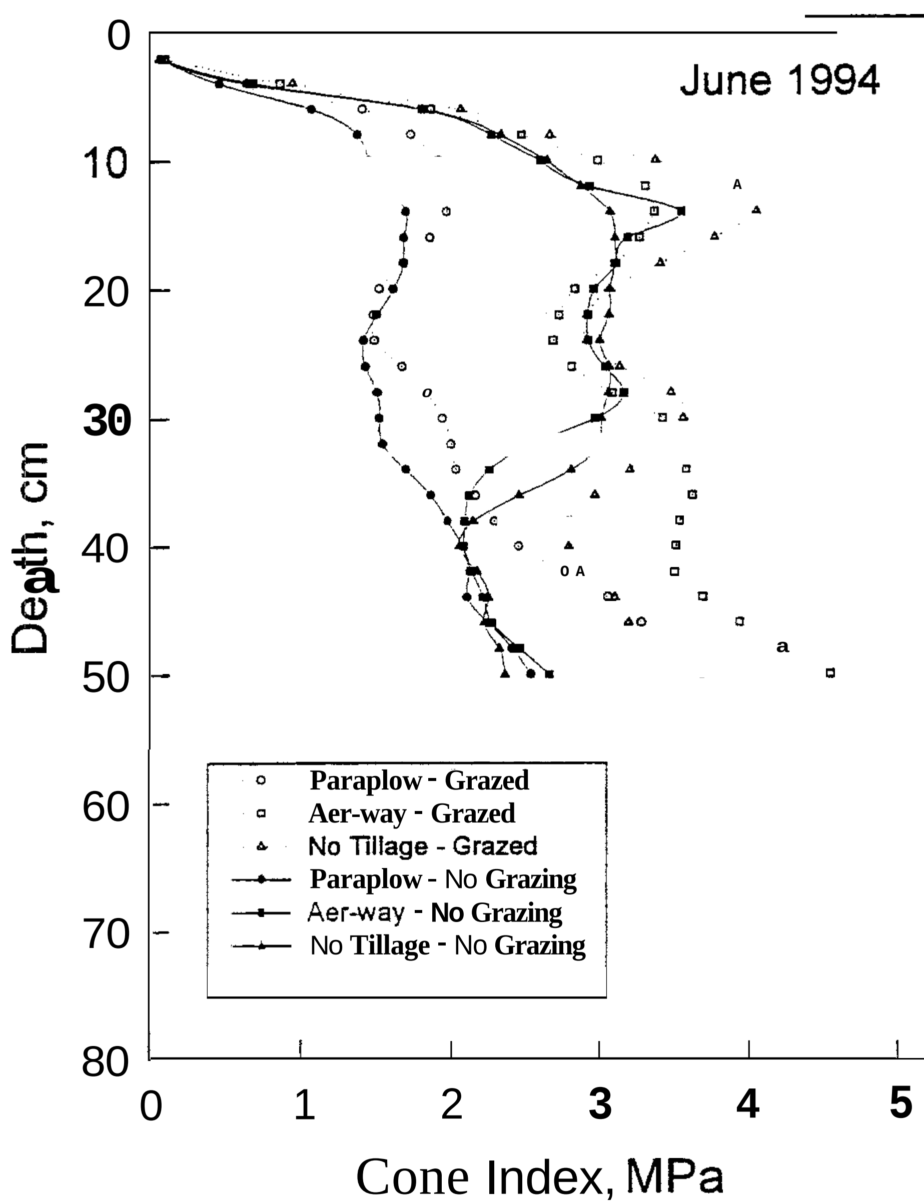
Soil Response to Renovation Tillage

Initial soil bulk density and cone index profile values were relatively uniform among designated treatment areas prior to renovation tillage. As expected, both bulk density and cone index varied with depth. Although changes in bulk density attributed to tillage were detected one year after initial treatment, well-defined trends were not observed. However, significant differences in cone index values related to tillage treatment were detected two (Fig. 1), six, and twelve (Fig. 2) months after initial renovation tillage treatments. Paraplow-treated sods had consistently lower cone index values when compared to the *Aer-Way* and no-tillage sods, regardless of grazing treatment. Also, annual Paraplow treatment effectively lowered soil strength to a depth of 32 cm compared to initial cone index values. Treatment with the *Aer-Way* renovator did not maintain lower soil strength compared with initial cone index values.

