# Spatial gradients in ecohydrologic properties in an eastern red cedar-grassland ecosystem

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## Statement of critical soil physical properties research need

Understanding eastern red cedar (*Juniperus virginiana*) effects on soil hydrologic properties in central Oklahoma is essential for landowners and government agencies to make informed decisions in managing soil and water resources and to deciding whether systematic government-funded cedar removal should be implemented. Soil hydrologic properties regulate the partitioning of throughfall into stream flow and evapotranspiration. Soil texture and vegetation are two important determinants of soil hydrologic properties that interact to affect hydrophobicity, soil water content, and the water cycle. Though many studies have found that the presence of trees increase infiltration and improves soil hydrologic properties, others have found that trees cause hydrophobicity thereby reducing the soils ability to absorb and conduct water. These differences are in part due to the presence or absence of vegetation and the effects of vegetation on soil moisture. However, it is not known how eastern red cedar encroachment along Oklahoma's grassland-forest ecotone affects the soil hydrologic properties in this region.

## Nature, scope, and objectives of the project

The long-term goal of this team of collaborators representing the departments of Natural Resource Ecology & Management, Plant & Soil Sciences, and Horticulture & Landscape Architecture is for students in the Soil Physics Practicum to learn and apply soil sampling and analytical methods through the lens of a modern issue of scientific and policy interest. The *objective of this proposal* is to complete a critical first stage of the research to improve our understanding of eastern red cedar encroachment on the water cycle through determining how soil moisture, hydrophobicity, sorptivity, and soil hydraulic conductivity change as a function of the distance from an eastern red cedar bole. Preliminary data presented in this proposal indicate that soil water content is lower under cedar trees than under grass and that hydrophobicity is not present. The rationale for the proposed research is that providing resource managers and state legislators with measurements of soil hydrologic property differences between red cedar and grassland areas will facilitate a fact-based cost-benefit analysis regarding the prudence of a highly resource intensive and highly iterative cedar cutting campaign across the vast area that has been encroached. The proposal team is well prepared to succeed with this project due to the extensive knowledge of the study area, experience carrying out prior soil sampling and analysis, and experience using Geographic Information Systems software to organize spatial data in a soil science context. The following *research approach* aims are proposed for the project:

**Specific aim #1: Determine how soil properties change along transects from an eastern red cedar tree boles to the grass intercanopy.** Leaf litter depth, infiltration, and soil water content will be measured at regular intervals along transects.

**Specific aim # 2: Infiltration measurements will be analyzed to determine soil sorptivity and soil hydraulic conductivity.** Sorptivity is a measure of the water initially absorbed into the soil and soil hydraulic conductivity is determined once infiltration occurs at a steady state.

**Specific aim # 3: Test statistically if measured soil hydrologic properties change with increasing distance from the tree bole and with soil type.** ANOVA or a Kruskal-Wallis test will be used to determine if soil properties are significantly different along transects and between fine and coarse textured soils.

## Project outcomes

The proposed project is a truly unique research opportunity because the Cross Timbers Experimental Range is the only site in the Great Plains where eastern red cedar encroachment impacts on the water cycle are being studied at the watershed scale. At the completion of the project it is expected that a geospatial database of soil type and hydrologic properties will have been developed to complement ongoing stream flow measurement efforts. It can then be determined if differences in stream flow are associated with different vegetation or different soil type. Furthermore it can be determined if soil hydrologic properties tend to differ within a soil type in association with the presence or absence of eastern red cedar.

## Significance

The critical need to improve our understanding of eastern red cedar's effects on soil properties and the water cycle is widely recognized. Eastern red cedar has little potential to affect the water cycle in western Oklahoma, where stream flow accounts for only 1% or less of precipitation on grassland watersheds (Berg et al., 1988). Stream flow measured at several grasslands in central Oklahoma, in contrast accounts for about 12% of annual precipitation (Smith et al., 1992), indicating that there is the potential for a substantial reduction in stream flow as a result of red cedar encroachment. This is of particular concern in central Oklahoma because surface waters are an important source of public water supply, irrigation water, and water for livestock and aquaculture in central Oklahoma (Tortorelli et al., 2009).

