H53B-1667 The Walnut Gulch – Santa Rita Wildland Watershed-Scale LTAR

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Introduction

The mission of the USDA-ARS Southwest Watershed Research Center (SWRC) is *"to develop knowledge and technology to conserve water and soil in semi-arid lands"*

To address this mission the SWRC established the Walnut Gulch Experimental Watersheds in 1953, and eight unit source watersheds in the Santa Rita Experimental Range (SRER) in 1974 (Figure 1).

These outdoor laboratories arguably constitute the most intensively instrumented semiarid watersheds in the world and have generated an enormous knowledge base (Moran et al., 2008).

With inclusion in the Long-Term Agro-ecosystem Research (LTAR) network the SWRC's mission has expanded to address the:

- Sustainability and profitability of rangeland agro-ecosystems
- Adaptation of these systems to climate change, and
- Development of management systems for increased production with heightened environmental stewardship

This is critical as rangelands:

- Constitute ~40% of the Earth's land surface
- Support the majority of the world's livestock, and
- Support significant proportions of terrestrial NPP

Each LTAR site will develop a common experiment to contrast a "Business as Usual" to an "Enhanced" agricultural production system

Figure 1. Location Map

Walnut Gulch LTAR Enhanced Production Experiment

In partnership with the Univ. of Arizona (UA) and Arizona State Univ. the ARS-SWRC will initiate an experiment to at the SRER (as it is managed by the UA) to assess the watershed-scale impacts of brush management while monitoring livestock production and a suite of ecosystem services (ES) including:

- Provisioning ES (forage production, water yield)
- Supporting ES (ecosystem primary production, soil moisture), and
- Regulating ES (C sequestration, peak flows, sediment yield, land surface-atmosphere interactions)

Brush management was selected as widespread conversion of grasslands and savannas to shrublands or woodlands is undermining rangeland sustainability.

A commonly-used brush management scheme (herbicide application) will be applied to velvet mesquite (*Prosopis velutina*) over ~16 ha (40 acres) that encompass watersheds 7 and 8 and the flux tower footprint (Figure 2). Watersheds 5 and 6 will serve as the control or "Business as Usual" portion of the experiment.

Methods and Progress to Date

In September, 2015, 120 mesquite of variable size classes situated in the area of the four watersheds were sampled for:

- Morphologic measurements to estimate woody annual net primary production
- Herbaceous diversity underneath the canopy and 1 m beyond the live canopy in the inter-shrub space

In October, 2015, the herbaceous vegetation composition near 100 of these mesquite were re-sampled to estimate annual net primary production, specifically:

- Morphologic measurements of herbaceous individuals (basal diameter, total height)
- Clippings of all individuals. Individuals were dried at 50 degrees C. for at least 24 hours to estimate dry biomass
- Morphologic measures and dry biomass will be used to develop site-specific allometry for local native and non-native grass species

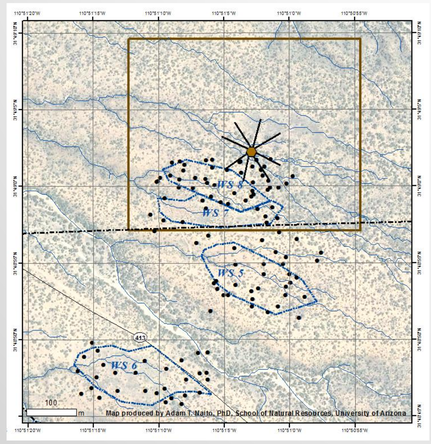


Figure 2.

- Flux tower
- Sampling locations
- Herbicide application boundary
- Transects
- Watershed boundary
- Pasture fence

Prospective Cross LTAR Network Analysis Based on Analysis of 29 Semiarid Eddy-Covariance Sites

- The Southwest Flux Synthesis results presented herein are from a synthesis of 29 semiarid sites in the Southwest & 170 site-years of observations (Figure 3)
- We are interested to expand these analyses across a much broader, nationwide range of agro-ecosystems, climate regions, and management practices with the LTAR network (Figures 3 and 4)

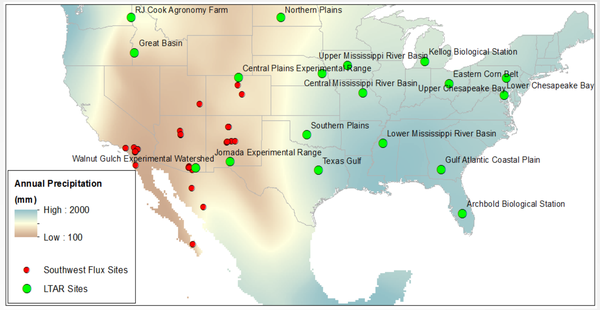


Figure 3. Location of SW Flux and LTAR sites and annual precipitation (mm)