Plant Response to Renovation Tillage

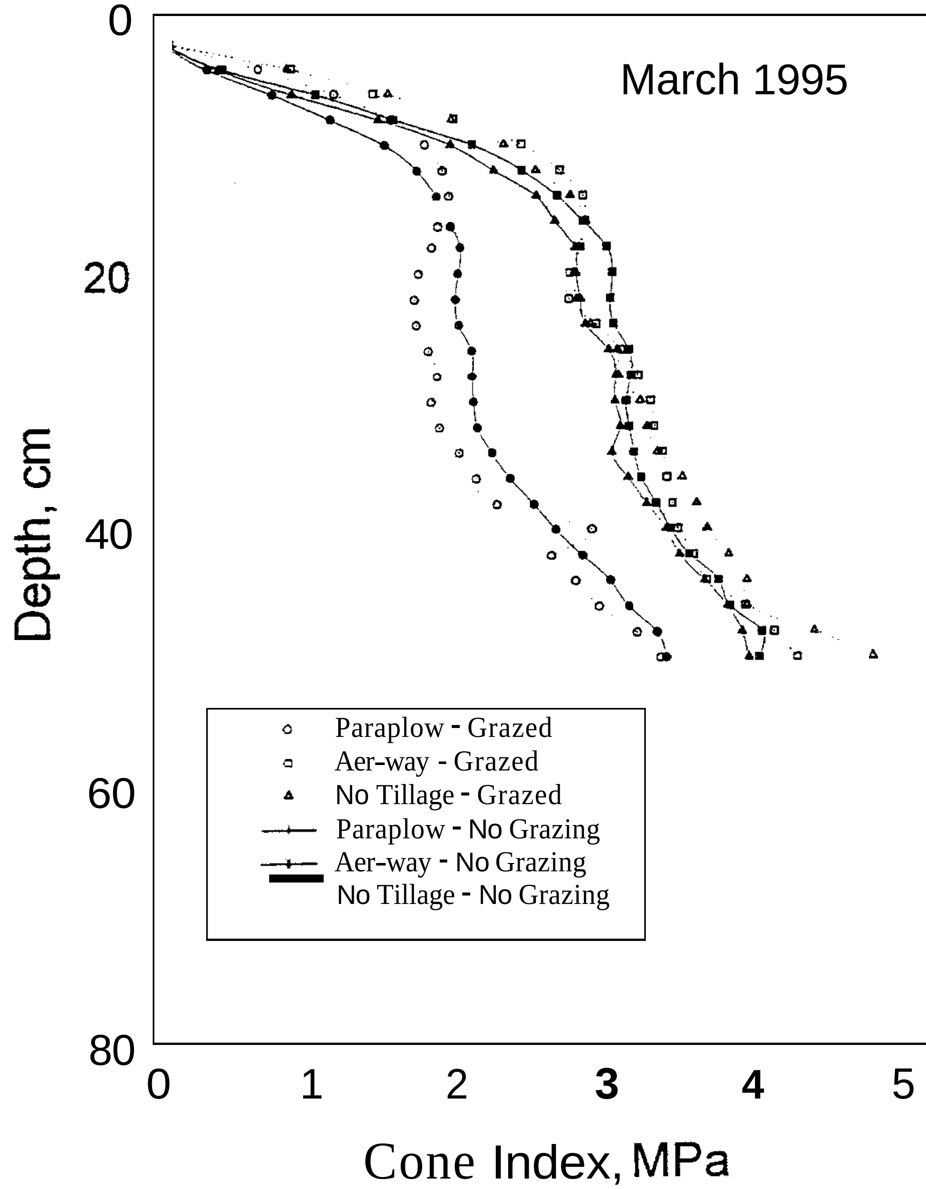
Ground cover composition revealed that in grazed plots, treatment with the Paraplow or the *Aer-Way* increased residue and bare ground percentages compared to no-tillage in May 1994 (data not shown). Cover composition measured in May 1995 indicated that treatment with the Paraplow resulted in greater amounts of residue in both grazed and ungrazed areas compared to *Aer-Way* or no-tillage treatment.

Root length density was approximately 26% lower at 0-5 cm in ungrazed plots one year after Paraplow treatment: 70.1 versus 52.3 cm cm^{-3} for 1994 and 1995, respectively. Root biomass increased approximately 19% at 0-5 cm in grazed plots one year following *Aer-* Way treatment: 9.I versus 15.9 mg cm^{-3} for 1994 and 1995. respectively. When total root length density of each core was analyzed, grazed and ungrazed Paraplow-treated plots had lower root length densities compared to *Aer-Way* or no-tillage plots (Table 1). However, there were no significant differences in total core root



Depth cm	$LSD_{0.10}$ G	$LSD_{0.10}$ NG
2	ns	ns
4	ns	0162
6	0.448	0.298
8	0.595	0.305
10	0.775	0421
12	0.760	0.387
14	0.610	0.370
16	0.573	0.462
18	0.419	0.554
20	0.353	0.593
22	0.218	0.548
24	0.276	0.598
26	0.474	0.792
26	0642	0.972
30	0.625	1.192
32	0.902	ns
34	1.067	ns
36	0.886	ns
38	0.687	ns
40	0.659	ns
42	0.513	ns
44	ns	ns
46	ns	ns
48	ns	ns
50	ns	ns

Figure 1. Cone index (June 1994) at 25 soil depths as influenced by renovation tillage treatments in a tall fescue-bermudagrass pasture, Crossville AL. G = grazed; NC = not grazed; ns = not significant (P≤0.10).



