B33H-2577: Response of Tallgrass Prairie to Management in the U.S. Southern Great Plains: Site Descriptions, Management Practices, and Eddy Covariance Instrumentation for a Long-Term Experiment

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INTRODUCTION AND RATIONALE

- Evaluating the responses of the same biome or land use type to different management practices within the same climatic condition is required to investigate the effects of non-climatic factors and management practices.
- Eddy covariance (EC) techniques have been widely used to study the exchange of energy, carbon dioxide (CO_2), and water vapor (H_2O) fluxes between agroecosystems and the atmosphere over the past two decades.
- Although several studies have reported CO_2 and H_2O dynamics in tallgrass prairie, most have utilized one or a small number of EC systems to examine individual forms of management.
- Comparative studies of CO_2 and H_2O fluxes in tallgrass prairie from different landscape positions (e.g., upland, intermediate, and lowland) that experience different management practices (e.g., grazing, spring burns, and haying) under the same climatic regime is scarce.
- Thus, there is a significant need to use multiple EC systems in co-located tallgrass prairie pastures to examine their responses to different frequencies and timing of spring burns and grazing regimes under similar environmental conditions.

OBJECTIVES

- To establish a cluster of EC towers within a suite of tallgrass prairie pastures to develop long-term databases of surface energy, CO_2, and H_2O budgets along with plant biometric measurements and climate data.
- To compare carbon and water dynamics/budgets, and vegetation phenology in tallgrass prairie under combinations of prescribed spring burns and grazing regimes in different landscape positions under a variable climate.
- To understand variability in forage production and quality, macronutrient availability, soil and landscape features, cattle grazing behavior, and forage utilization within prairie systems using geospatial techniques and sensors.

MATERIALS AND METHODS

- The experiment includes three different replicate areas of southern tallgrass prairie. One area is composed of four pastures (P13, P14, P15, and P16) that are components of a 247 ha area managed to support a beef cow herd. A second 32 ha area (P18) is divided into nine paddocks and grazed by yearling stocker cattle during the early growing season (May–July). A third 36 ha area (P20) is managed to provide high quality hay, harvested in early July.
- A cluster of six EC systems has been established in tallgrass prairie pastures as a part of the GRL-FLUXNET, a network of 16 integrated flux measurement systems established at the USDA-ARS, GRL.