Therefore, the proposed project is *significant* because it will contribute to the understanding of the relationship between stream flow, soil type, vegetation, and soil hydrologic properties in a landscape where surface water supply is a growing concern. The project will culminate in a comprehensive understanding of how eastern red cedar affects soil hydrologic properties and aid in understanding the complexities of eastern red cedar encroachment as it relates to stream flow generation processes.

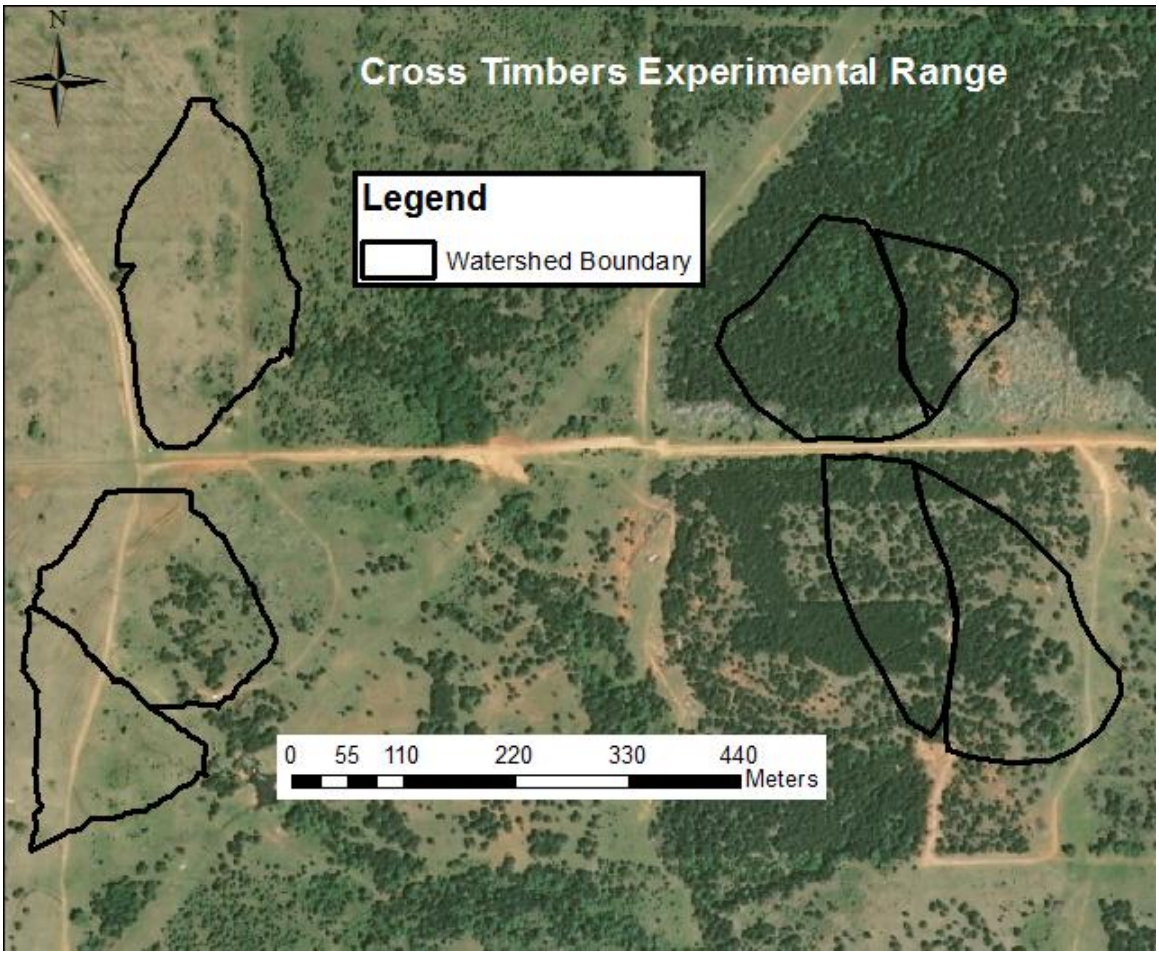


Figure 1. Location of experimental watersheds at the Cross Timbers Experimental Range

## Materials and methods

Methods in this study were modified from Madsen et al. (2008).