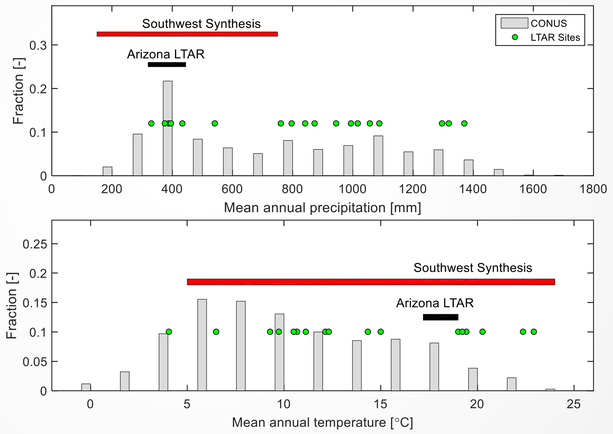


Figure 4. Fraction of Continental U.S. in mean annual precipitation and temperature ranges and where SW and LTAR sites fall in these ranges

- In contrast to temperate sites, semiarid sites can be carbon sinks or sources
- WGEW and SRER sites switch between source/sink functioning
- These observations support recent global modeling studies indicating semiarid regions dominate the increasing trend and interannual variability of the global land CO_2 sink (Figure 5)

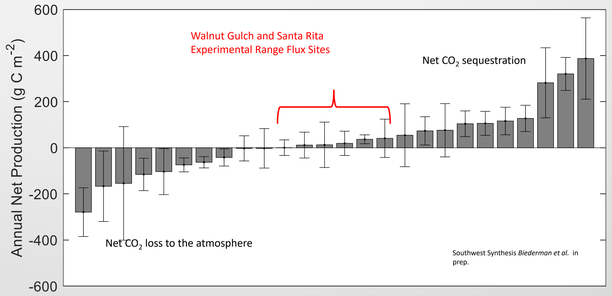
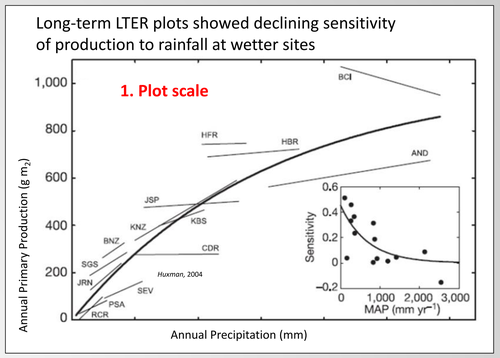
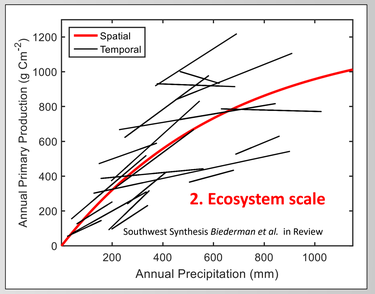


Figure 5. Net Ecological Productivity (NEP) of the 29 SW flux sites (~50% of sites switched sink/source)

Eddy covariance offers new insight into water use efficiency for primary production

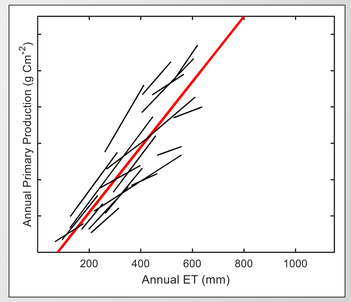


Ecosystem-scale eddy covariance measurements showed same declining sensitivity



- Productivity vs. ET is linear, suggesting common water use efficiency.
- Curvature in Production vs. Precipitation instead suggests more runoff at wetter sites
- Both temporal variation in available water at a site and differences in climatic water availability across sites had the same effect on productivity
- Future: separate evaporation from transpiration and account for runoff

Eddy covariance measures ET, a metric of water available after runoff



Conclusions

- The Walnut Gulch LTAR builds on a rich historical data and knowledge base (60+ years - see also H53B-1662 Quantifying Temporal Changes in Sub-daily Precipitation Intensities Across Agricultural Regions of the U.S. in this session)
- The "enhanced" production experiment on small experimental watersheds in the SRER will assess the impact of brush management using herbicides on a range of ecosystem services
- The LTAR network can increase the range of hydro-climatic conditions of network analysis to regional and national scale, beyond the initial analysis in the SW
- A key challenge for LTAR will be to determine the fraction of precipitation available for production

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