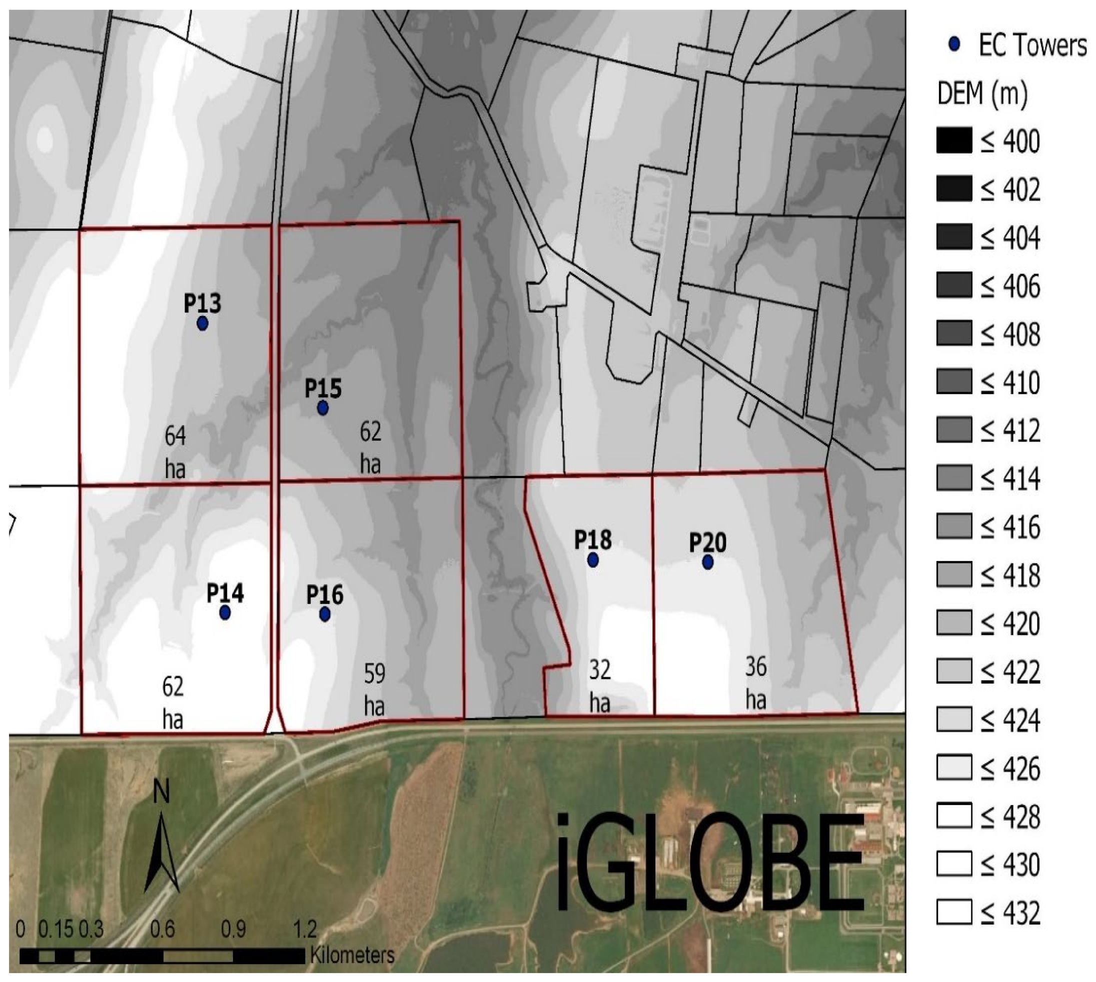


Fig. 1. Layout of experimental tallgrass prairie pastures at the United States Department of Agriculture - Agricultural Research Service (USDA-ARS), Grazinglands Research Laboratory (GRL), El Reno, Oklahoma. The red borders represent the experimental pastures used in this study.

