Hydrologic Impacts of a Lehmann Lovegrass Invasion in a Semiarid Native Grassland

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Introduction

Semiarid grasslands such as those in southeastern Arizona are sites of rapidly shifting vegetation patterns, and key drivers of change in the region are invasive transplanted African grasses such as buffelgrass, Boer lovegrass, and Lehmann lovegrass. These species are well-adapted to take advantage of scarce resources, enabling them to often out-compete native grasses following disturbances such as drought and fire.

In this and other arid and semiarid ecosystems, the availability of water (or lack thereof) largely governs biological productivity. Yet despite decades of research on various ecological aspects of the presence of these alien species in the landscape, relatively little is known about the hydrological changes wrought by these invasions. Recent studies comparing natives to Lehmann lovegrass have begun to increase our understanding of these impacts on ecosystem gas exchange and evaporation and transpiration. These studies have been conducted on test-plots and we know little about how these factors are changed by naturally occurring invasions.

During the period 2005-2007 the Kendall grassland site at Walnut Gulch Experimental Watershed underwent a change from an assemblage of native grasses to the invasive alien *E. lehmanniana* (Lehmann lovegrass). The transition followed a multi-year drought that resulted in the mortality of the native grasses in 2005. In 2007 Lehmann lovegrass became the dominant species.

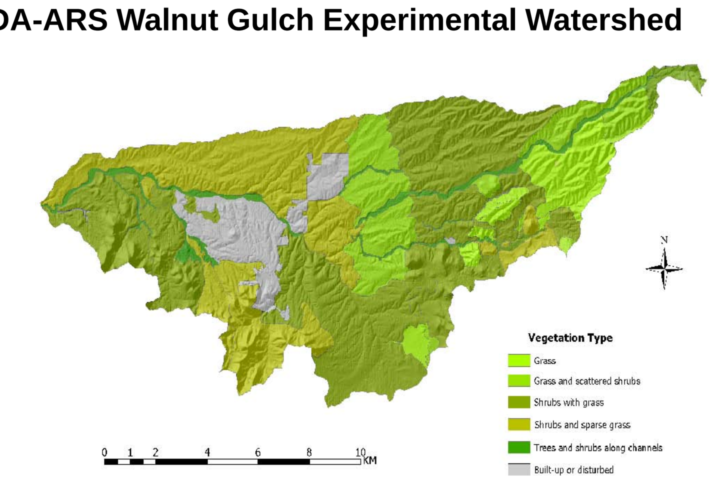
This transition presented an opportunity to investigate the effect the invasion had on ecosystem response to individual pulse precipitation events using recorded hydrometeorological measurements. This analysis compares pulse storm response among different vegetation types in different phases of the transition as a way to learn about the concomitant changes in water balance. More specifically, analyzing immediate post-storm hydrologic dynamics provided insight into the effects that the invasion had on evaporation (E) and transpiration (T) dynamics, and the relationship between the two. This is important because changes in these variables will have implications for ecological functions such as carbon and nutrient cycling, and may favor the persistence of Lehmann lovegrass in the landscape.

Study Site

Kendall grassland in the Walnut Gulch Experimental Watershed

- Located in the Upper San Pedro Watershed
- USDA operated
- Semi-arid, sparse vegetation, sandy soils
- Historically dominated by diverse native bunchgrasses.
- Instrumentation: Precipitation, ET, Soil moisture at 5 and 15 cm, CO2 flux