**Specific aim #1: Determine how soil properties change along transects from eastern red cedar tree boles to the grass intercanopy.** Seven trees will be chosen from Stephenville-Darnell complex soil and seven from Stephenville fine sandy loam. Within each soil type trees will be selected such that each tree's transect faces one of seven different directions (0, 50, 100, 150, 200, 250, and 300 degrees). At each site the tree's canopy radius and height will be measured. A transect will be sampled from each tree's bole to the center of the inter-canopy space at intervals of one or two feet (30 or 60 cm) such that under each tree's canopy at least four samples are taken. At each sampling location leaf litter depth, soil water content, hydrophobicity, and infiltration will be measured. Two samples of soil will be collected at each sampling location for soil particle size distribution analysis.

**Specific aim # 2: Infiltration measurements will be analyzed to determine soil sorptivity and soil hydraulic conductivity.** We will use methods from Zhang (Zhang, 1997) to convert the infiltration data to sorptivity and hydraulic conductivity.

**Specific aim # 3: Test statistically if measured soil hydrologic properties change with increasing distance from the tree bole and with soil type.** We will first group data by their distance from the bole of the tree, normalized by the radius of the tree canopy to determine if a change in hydrologic properties occurs as a function of distance from the tree. Secondly we will group data into four hydrologic functional units, of a given vegetation type and soil type to determine how vegetation and soil type affect hydrologic properties at the field scale.

## Budget

*Transportation*
12 Passenger Van

- Daily Rental $45 — $180.00
- Mileage $0.45 per mile — $72.00

*Soil physical property analyses and field supplies*
Mini Disc Infiltrometers ($220 each) — $660.00
Total Estimated Costs for Proposal — $912.00

GPS — N/A
Measuring Tape
Sand
Hypsometer or clinometer
Hand saw
Water
Soil water content probe
10 cm diameter, 15 cm depth cylinders
Minidisk infiltrometer

## Timeline

| Monday, September 20 | Tuesday, September 21 | Wednesday, September 22 |
|---|---|---|
| 10:30am-3:30pm | 8:00am-12:00pm | 10:30am-3:30pm |
| **Trees 1-7**<br>Litter depth<br>Soil Water Content<br>Hydrophobicity | **Trees 1-7**<br>Infiltrometer measurements | **Trees 1-7**<br>Finish any measurements |
| 4:00pm-8:00pm | 1:00pm-6:00pm | 4:00pm-8:00pm |
| **Trees 8-14**<br>Litter depth<br>Soil Water Content<br>Hydrophobicity | **Trees 8-14**<br>Infiltrometer measurements | **Trees 8-14**<br>Finish any measurements |

## References

Berg, W.A., Smith, S.J. and Coleman, G.A., 1988. Management Effects on Runoff, Soil, and Nutrient Losses from Highly Erodible Soils in the Southern Plains. Journal of Soil and Water Conservation, 43(5): 407-410.
Madsen, M.D., Chandler, D.G. and Belnap, J., 2008. Spatial gradients in ecohydrologic properties within a pinyon-juniper ecosystem. Ecohydrology, 1(4): 349-360.
Smith, S.J., Sharpley, A.N., Berg, W.A., Naney, J.W. and Coleman, G.A., 1992. Water Quality Characteristics Associated with Southern Plains Grasslands. Journal of Environmental Quality, 21(4): 595-601.
Tortorelli, R.L., Oklahoma Water Resources, B. and Geological, S., 2009. Water use in Oklahoma 1950-2005. U.S. Geological Survey, Reston, Va.
Zhang, R.D., 1997. Determination of soil sorptivity and hydraulic conductivity from the disk infiltrometer. Soil Science Society of America Journal, 61(4): 1024-1030.

# Michael Wine

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## Education

Oklahoma State University, College of Agricultural Sciences and Natural Resources
Pursuing M.S. Natural Resource Ecology and Management, Anticipated December 2011
GPA: 3.8

Cornell University, College of Agriculture and Life Sciences, Ithaca, NY
B.S. Natural Resources: Applied Ecology, May 2009

## Experience

**Graduate Research Assistant** **August 2009-present**
Oklahoma State University, Stillwater, Oklahoma
Review land use land cover change literature and design and implement studies to determine the hydrologic effects of land-use and land cover change in Oklahoma's highly erodible Rolling Red Hills.