[1]Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

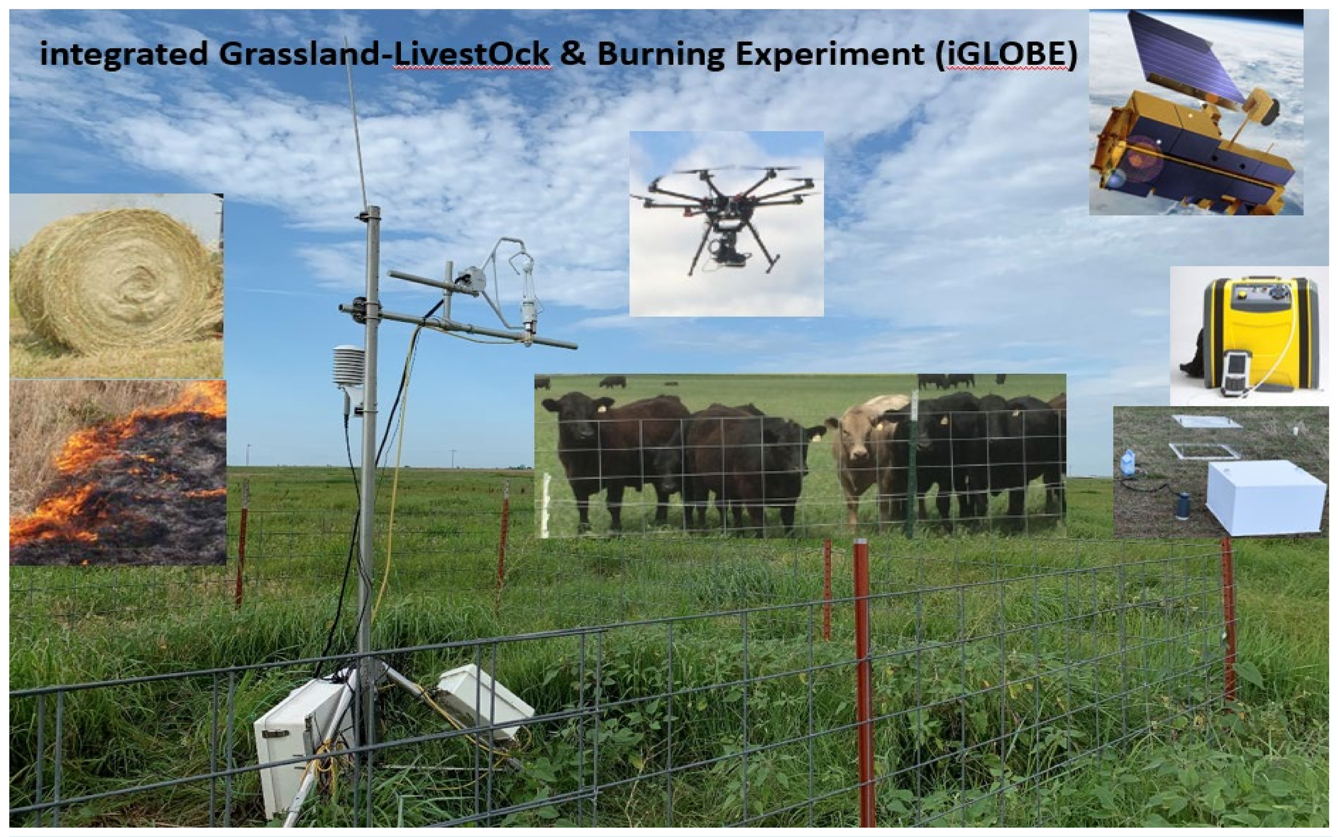
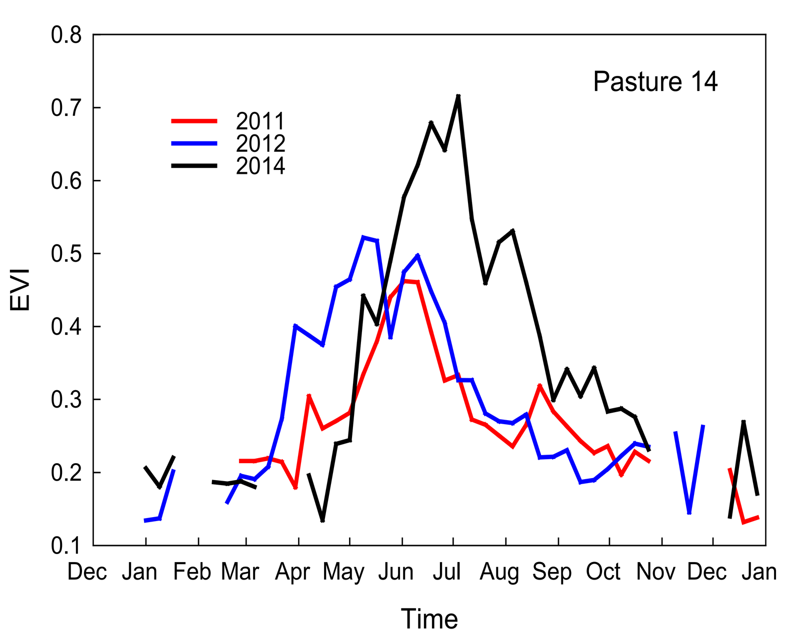


Fig. 2. Graphical presentation of the experiment.

RESULTS AND DISCUSSION

Impact of Precipitation Distribution on Vegetation Phenology and Forage Production



- Due to higher precipitation in summer 2014, the EVI remained substantially higher throughout the growing season. The results illustrate the importance of timely distribution of precipitation during the growing season to productivity.

Fig. 3. Seasonal dynamics of the enhanced vegetation index (EVI) in three selected years with different distribution patterns of precipitation at the uppermost landscape position (Pasture 14). The pasture was burned in 2014.