USDA-ARS Walnut Gulch Experimental Watershed



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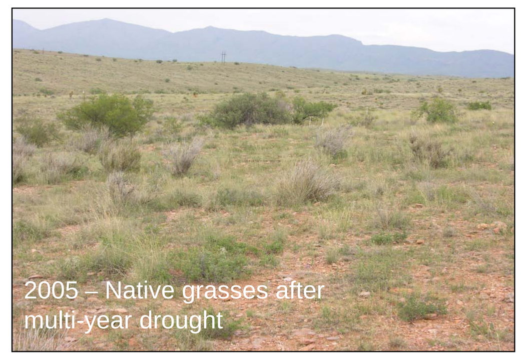
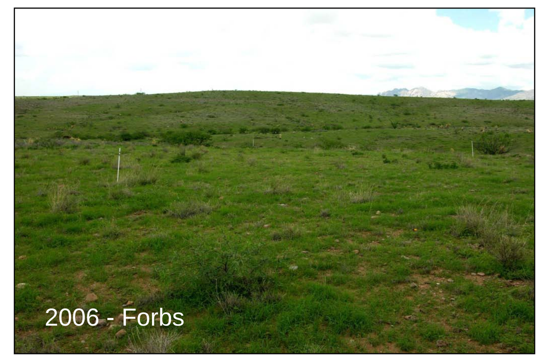
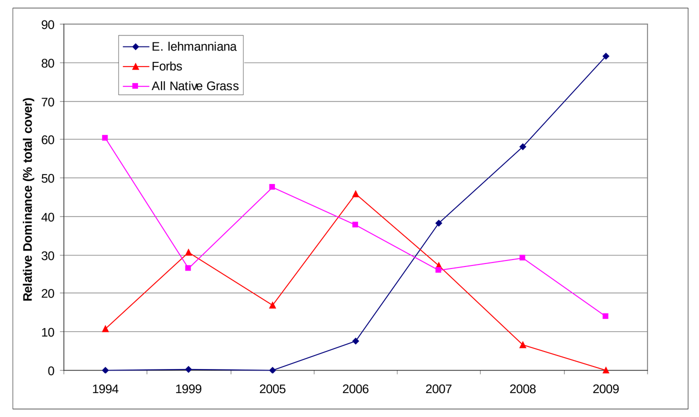
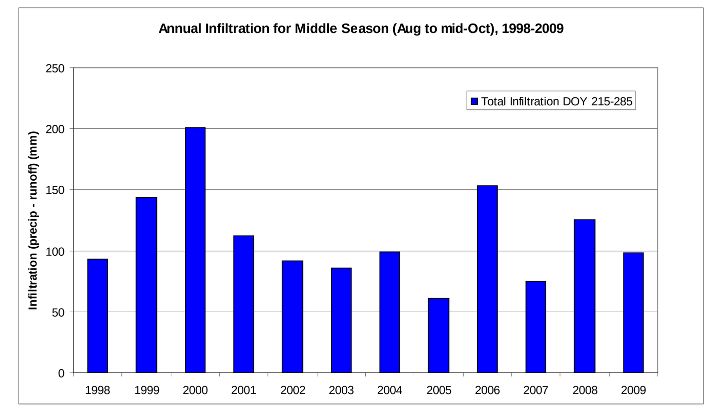
Observing the Transition



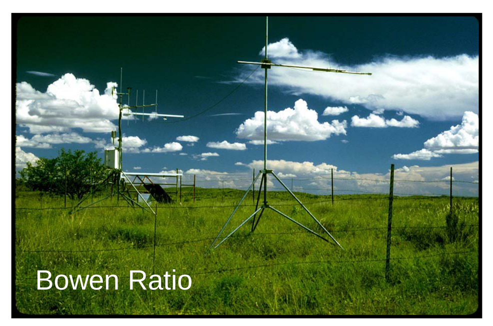


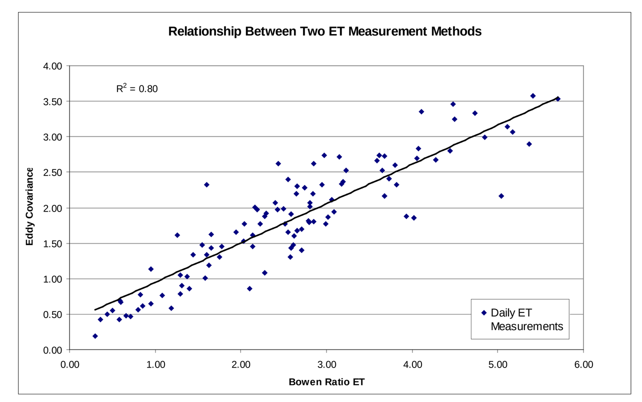




Declining native grasses correspond closely with consecutive years of low monsoon infiltration.

