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## Undergraduate Research Articles

# Evaluation of water-retention ability of eastern Arkansas prairie and agricultural soil

*Maria L. Barrenechea* and Kristofor R. Brye†*


## ABSTRACT

Agricultural land use affects soil physical properties, such as bulk density, water content, organic matter content, and soil structure; all of which in turn affect ecosystem productivity. The objective of this study was to evaluate the effects of: 1) time since aboveground biomass has been removed by haying (i.e., 0 vs. 23 years), and 2) land use (i.e., undisturbed tallgrass prairie vs. cultivated agriculture) on water-retention characteristics in a silt-loam soil of the Grand Prairie region of eastern Arkansas. Soil samples were collected from the 0- to 10-cm depth and were wetted with varying amounts of distilled water to create a range of soil water contents. After overnight equilibration, the water potential of the soil was measured using a dewpoint potentiameter. The relationship between water potential and water content for the prairie and the agricultural soils was modeled using the equation $Y=aX^{-b}$, where Y was the water potential and X was the gravimetric soil water content and the coefficients a and b were determined from fitting the data. The modeled a and b coefficients did not differ significantly by land use of soil series evaluated. The results of this study do not support the original hypothesis that water-retention characteristics in cultivated agricultural soils differ significantly from that of undisturbed, tallgrass prairie soil.



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## MEET THE STUDENT-AUTHOR

*Maria L. Barrenechea*

I am an international student from Tarija, Bolivia. I am currently a senior in the Department of Crop, Soil, and Environmental Sciences and am pursuing a B.S. degree in environmental, soil, and water sciences with an agricultural business minor. The partnership between Bolivia and Arkansas gave me the opportunity to come to this university. I have been awarded the Dale E. and Wilhemina S. Hinkle Scholarship. Throughout a year and-a-half as a student at the University of Arkansas, I have had the opportunity to be an active member and an officer in both the undergraduate Crop, Soil, and Environmental Science Club and in the International Bolivian Organization. My future plans are to possibly help Bolivia with all the environmental concerns and issues that we are facing, and to help improve environmental management and the quality of life for people in my home country. I would like to thank Dr. Brye for encouraging me to do this project and for all his help throughout research development. The project has taught me a lot about the research process. I am happy I decided to come to this department because I know I am getting a lot of benefits from this program.

## INTRODUCTION

Compared to natural, undisturbed ecosystems, such as native tallgrass prairie, cultivated agricultural land use significantly affects soil physical properties, such as bulk density, water content, organic matter content, and soil structure; all of which in turn affect ecosystem productivity. Cultivated agriculture has also been shown to negatively affect the soil biological community. In contrast to cultivated agricultural soil, prairie soils that have not been affected by agricultural practices typically have higher organic- matter content than cultivated soils, thus prairie soils tend to have better soil structure and better water-retention characteristics than cultivated agricultural soils (Brye, 2003). However, few studies have been conducted in the Grand Prairie region of eastern Arkansas, which was once dominated by tallgrass prairie, to evaluate the effects of land-use transformation from native prairie to cultivated agriculture. Knowledge of the properties affected and the extent to which those properties have been altered by land-use change will provide the foundation with which better management decisions can be made towards future sustainability of the soil and water resources in the Grand Prairie.

The objective of this study was to evaluate the effects on soil water retention characteristics in a silt-loam soil of the Grand Prairie region of eastern Arkansas of: 1) time since aboveground biomass has been removed by haying (i.e., 0 vs. 23 years), and 2) land use (i.e., undisturbed tallgrass prairie vs. cultivated agriculture). It was hypothesized that water-holding capacity, due to differences in organic matter inputs, will be lower in the prairie area in which aboveground vegetation is still removed by annual haying than in the prairie area where aboveground vegetation removal by haying ceased in 1980. It was also hypothesized that, within the same soil series, the undisturbed prairie will have a better ability to hold moisture than cultivated agricultural land use.

## MATERIALS AND METHODS

*Site description*

The Konecny Prairie Natural Area is a 20.2-ha (50 acre) tract of native tallgrass prairie in Prairie County, Ark., located within the region known as the Grand Prairie. The Konecny Prairie Natural Area was established in 1976 when the land was acquired by the Arkansas Natural Heritage Commission. The Konecny

Prairie resides on the Mississippi Alluvial Plain, which consists of soils that have developed in alluvial sediments laid down by periodic historical flooding of the Mississippi River. Vegetation within the Konecny Prairie is a mix of tall grasses, including big bluestem (*Andropogon gerardii*); little bluestem (*Schizachyrium scoparium*); indiangrass (*Sorghastrum nutans*); and switchgrass (*Panicum virgatum*), and numerous forbs, including several coneflowers (*Echinacea* spp.); black-eyed susan (*Rudbeckia hirta*); and goldenrod (*Solidago* spp.).