**Research Technician** **Summer 2009**
Hubbard Brook Experimental Forest, North Woodstock, New Hampshire
Identified, cored, and mapped northern hardwood and softwood trees. Measured signs of moose distribution and abundance.

**Stream Research Assistant** **September 2008-May 2009**
Cornell University, Ithaca, New York
Researched relationship between stream fragment size and fish abundance and diversity using ArcGIS 9.3.

**Extension Research Assistant** **Summer 2009**
Cornell Cooperative Extension, Mount Pleasant, New York
Led research team to carry out forest inventory, flame weeding, beech and crop tree management research using GPS throughout New York state as part of a highly independent team working through all weather. Mentored fellow team members on plant identification and used sound judgment to minimize sources of error in research.

**Research Intern** **Summer 2007**
Arnot Teaching and Research Forest, Ithaca, New York
Carried out flame weeding and beech research projects including field work, statistical analysis, and presentation of results under the direction of Dr. Peter Smallidge.

## Publications and Accomplishments

2010 Afanasiev Distinguished Graduate Student Fellowship recipient.

2010 Grant A. Harris Research Instrument Fellowship recipient.

"Testing Predictions of Stream Landscape Theory for Fish Assemblages in Highly Fragmented Watersheds." Bain, M. and Wine, M. Folia Zoologica. Accepted 05 January 2010. In press.

Zou, C. B., P. F. Ffolliott, and M. Wine. 2010. Streamflow responses to vegetation manipulations along a gradient of precipitation in the Colorado River basin. Forest Ecology and Management 259:1268-1276.

Dean's List, Spring 2009 semester, Cornell University.

Honorary Mention, Pack Natural Resources 2009 Pack Essay writing contest, Cornell University.

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## Education

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|---|---|
| **Current Student:** | Soil Science, PhD , Department of Plant and Soil Sciences, Oklahoma State University |
| Advisor: | Dr. Kefyalew Desta |
| Expected to graduate: | December, 2012 |
| Dissertation: | Title: 1.Effect of Different Winter legumes as Nitrogen Sources for Switchgrass Grown for Cellulosic Ethanol.<br>Title 2: To be determined. |
| **M.S.** | Agroforestry, Bangladesh Agricultural University, Mymensingh, Bangladesh |
| Major Field: | Agriculture |
| Date: | June, 2004 |
| **B.S.** | Agriculture, Bangladesh Agricultural University, Mymensingh, Bangladesh |

## Work Experience

August 2009 to Current: Graduate Research Assistant, Department of Plant and Soil Sciences, Oklahoma State University

Responsibilities: Research field work, sample processing, extension, data collection and processing, and management of 10+ ongoing field experiments including teff variety and fertilizer trials.

# Investigator Qualifications

**Rachael Pepin**

Oklahoma State University,

Department of Horticulture and Landscape Architecture

**Coarse Work and Field/Lab Experience:**

| | | |
|---|---|---|
| Soil, Water and Weather | Fall 2010 | Oklahoma State University |
| Soil Nutrient Management | Fall 2006 | Oklahoma State University |
| (Laboratory Requirement) | | |
| Soil and Water Conservation | Spring 2006 | Oklahoma State University |
| Soil Chemistry and Environmental Quality | Spring 2006 | Oklahoma State University |
| Introduction to Soil Science | Spring 2004 | Coffeyville Community College |

**Experience through Industry:**

**Fiore Lawn and Landscape** **August 2008 to Present**

- Owner, primary field supervisor and customer relation coordinator
- Soil fertility recommendations
- Design and construction of sustainable landscapes
- Consultations with local community garden

**Stonebridge Quality, LLC.** **June 2007 to August 2008**

- Crew supervisor with emphasis in quality landscape management in relation to plantings, soil fertility, and water management
- Consultations for consumers investigating issues in their landscape
- Soil sample collection

**Written Proposals:**

Effects of Paclobutrazol, Uniconazole, and Flurprimidol on Growth of *Monarda didyma* When Applied Directly to Potting Media as a Drench Application or Through Subirrigation