Characteristics of Oak Mottes, Edwards Plateau, Texas

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Abstract

Infiltration of live oak mottes on watershed properties was evaluated in July 1979 at the Sonora Agricultural Research Station. Infiltration rates of undisturbed live oak mottes and those with mulch layers removed were greater than rates of adjacent grass-dominated areas. However, infiltration rates of oak mottes with mulch layer and organic layer removed exposing the mineral were similar to those of adjacent grass-dominated areas. Infiltration rates of midgrass-dominated sites were greater than those of shortgrass-dominated sites. Greatest soil loss occurred from oak motte with mineral soil exposed with little differences between other treatments. Infiltration rates and sediment production of oak mottes were most influenced by grass standing crop, mulch and organic layers, soil organic matter, and water stable aggregates. Organic matter and water stable aggregates in the oak motte were similar and significantly greater than in the adjacent grass-dominated areas. Surface soil bulk density and texture were similar for the oak mottes and grass-dominated areas. Grass standing crop was similar for the oak motte and midgrass-dominated areas but significantly greater than for shortgrass-dominated areas. Mulch accumulation was 6 times greater in oak motte than midgrass areas and 43 times greater than in shortgrass areas.

Infiltration, the movement of water into the soil, and soil erosion are modified by the amount and kind of vegetation (Blackburn 1975). Range practices such as brush control and livestock grazing that alter vegetation also have the potential to alter soil surface hydrologic characteristics (Blackburn et al. 1982, Blackburn 1983). Infiltration rates of sagebrush (*Artemisia* spp.) canopy zones in Nevada were greater than the adjacent interspace areas (Blackburn 1975). Infiltration rates of honey mesquite *(Prosopis glandulosa* var. *glandulosa)* canopy zone in the Rolling Plains of Texas were greater than in adjacent midgrass- or shortgrass-dominated areas. The lowest infiltration rates and greatest sediment loss occurred in shortgrass-dominated areas. Livestock grazing and brush control practices altered infiltration rates and sediment loss of midgrass-dominated areas the most but had little or no influence on the shrub canopy zone or shortgrass-dominated areas (Wood and Blackburn 1981, Brock et al. 1982).

Live oak *(Quercus virginiana* var. *virginiana)* mottes generally occur on 20 to 50% of the land of the Edwards Plateau region of Texas. The mottes provide important goat and wildlife forage and wildlife cover. The objectives of this study were to determine: (1) soil hydrologic properties of oak mottes and adjacent grass-dominated areas, and (2) the influence of mulch and organic layers on infiltration rates of oak mottes.

Study Area

The study was conducted during July 1979 at the Texas Agricultural Research Station located about 45 km south of Sonora, Texas. The rolling, stoney hill topography that characterizes the station is typical of the Edwards Plateau. The study area was located on a gentle sloping (4%) Tarrant silty clay soil series. Tarrant soils are members of the clayey-skeletal, montmorillonitic, thermic family of Lithic Haplustolls. The station is approximately 632 m in elevation with an average growing season of 240 days and mean annual precipitation 554 mm. The Edwards Plateau is second only to the Trans-Pecos region of Texas in length and frequency of drought (Sprott 1971). The site is characterized by live oak mottes with short and midgrasses dominating the interspace between mottes. Dominant herbaceous plants on the study site include common curly mesquite *(Hilaria belangeri)* the dominant shortgrass, sideoats grama *(Bouteloua curtipendula)* the dominant midgrass, and threeawn (*Aristida* spp.). Dominant woody plants

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are live oak, honey mesquite, shinoak *(Quercus pungens* var. *vaseyana),* and ash juniper *(Juniperus ashei).* The study area was grazed by cattle, sheep, and goats stocked at a moderate rate (8.1 ha/AU/yr), on a continuous yearlong basis.

