Effect of landscape position on the soil hydraulic properties in an eastern redcedar-grassland ecosystem

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Proposal Submitted September 05/2012

1. Overview and Objectives

Many studies have identified soil hydraulic properties to be important factors controlling the soil water balance; yet our understanding on the effect of landscape position and its interaction with land cover on these soil properties is limited. The hydraulic properties of the soil affects the movement of matter and energy in an ecosystem, and exhibits a high spatial variability across landscapes (Guzman and Al-Kaisi, 2011; Oztas et al., 2003; Western et al., 1999; Ziadat et al., 2010) and among different land covers (Wine et al., 2012). Previous studies have largely focused on the effect of either land scape or land cover, but not on the interaction. Because of the limitation of studies dedicated on the interaction, our understanding on the spatial variability of soil hydraulic properties is limited. Therefore, there is a critical need to study the effect of landscape, land cover and landscape-land cover interactions to better understand different ecosystem processes like soil moisture dynamics, surface and groundwater hydrology, contaminant transport, and erosion processes.

The long term goal of this research team is to advance scientific understanding of the interaction among landscape characteristics, land use/ land cover, soil, and water, and to apply this knowledge to utilize soil and water resources efficiently and sustainably. *The objective of this proposal* is to study how the hydraulic properties of the soil changes with change in landscape position, land cover, and their interaction. The land cover types considered in this proposal are eastern redcedar and tallgrass prairie, as these plants become the topic of interest for many stakeholders in north-central Oklahoma because of the widespread eastern redcedar encroachment into grasslands. Three major landscape positions will be considered based on their positions on the slope: the summit, back-slope, and toe-slope. Previous study on the effect of eastern redcedar on hydraulic properties of the soil by Wine et al. (2012) showed that there was a distinct pattern of changes in soil properties as we move from the center of the redcedar bole towards the center of grassland intercanopy. In our research proposal we include the effect of landscape position on these patterns, since landscape position is one of the important factors that affect soil hydraulic properties. The central hypothesis of this proposal is that the pattern of change in soil hydraulic properties along the transect from the redcedar bole to the grassland intercanopy varies significantly along landscape positions. The rationale of the proposed research is that having a clear understanding of the interaction among landscape, land cover, and soil properties will help landowners, researchers and policy makers in planning wise natural resource conservation strategies. The PI and Co-PI have a strong knowledge on designing data collection strategies, and collecting and analysis different soil physical properties. In addition, the research team has an extensive knowledge of the study area. The following specific aims are proposed for this project:

Specific aim #1: Evaluate soil hydraulic properties and surface soil moisture conditions along transects from an eastern redcedar tree boles to the grass inter-canopy at different positions along the slope. Soil water content, Bulk density, pore size and texture distribution, aggregate stability, saturated hydraulic conductivity, and water holding capacity will be measured at regular interval along the transect parallel to the contour.

Specific aim #2: Statistically test if there is a difference in soil hydraulic properties because of its position along a slope, land cover, and their interaction.

2. Project outcome

The proposed research project will advance our understanding while helping students of Soil Physics Measurement Techniques understand and perform different soil physics field and laboratory methods, as this research requires many of them. At the end of this project it is expected to have a clear understanding of the effect of landscape position and its interaction with vegetation supported with a good quality data collected throughout the process. This research is unique in a way that limited attempted had done to relate the effect of interaction of landscape and vegetation on soil hydraulic properties.

3. Expected Significance

In Oklahoma the invasion of eastern redcedar and its impacts has gained attention from researchers, landowners, and government official. Recent individual tree level study on the effect of redcedar on selected soil physical properties (Wine et al., 2012) showed an increased in water repellence and reduced in sorptivity and unsaturated hydraulic conductivity under eastern redcedar tree compared to adjacent grass. Due to the complexity of natural condition, for better understanding of hydrological processes, researchers (Mohanty and Mousli, 2000; Western et al., 1999) suggested the importance of having further research that combines the effect of landscape position and land cover on the spatial variability of soil hydraulic properties.

The proposed research is significant because it will improve our understanding of the effect of eastern redcedar encroachment into grassland on the soil hydraulic properties and soil moisture variability by adding the effect of landscape position from the previous work done by Wine et al. (2012) in the same study area.

4. Materials and Methods

This study will be conducted at the Cross Timbers Experimental Range (Figure 1), Marena, Oklahoma, and the methods for this proposal are modified from Wine et al. (2012).

Figure 1. Location of the proposed study area at the Cross Timber Experimental Range

Specific aim #1: Measure soil hydraulic properties and surface soil moisture conditions along transects from an eastern redcedar tree boles to the grass intercanopy at different position along the slope. Three landscape positions will be selected along a slope to represent the main components of landscape position: summit, back-slope and toe-slope. On each landscape position, four trees will be selected as replicates. A transect will be sampled from each tree's bole to the center of the inter-canopy space at intervals of 50 cm. All the transect directions are along the contour lines. At each sampling location, surface soil water content, bulk density, pore size and texture distribution, aggregate stability, saturated hydraulic conductivity, and water holding capacity will be measured.

Specific aim #2: Statistically test if there is a difference in soil hydraulic properties because of its position along a slope, distance on the transect, and their interaction. Matlab will be used to test the ANOVA.