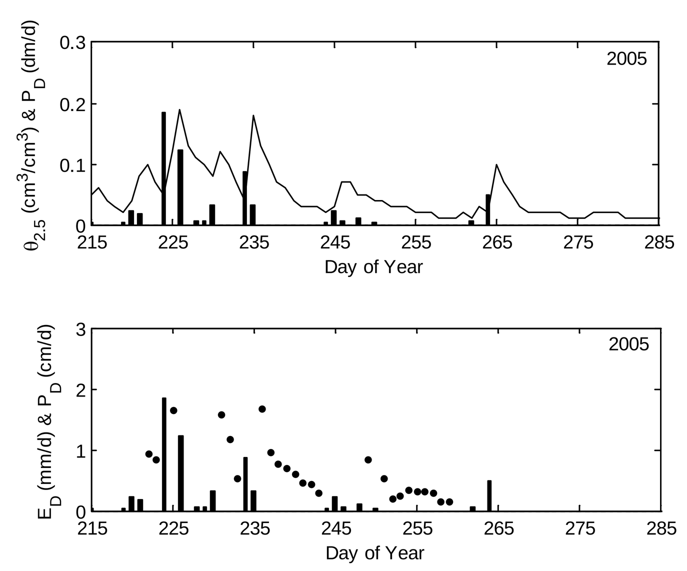
Two Methods of ET Measurement

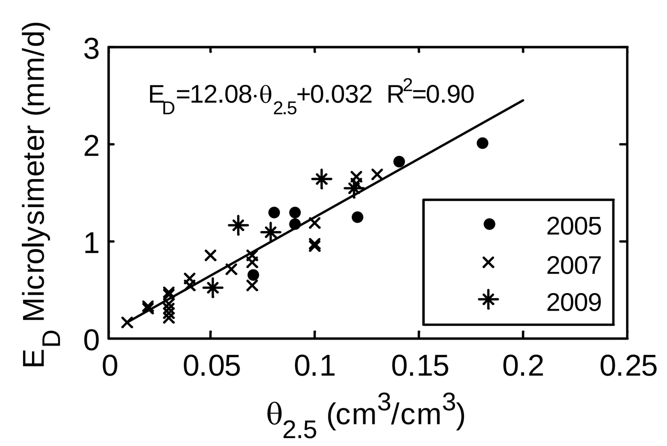




Because eddy covariance ET data are unavailable before 2004, a relationship between the Bowen ratio and eddy covariance measurement methods was used to model ET to allow the inclusion in the analysis of pre-transition years 2002 and 2003.

Correlation of Soil Moisture and Evaporation





Measurements from soil moisture sensors at 2.5 cm depth and soil evaporation from weighing microlysimeters at the Kendall site are strongly correlated. This relation was used to estimate E_D.

References:

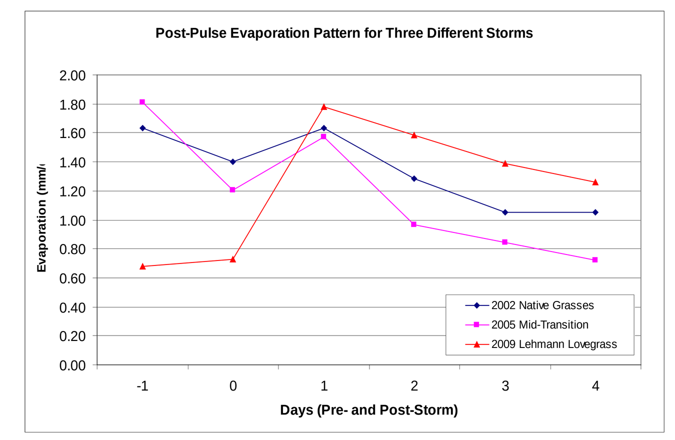
Huxman, T.E., Cable, J.M., Ignace, D.D., Eilts, J.A., English, N.B., Weltzin, J., Williams, D.G. 2004. Response of net ecosystem gas exchange to a simulated precipitation pulse in a semi-arid grassland: the role of native versus non-native grasses and soil texture. *Oecologia 141*(2):295-305.