Impact of Burning on Vegetation Phenology

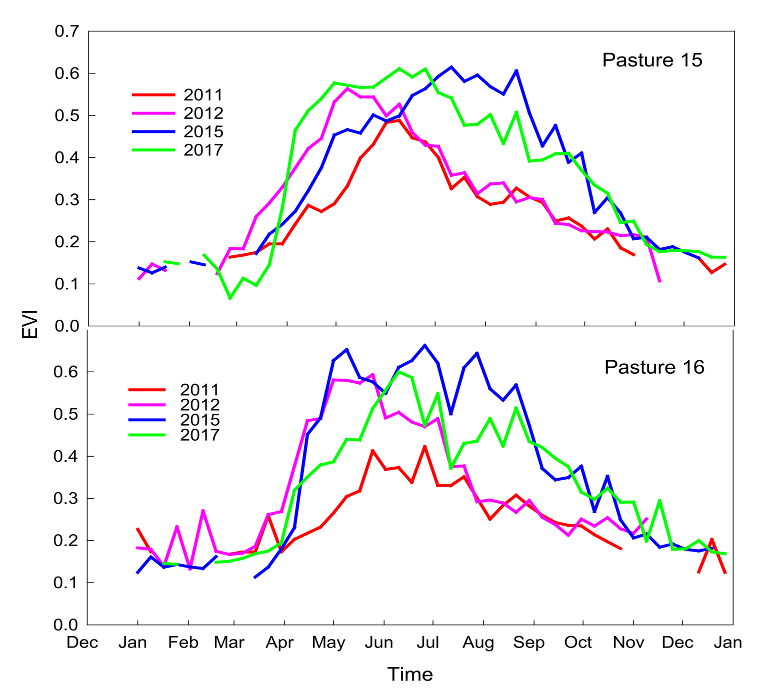


Fig. 4. Seasonal dynamics of the enhanced vegetation index (EVI) in dry (2012) and wet (2017) burned years vs. dry (2011) and wet (2015) unburned years for pasture 15, and in dry (2011) and wet (2015) burned years vs. dry (2012) and wet (2017) unburned years for pasture 16.

- Burning showed a clear impact on early green-up during wet years but not in dry years.
- Results illustrated negative impacts of the combination of burning and drought.
- In comparison, burning had minimal or no impact on the timing of green-up in burned and unburned pastures in 2012, when spring was warm with well-distributed precipitation. Results indicate that greater temperature and availability of solar radiation at the soil surface are the main reasons for early green-up of vegetation following prescribed spring burns.