Depth cm	$LSD_{0.10}$ G	$LSD_{0.10}$ NG
2	ns	ns
4	0.165	ns
6	0.212	ns
8	0.175	ns
10	0.103	0.396
12	0.166	0.428
14	0.195	0.379
16	0.236	0.318
18	0.204	0.198
20	0.151	0.200
22	0.183	0.274
24	0.336	0.367
26	0.419	0.182
28	0.502	0.251
30	0.515	0.310
32	0.384	0.257
34	0.410	0.324
36	0.471	0.279
38	0.509	0.178
40	0.374	0.184
42	0.554	0.150
44	0.591	0.236
46	0.451	0.322
48	0.511	0.578
50	0.445	0.516

Figure 2. Cone index (March 1995) at 25 soil depths as influenced by renovation tillage treatments in grazed and ungrazed tall fescue-bermudagrass pasture, Crossville AL. G =grazed: NG = not grazed; ns = not significant ($P \leq 0.10$).

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Table 1. Total root length density and total root biomass prior to and one year after renovation tillage treatments in grazed and ungrazed tall fescue-bermduagrass pasture, March 1994 and March 1995, Crossville, Al.

	Initial root measurements (1394)		Root measurements one year after treatment (1395)	
	Designated Grazed	Designated Ungrazed	Grazed	Ungrazed
	Total root length density cm cm^{-3}			
Paraql	103 8	101 4	101 [illegible]	35 z5
Aer-way	103 4	104 4	1z8 8	120 5
No Tillage	100 5	88 01	13≤ 0	110 ≤
$LSD_{0\ 1}$	ns	ns	23 19	z1 71
	Total root biomass mg cm^{-3}			
Paraplow	12 03	10 43	14 01	10 6z
Aer-way	11 51	13 ≤z	13 1z	14 45
No Tillage	13 7[illegible]	10 44	13 08	10 45
$LSD_{0\ 1}$	ns	3 201	ns	ns

ns = Differences between treatments within a grazing pressure were not significant at the 10% probability level biomass values between treatments. This data suggests that Paraplow treatment may alter structure and distribution of forage root systems, but not total biomass.

Despite decreased root length densities for Paraplow-treated plots, forage dry matter yield was not reduced. Comparison of dry matter yields revealed no significant differences between tillage treatments during the wet year of 1994. However, during the exceptionally dry spring of 1995, dry matter yields in *Aer- Way*-treated plots were 23% higher than yields in Paraplow plots. Also, Paraplow tillage and *Aer-Way* renovation increased forage yield 24% and 53%, respectively compared to plots that did not receive tillage.

Within a season, forage quality differed little between renovation tillage treatments (data not shown). However, forage harvested from ungrazed plots treated with either the Paraplow or *Aer- Way* renovator had higher N and P contents compared to forage harvested from no-tillage plots in May 1995 (data not shown).

Conclusions

Preliminary data suggest that reduction and maintenance of lower soil strength in compacted soil layers is a potential advantage of using the Paraplow for pasture renovation on the soil studied. From the standpoint of soil loss, a potential advantage of *Aer- Way* renovation tillage is increased root biomass at shallow depths. Also, while plants may produce a larger root system than is needed simply for uptake of soil nutrients and water, the extra investment serves primarily for increased competitive effectiveness (Caldwell 1987). Thus, weed invasions may be decreased in pastures renovated with this implement. Both renovation tillage practices appear to have the potential to increase dry matter yields from hayed pastures. and thus, increase nutrients removed in hay.

Even though hay yields were not reduced, a potential disadvantage of Paraplow tillage is a decrease in root length density at shallow depths. Long-term observations should help determine whether or not this decrease translates into a loss of competitive effectiveness of the desirable grasses. Another potential disadvantage of treatment with either the Paraplow or *Aer-Way* is that an increase in percentage bare ground in grazed pasture may result and this increase may also occur in ungrazed Paraplow-treated pastures.

Additional data are being collected through 1998 to determine if observed trends in soil and vegetative characteristics continue and if cumulative effects occur. Also, data are being collected that will allow correlation ofchanges in sediment and nutrient loss through runoff, and nutrient loss through leaching, to modifications in soil and vegetative properties. Energetic and economic analysis of power requirements will also be obtained. Based on the current data, a final recommendation about the effectiveness of either tillage practice for sustaining pasture soil quality or forage productivity is premature at this time.

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