Moran, M.S., Scott, R.L., Hamerlynck, E.P., Green, K.N., Emmerich, W.E., Holifield Collins, C.D. 2009. Soil evaporation response to Lehmann lovegrass (Eragrostis lehmanniana) invasion in a semiarid watershed. *Agric. Forest Meteorol.* (in press).

Analysis

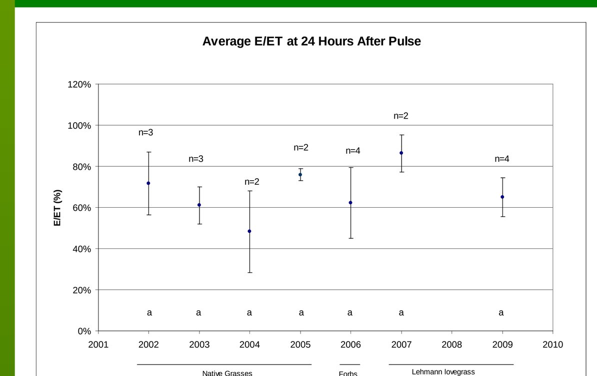
- The object of the analysis was to see how the transition from a native- to Lehmann lovegrass-dominated vegetation assemblage related to evaporative response to individual monsoon pulsed storm events. Based on results from test-plot studies, we hypothesized that Lehmann lovegrass would be associated with higher post-pulse E/ET than native grasses.
- To evaluate this, we used the relationship between empirical soil moisture and evaporation data to partition ET into E and T, and then determined E/ET for the days immediately following pulses in each year of the transition period (2002-2009). 2008 data were omitted due to instrument failure.

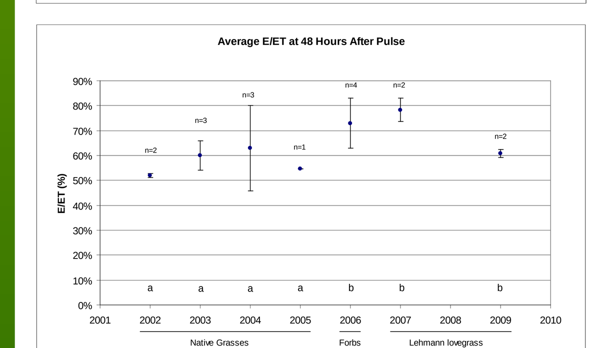
Pulse Storms



- The typical post-pulse evaporative response is an increase in E within the first 24 hours followed by a downward trend during the next one to two days. Variations in response among similar storms in different years suggested that changes in dominant vegetation type may have a detectable impact on E and T.
- Because the bulk of ET tends to occur within the first 2 days after a pulse, we focused on the E/ET of the first 24- and 48-hour periods following each pulse.

E/ET





- During the first 24 hours after the pulse, E/ET for each year of the transition showed no significant differences from E/ET pre-transition (2002). However, after 48 hours, E/ET means were significantly higher than 2002 for each of the years after the decline of native grasses (2006, 2007, and 2009).
- The greatest inter-annual variation occured during the major years of transition (2005-2007), with the highest average E/ET for both 24- and 48-hr periods observed in 2007, after Lehmann lovegrass had first become dominant.

The subscript "**a**" signifies **NO significant difference** between E/ET in 2002 and E/ET in the given year, and subscript "**b**" signifies **a significant difference** based on one-tailed t-tests with α=0.05.

Conclusions

1. The three years after the decline of native grasses were associated with significantly higher E/ET 48 hours after pulses, but not after 24 hours. This suggests the effect of vegetation type on evaporation may not occur until after the plants begin transpiring, usually after the first 24 hours.
2. This may be an observable manifestation of test-plot comparisons that found higher E/ET in the first few days after a pulse for Lehmann lovegrass compared to a native grass species (Huxman et al. 2004).
3. The increase in E/ET after 48 hours could help explain the results by Moran et al. (2009) that showed a substantial increase in monsoon E/ET after Lehmann lovegrass invasion for similar hydrologic years and the same location.