5. Budget

Supplies and Equipment		
	Theta Probe	0
	Mini Disk Infiltrometer	0
	GPS	0
	Measuring tape	0
	Soil sampling kit	0
	Hydrometer, tempe cell, pressure cell, Permeameter	0
	Subtotals: Supplies and equipment	0
Transportation		
	12 Passenger van:	
	Daily rental $60	$360
	Mileage $0.45	$96
	Subtotal: transportation	$456
Wage for laboratory assistant		
	Hiring undergraduate student for lab work:	
	Hourly wage $10	$400
	Subtotal: wage	$400
	Total Project Cost	**$856**

6. Timeline

	1-Oct	8-Oct	15-Oct	22-Oct	29-Oct	5-Nov	12-Nov	19-Nov	26-Nov	3-Dec	10-Dec
Field data collection											
Laboratory analysis											
Write Manuscript											
Submit the manuscript for revision											
Write and submit the final manuscript											

References

Guzman, J.G., and M.M. Al-Kaisi. 2011. Landscape position effect on selected soil physical properties of reconstructed prairies in southcentral Iowa. J Soil Water Conserv 66:183-191.

Mohanty, B.P., and Z. Mousli. 2000. Saturated hydraulic conductivity and soil water retention properties across a soil-slope transition. Water Resour Res 36:3311-3324.

Oztas, T., A. Koc, and B. Comakli. 2003. Changes in vegetation and soil properties along a slope on overgrazed and eroded rangelands. J Arid Environ 55:93-100.

Western, A.W., R.B. Grayson, G. Bloschl, G.R. Willgoose, and T.A. McMahon. 1999. Observed spatial organization of soil moisture and its relation to terrain indices. Water Resour Res 35:797-810.

Wine, M.L., T.E. Ochsner, A. Sutradhar, and R. Pepin. 2012. Effects of eastern redcedar encroachment on soil hydraulic properties along Oklahoma's grassland-forest ecotone. Hydrol Process 26:1720-1728.

Ziadat, F.M., A.Y. Taimeh, and B.I. Hattar. 2010. Variation of Soil Physical Properties and Moisture Content Along Toposequences in the Arid to Semiarid Area. Arid Land Res Manag 24:81-97.

Curriculum Vitae

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Educational Background

Institution/ country	Major	Degree, year
Oklahoma State University / United States	Soil Sciences (Soil Physics)	Ph.D., expected to graduate in 2014
Dissertation: Interaction between bioenergy cropping systems and water resources		
Free University of Brussels, and Gent University/ Belgium	Physical Land Resources (Land Resources Engineering option)	M.S., 2010
Thesis: Groundwater-Surface water Interaction Modeling of the Grote-Nete Catchment using GSFLOW		
Haramaya University/ Ethiopia	Soil and Water Engineering and Management	B.S., 2006
Research project: Designing small scale sprinkler irrigation systems for Rare, Haramaya University		

Professional Experience

- Graduate Research Assistant, from 01/2011 to present

Plant and Soil Sciences, Oklahoma State University, Stillwater OK

- Graduate Assistant, from 06/2006 to 08/2008

Soil and Water Engineering and Management, Haramaya University, Dire Dawa, Ethiopia

- Undergraduate research internship, from 06/2005 to 08/2005

Gonder Agricultural Research Center, Gonder, Ethiopia

- Summer school teacher, two summers in 2003 and 2004

Gonder, Ethiopia

Posters and Oral Presentations

- Yimam, Y.T. and Ochsner, T.E. Converting Marginal Croplands to Switchgrass Production: Modeling the Effects on Streamflow. Will be presented at ASA-CSSA-SSSA International Meeting. Cincinnati, OH, 2012

- Yimam, Y.T. and Ochsner, T.E. Evaluating Water Budget and Water Use Efficiency of Switchgrass and High Biomass Sorghum. Student Water Research Conference. Oklahoma State University, Stillwater, OK. 2012
- Yimam, Y.T., Ochsner, T.E., Gopal, K., and Warren, J. Soil Water Depletion under Annual and perennial Bioenergy Cropping Systems. ASA-CSSA-SSSA International Meeting, San Antonio, TX. 2011.

Awards

- Sitlington Enriched Graduate Scholarship, Dept. of Plant and Soil Sciences, OSU ($5000/ year, for 3 years)
- VLIR Scholarship from Belgium Government in 2008 for M.S. study in Gent University and Free University of Brussels, Belgium

Curriculum Vitae

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Educational Background

Institution/ Country	Major	Degree, year
Oklahoma State University / United States	Plant and Soil Sciences	M.S., expected to graduate in 2012
Thesis: New approaches to measure and map soil moisture spatial variability		
China Agricultural University / China	Resource and Environmental Science	B.S., 2010
Research project: Energy analysis of planting sweet sorghum on saline soils		

Professional Experience

- Graduate Research Assistant, from 08/2010 to present

Plant and Soil Sciences, Oklahoma State University, Stillwater OK

Posters and Oral presentations

- Dong, J., Ochsner, T.E., and Cosh, M.H. Bayesian Maximum Entropy Approach to Mapping Soil Moisture at the Field Scale. AGU Fall Meeting. San Francisco, CA. 2012
- Dong, J., Ochsner, T.E., and Cosh, M.H. Analysis of Field-Scale Soil Moisture Spatial Distributions by Geostatistics and Maximum Entropy Theory. ASA-CSSA-SSSA International Meeting, San Antonio, TX. 2011.

Awards

- Third Class Academic Scholarship --- 2007, and 2009
- Second Class Academic Scholarship --- 2008