Methods

Infiltration rates and sediment production were determined using a drip-type rainfall simulator (Blackburn et al. 1974) on ten 0.5-m^2 randomly located runoff plots in each vegetation type and treatment. Runoff plots in the grass-dominated areas were pre-wet with 120 liters of water, using a sprinkler system, to remove antecendent soil-water content differences and covered with plastic to maintain uniform surface water conditions. After the runoff plots drained to field capacity (approximately 24 hr), simulated rainfall was applied at a rate of 20.3 cm/hr for 0.5 hr. Simulated rainfall at a rate of 22.9 cm/hr was applied to oak mottes with soil antecedent moisture condition initially dry and at field capacity (approximately 24 hr after the first simulated rainfall). Between simulated rainfall events the plots were covered with plastic to maintain uniform surface water conditions. These application rates approximate a storm with a 150-year return period and were necessary in order to insure runoff from all plots. Runoff was collected continuously and measured by weight at 5-minute intervals. Infiltration rates were determined by calculating the difference in simulated rainfall applied and runoff collected from each plot. Runoff collected at the termination of the simulated rainfall event was thoroughly mixed and a 1-liter subsample was collected. The sediment from each subsample was collected on #1 Whatman filter paper, dried at 105°C for 24 hr., weighed, converted to sediment yield in kg/ha, and used as an index of sheet erosion.

The percentage ground cover by midgrass, shortgrass, and forb foliage and mulch, rock, and bare ground were determined by ocular estimates on each runoff plot from a gridded sampling quadrat. Grasses, forbs, and standing dead material were clipped to a 2-cm stubble height and mulch was hand-collected from each runoff plot. The herbaceous material was dried at 60° C for 48 hr and weighed.

Soil bulk density and soil moisture content were measured at depths of 0 to 3 cm and 5 to 8 cm on areas adjacent to runoff plots prior to each simulated rainfall event. Soil bulk density was determined by the core method (Black 1965), and soil moisture content by the gravimetric method (Gardner 1965). A soil sample was collected to 3 cm deep within each plot after each simulated rainfall event and analyzed for organic matter content by the Walkley-Black method (Walkley and Black 1934), aggregate stability by the wet sieve method (Kemper and Koch 1965), and texture by the hydrometer method (Bouyoucos 1962).

Oak trees were removed from the study plots by hand slashing and the following conditions within the oak mottes were evaluated with soil moisture initially dry and at field capacity: (1) mulch layer and organic layer (decomposed mulch) left in place, (2) mulch layer removed, and (3) mulch layer and organic layer removed. The adjacent midgrass- and shortgrass-dominated areas were evaluated with antecedent soil moisture initially at field capacity. The 7-ha study area was stratified by oak mottes, midgrass, and shortgrass-dominated areas. Ten plots were randomly located within each vegetation type and oak motte mulch and organic layer condition for the 2 antecedent moisture conditions. Sample size was 80 plots. Data normality was determined by tests for skewness and kurtosis (Snedecor and Cochran 1971). Values for sediment production were highly skewed, requiring a log10 transformation of the data set. Differences between treatments were determined by analysis of variance, and treatment means were separated by Duncan's multiple range test. Within treatment variation (variation among subplots) was allocated to residual for testing differences ($p \leq .05$) among treatments (Steele and Torrie 1980).

Results and Discussion

Vegetation and Soils

Grass standing crop of the shortgrass and oak motte-dominated areas were similar and significantly lower than midgrass-dominated areas (Table 1). Forb standing crop was low but similar on all 3 vegetation types. Mulch accumulation was greatest in the oak mottes and lowest in the shortgrass-dominated areas. Mulch accumulation in the midgrass areas was 6.8 times greater than in shortgrass areas, and 6.3 times less than in oak mottes. The decomposed surface organic layer averaged 23,000 kg/ha in oak mottes, but could not be separated from the mulch layer on the grass-dominated areas. Bare ground was not exposed in the oak mottes; however, in the midgrass and shortgrass-dominated areas, bare ground was exposed on 16 and 22%, respectively (Table 2). Rock cover was low and similar in all 3 vegetation types. The percentage of the study plots covered by mulch was greater in the oak mottes than in the midgrass or shortgrass-dominated areas. Although mulch accumulation on midgrass-dominated areas was significantly greater than on shortgrass areas, the percentage of the area covered by mulch was the same for these 2 vegetation types. Forb cover was low and similar for the 3 vegetation types. Midgrass foliar cover was greater on midgrass-dominated areas than in oak mottes or on shortgrass areas. Shortgrasses did not occur in oak mottes and only covered 5% of the midgrass areas.

Table 1. Mean above ground plant biomass accumulation (kg/ha) for undistrubed oak mottes and grass dominated areas, Edwards Plateau, Texas.