The Konecny Prairie Natural Area is rather unique in that it has several distinct sections based upon the number of years since vegetation has been removed annually by haying (Brye and Moreno, 2006). Approximately 4.0 ha (10 acres) of prairie vegetation was cut and vegetation removed annually until 1980. Approximately 6.1 ha (15 acres) of the prairie was cut and the vegetation removed annually until 2003. In addition, four different silt-loam soils (i.e., the Stuttgart, Loring, Calloway, and Crowley/DeWitt series) are present within the Konecny Prairie boundaries.

The Konecny Prairie is also unique in that the native (i.e., undisturbed) tallgrass prairie is adjacent to cultivated (i.e., disturbed) agricultural land that is cropped to either rice (*Oryza sativa*) or soybeans (*Glycine max*). The same four soil series that exist in the prairie also exist in the adjacent cultivated agricultural land.

*Sampling scheme*

Soil samples 4.8-cm in diameter were collected in April 2003—using a slide hammer—from each soil series within each of the two prairie sections and adjacent cultivated agricultural soil. Soil samples were collected from the 0- to 10-cm depth at 15-m intervals along a 60-m transect (i.e., at 0, 15, 30, 45, and 60 m) in the prairie and in a nearby portion of the adjacent agricultural land within the same soil series. The total number of transects was eight. The transects through the two land uses with the same soil series were positioned such that they were within 10 to 50 m of each other. Soil samples were oven dried at 70°C for 48 h, crushed, and sieved to pass a 2-mm mesh screen.

*Laboratory analyses*

Two of the five soil samples collected along each transect through the prairie areas in which vegetation removal ceased in 1980 (and in which vegetation removal by haying still continued in 2003) along with the soil samples from the adjacent cultivated agricultural land were used to determine water-retention characteristics. There was a total of 16 soil samples analyzed, 10 prairie and six cultivated agricultural soil samples.

Nine 5 ± 0.1 g-samples of soil from each replicate sample were weighed out into small cups. Varying amounts of distilled water (i.e., 2, 4, 6, 8, 10, 12, 15, 17, and 20 drops) were added to the cups and the soil mixed thoroughly. The cups were covered and allowed to equilibrate overnight. The following day the water potential of the soil in each cup was measured with a dewpoint potentiameter (Model WP4, Decagon Devices, Inc., Pullman, Wash.). The dewpoint potentiameter measures the water-vapor pressure of the air in the sample chamber after the air in the sample chamber has equilibrated with the liquid water in the soil sample. After measuring the water potential, the gravimetric water content of the soil in each cup was determined by drying at 70°C for approximately 10 to 12 h.

*Statistical analyses*

Water potential (y-axis) was plotted against gravimetric water content (ıg, x-axis) for each soil sample and analyzed using a spreadsheet. The power function (Y = aX-b) was fit to the plotted data and the "a" and "b" coefficients were recorded for each soil sample. Analysis of covariance techniques were used to evaluate the treatment effects of land use, soil series, and time since vegetation removal by haying ceased on modeled water-retention curve characteristics (i.e., the a and b coefficients) using SAS (Version 9.1, SAS Institute, Inc., Cary, N.C.)

## RESULTS AND DISCUSSION

As expected, the soil-water potential increased and leveled off as water content increased in both the native prairie and cultivated agricultural soils (Fig. 1). The modeled "a" coefficient for the prairie in which vegetation removal ceased in 1980 was nearly 10-fold greater than that for the adjacent cultivated agricultural soil, indicating that there may be a land-use effect. However, neither the modeled "a" and "b" coefficients, from the equation Water Potential = $a(\theta_g)^{-b}$ and as determined using soil wetting curves, differed ($P > 0.05$) by land use (Table 1). Similarly, neither the "a" or "b" coefficient differed ($P > 0.05$) among soil series (Table 1). In addition, the potential interactive effect between land use and soil series on water-retention characteristics was not significant ($P = 0.59$). Similar to the prairie area in which vegetation removal by haying ceased in 1980, neither the "a" or "b" coefficient differed ($P > 0.05$) between the prairie area in which vegetation removal by haying ceased in 2003 and the adjacent cultivated agricultural soils (Table 1). Finally, the "a" and "b" coefficients did not differ ($P > 0.05$) between the two prairie areas where vegetation removal by haying ceased in 1980 and 2003. Therefore, the results of this study do not support the hypothesis that land use affects water-retention characteristics.

These results are similar to the findings of Colton and Brye. (2002), who evaluated the water-retention characteristics of a cultivated and undisturbed (i.e., prairie restoration) Jay silt-loam soil in northwest Arkansas and showed no significant difference in modeled water-retention characteristics among the two land uses.