Impact of Landscape Positions on Vegetation Phenology

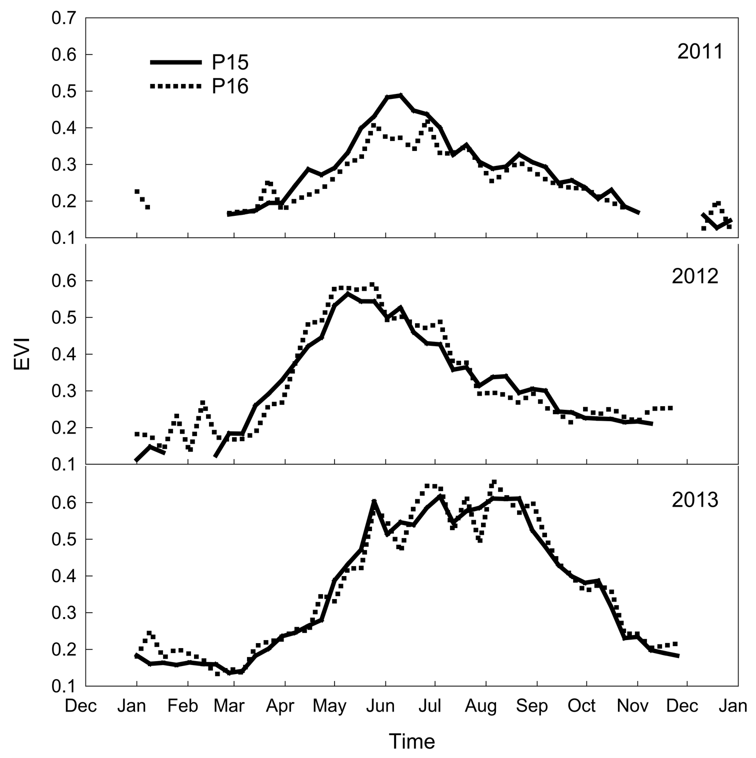


Fig. 5. Seasonal dynamics of the enhanced vegetation index (EVI) for three selected years (dry years 2011 and 2012, and wet year 2013) in adjacent pastures located at different landscape positions. Pasture 15 (lowland along stream) was burned in 2012 and Pasture 16 (upper rise to toe) was burned in 2011.

- The EVI values were similar in a wet year 2013 in both pastures.
- Burning did not induce early green-up in P16 during 2011.
- In 2011, both pastures greened-up around the same time and P15 (unburned pasture) had higher EVI values throughout the entire growing season, most likely because of greater availability of soil water due to differences in landscape position and burning treatment.

Role of Vegetation Phenology on Eddy Fluxes

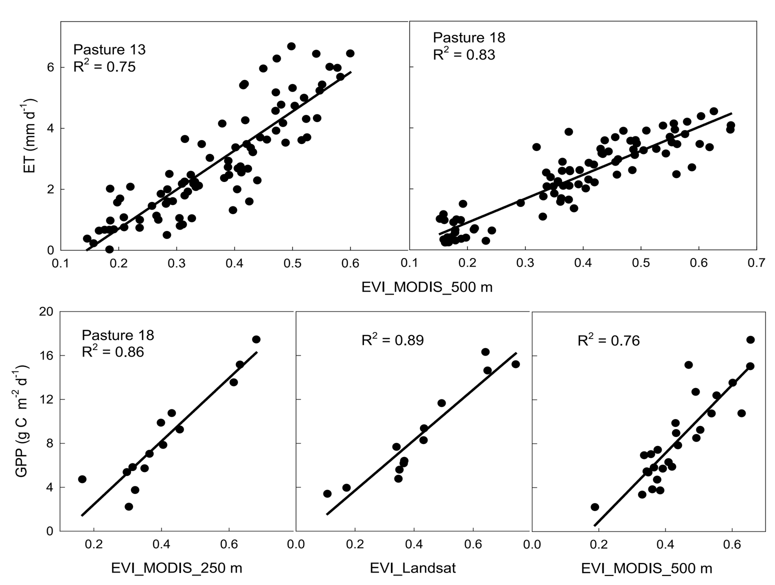


Fig. 6. Regressions of evapotranspiration (ET) and gross primary production (GPP) with Landsat-derived and Moderate Resolution Imaging Spectroradiometer (MODIS)-derived enhanced vegetation index (EVI) for pastures 13 and 18. The Landsat-derived EVI calculated for the paddock containing flux tower was used in the regression.

- Strong correspondence between eddy fluxes and EVI suggests that changes in vegetation phenology or ecosystem structures with respect to management practices will influence carbon and water budgets in tallgrass prairie.
- The strong correspondence between eddy fluxes and EVI resulted in strong linear relationships of EVI with ET and GPP.
- The EVI at finer scales of spatial resolution showed stronger relationships, most likely due to less heterogeneity within the pixels (i.e., reduction in numbers of mixed pixels).

Summary and Future Directions

- Continuous collection of EC-measured ET and CO_2 fluxes, biometric measurements, vegetation phenology, and climate data from tallgrass prairie systems.
- Monitoring cattle behavior and pasture utilization using GPS collars.
- Identifying spatial variations within a pasture.
- Assessing environmental impact on animal behavior.
- This long-term experiment will allow us to undertake a series of comparisons of prairie responses to develop a holistic approach in defining best management practices for this important land use type in the Southern Great Plains.

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