	Vegetation type		
Variable	Oak motte	Midgrass	Shortgrass
Grass standing crop	332 b[1]	682 a	150 b
Forb standing crop	18 a	11 a	13 a
Mulch layer	21,500 a	3,400 b	500 c
Surface organic layer	23,000	—[2]	—

[1]Means of each variable with the same letter are not significantly different ($P \leq .05$).
[2]No measurement taken.
[3]Organic layer was included in mulch determinations for grass dominated areas.

Table 2. Mean herbaceous and ground cover values (%) for undisturbed oak mottes and grass dominated areas, Edwards Plateau, Texas.

	Vegetation type		
Cover component	Oak motte	Midgrass	Shortgrass
Bare ground	0 b[1]	16 a	22 a
Rock	0 a	3 a	3 a
Mulch	77 a	46 b	46 b
Forb	2 a	2 a	2 a
Midgrass	21 b	28 a	1 c
Shortgrass	0 c	5 b	26 a

[1]Means of each cover component followed by the same letter are not significantly different ($P \leq .05$).

Surface soil organic matter content was similar for the 3 oak motte treatments and more than double that of the adjacent grass dominated areas (Table 3). Soil organic matter content of the midgrass and shortgrass dominated area was similar. No differences occurred in bulk density or texture between the oak mottes and grassland areas. However, there was a trend for greater percentage of sand size particles in the oak motte soils.

Infiltration Rate and Sediment Production

Oak motte infiltration rate under dry antecedent moisture conditions with the mulch layer removed was significantly lower than under undisturbed conditions or with the mulch layer plus the organic layer removed exposing the mineral soil (Fig. 1). However,

Table 3. Mean infiltration rate (after 30 min), sediment production and surface soil characteristics of oak mottes and adjacent grass dominated areas of the Edwards Plateau, Texas.

	Oak motte				
Variable	Undisturbed	Mulch removed	Mulch and organic layers removed	Midgrass	Shortgrass
Infiltration rate (cm/hr)					
Dry	22.0 a	19.9 b	21.3 a	—	—
Field capacity	22.0 b	21.4 a	19.6 b	19.9 b	19.4 b
Sediment production (kg/ha)	5 c	141 b	796 a	69 b	315 ab
Soil organic matter (%)	14.2 a	16.6 a	14.8 a	5.7 b	5.9 b
Soil water stable aggregates (%)	81 a	80 a	78 a	69 b	68 b
Bulk density (g/cc)					
0-3 cm	1.2 a	1.3 a	1.2 a	1.2 a	1.3 a
5-8 cm	1.3 a	1.4 a	1.3 a	1.4 a	1.4 a
Texture (%)					
Clay	43.4 a	43.9 a	44.3 a	50.1 a	51.2 a
Sand	20.0 a	19.2 a	20.2 a	12.6 a	13.3 a

[1]Means of each variable with the same letter are not significantly different ($P \leq .05$).
[2]No measurement taken.

infiltration rates under field capacity antecedent moisture conditions with the mulch layer removed were similar to those on the undisturbed oak mottes and significantly greater than with the mulch and organic layers removed (Fig. 2). Normally, areas with a dry organic layer would have a greater infiltration rate than areas with mineral soil exposed to raindrop impact. The greater infiltration rate of the areas with exposed mineral soil was attributed to the presence of non-wettable areas in the organic layer. Dry organic layers often become difficult to wet. This can occur because of an irreversible drying of organic matter (Hooghoudt 1950) or because of fungal mycelia in the organic layer (DeBano 1981). A dry water repellent layer strongly resists water penetration. The initial infiltration rates are slow but generally increase if water remains in contact with the repellent layer. Once the repellent layer is saturated, the infiltration rate will usually be as rapid as that on a wettable layer (DeBano 1981). The non-wettable areas covered 10 to 20% of the undisturbed and mulch-layer removed plots. Small amounts of non-wettable areas, generally less than 1%, were present on the plots with mineral soil exposed.

The mulch layer on the undisturbed plots retained water longer, thus allowing infiltration around the non-wettable areas. The relatively rapid infiltration rate of the plots with mineral soil exposed was due to well-aggregated soils and large macropores. However, infiltration rate after 30 minutes on the bare mineral soil plots was 1.7 cm/hr greater with antecedent soil moisture initially dry rather than at field capacity (Table 3). The lower infiltration rate on field capacity plots was attributed to the swelling of clays and the sealing of soil pores from raindrop impact. Infiltration rates of undisturbed oak mottes were similar regardless of antecedent soil moisture.