Two reasons possibly explain the results of this study. One reason may have been the small number of samples, since only two of the five soil samples collected along each transect were used to determine water-retention characteristics. If all five soil samples collected had been used, the variability associated with the mean values of the "a" and "b" coefficients might have been lower. Standard error values clearly show high variability relative to the mean for both the "a" and "b" coefficients (Table 1). Hence, for improved results, more soil samples and replicates analyzed would have been better.

Another reason that may explain the results obtained in this research could be the procedure used to determine the water-retention characteristics, in which soil samples were air dried, crushed, and sieved, altering the original structure of the soil. In contrast, Scott et al. (1983) placed intact soil cores in a chamber and pressurized them at various levels in order to dry the soil core from saturation. Therefore, the original structure of the soil was left undisturbed given that soil cores were neither air-dried nor crushed and sieved. Altering the original structure of the soil affected the results of this study, leaving the authors unable to demonstrate significant differences in water-retention characteristics due to time since aboveground biomass had been removed by haying and to land-use effects.

## ACKNOWLEDGMENTS

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## LITERATURE CITED

Brye, K.R. 2003. Long-term effects of cultivation on particle size and water-retention characteristics determined using wetting curves. Soil Sci. 168:459-468.

Brye, K.R., C.P. West, and E.E. Gbur. 2004. Soil quality differences under native tallgrass prairie across a climosequence in Arkansas. Am. Midl. Nat. 152:214-230.

Brye, K.R., and L. Moreno 2006. Vegetation removal effects on soil quality in a native tallgrass prairie fragment in east-central Arkansas. Nat. Areas J. 26:94-100.

Colton, N.C., and K.R. Brye. 2002. Land-use effects on soil-water retention characteristics. *DISCOVERY* 3:23-28.

Scott, H.D., E.M. Rutledge, and W.M. Miley. 1983. Effects of tillage on soil physical properties. Ark. Farm Res. 32(6):5.

**Table 1. Summary of the effects of land use (prairie versus cultivated agriculture) and soil series on modeled water-retention characteristics at the Konecny Prairie Natural Area, Slovak, Ark., for a prairie area where aboveground vegetation removal by haying ceased in 1980.**

| Effect | n | a-coefficient | b-coefficient |
|---|---|---|---|
| Landuse | | | |
| Prairie | 6 | 0.0024 (0.002)[z] | -3.08 (0.17) |
| Agriculture | 6 | 0.0003 (< 0.001) | -3.51 (0.38) |
| P-value | | 0.31 | 0.21 |
| Soil series | | | |
| Loring | 4 | 0.0032 (0.003) | -2.92 (0.29) |
| Stuttgart | 4 | 0.0006 (< 0.001) | -3.70 (0.49) |
| Calloway | 4 | 0.0003 (< 0.001) | -3.27 (0.22) |
| P-value | | 0.42 | 0.20 |

[z] Mean values (± standard error).

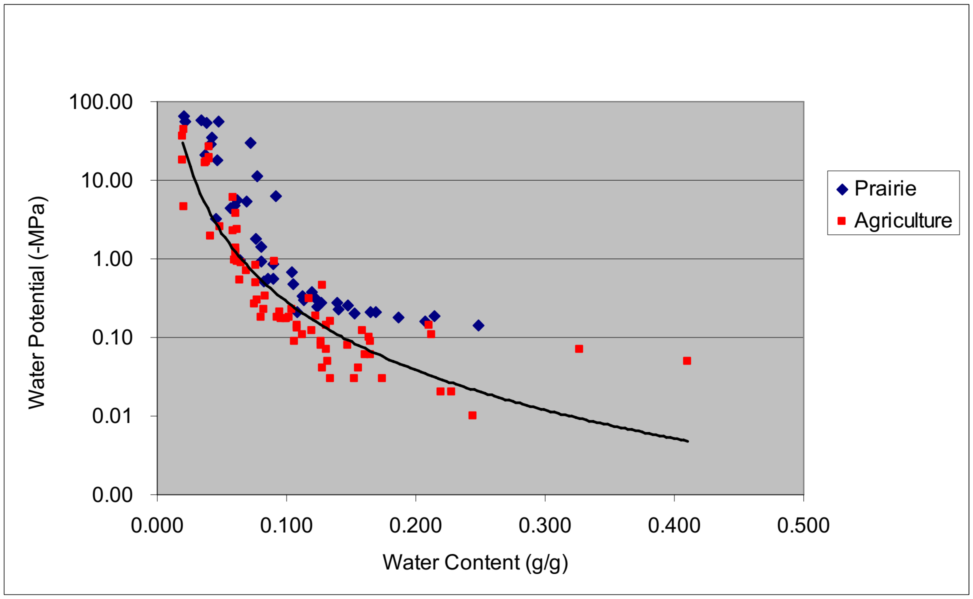


**Fig. 1.** Relationship between water potential, plotted on a log scale, and gravimetric water content for a prairie versus an agricultural soil in eastern Arkansas. The single line indicates no land-use effect on water-retention characteristics.