Infiltration rates of the grass-dominated areas were lower than those of undisturbed oak mottes and mottes with mulch layer removed, but were similar to oak mottes with mineral soil exposed (Table 3). Infiltration was more rapid in midgrass (bunchgrass) dominated areas than in shortgrass (sodgrass) dominated areas. Although the difference between these 2 vegetation types was not

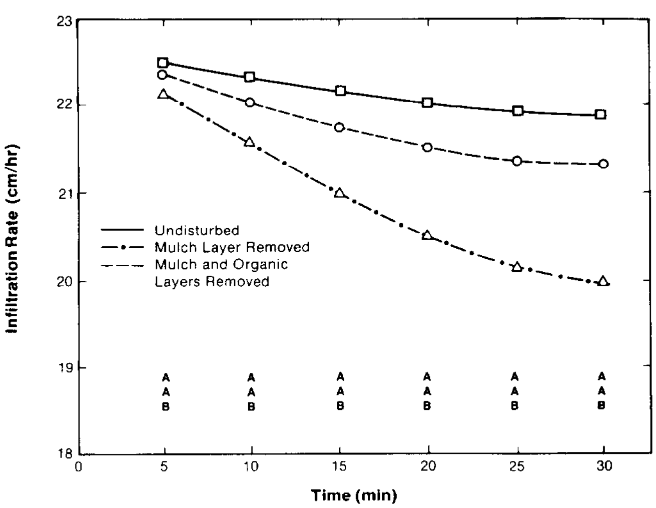

Fig. 1. *Mean infiltration rates for the oak motte treatments with dry antecedent soil moisture conditions, Edwards Plateau, Texas. Means for each 5-minute interval with the same letters are not significantly different (P≤.05).*

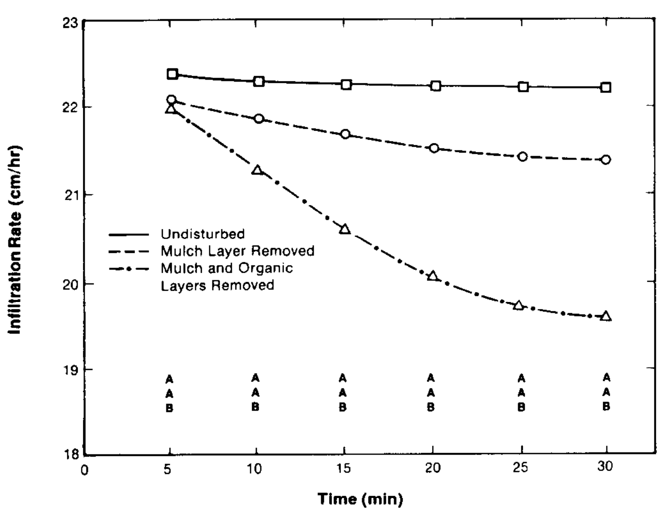

Fig. 2. *Mean infiltration rates for the oak motte treatments, antecedent soil moisture at field capacity, Edwards Plateau, Texas. Means for each 5 minute interval with the same letter are not significantly different (P≤.05).*

significant, more recent long-term studies on this area have shown significantly greater infiltration rates on midgrass area than on shortgrass areas (Blackburn 1983, McCalla et al. 1984).

Sediment production was variable and few differences occurred among the various soil cover situations. Soil loss was greatest from oak mottes with mineral soil exposed and shortgrass areas and lowest from undisturbed oak mottes (Table 3). The greater soil loss from the areas with mineral soil exposed than the other treatments was attributed to raindrop impact which destroys soil aggregates and dislodges soil particles from the soil surface.

Infiltration rates and soil loss not only are influenced by the amount of vegetation but by the kind of vegetation. Plant foliage and mulch provide protection to the soil from raindrop impact, slow down runoff, and provide organic matter that aggregates soil particles. Thus as the amount of vegetation increases, infiltration rates should increase and soil loss decrease. However, some plants have a greater influence on infiltration rates and sediment production than others. The soils under oak mottes are strongly aggregated and covered with mulch, organic layers, and bunchgrasses, which results in greater infiltration rates and lower soil loss than from adjacent grassland areas. Likewise, midgrasses (bunchgrasses) are more effective in modifying adjacent grassland areas than shortgrasses (sodgrasses). Thus, greater infiltration rates and lower soil losses occurred from midgrass-dominated areas than shortgrass-dominated areas.

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