Spatially Explicit Modeling of Switchgrass Carbon Sequestration in Oklahoma

Kundan Dhakal, Pradeep Wagle, and Vijaya Gopal Kakani
Department of Plant and Soil Sciences, Oklahoma State University

Introduction

Bioenergy growth holds potential to positively contribute to economic and environmental issues on both the farm and global scale. Switchgrass (*Panicum virgatum* L.) is a productive perennial grass native to North America and was selected by the U.S. Department of Energy as a model energy crop. Research is on going to confirm whether switchgrass can prove itself to be a long-term carbon sink under biofuel production management practices.

Information on ecosystem level study of carbon sequestration potential of switchgrass in the Southern Great Plain regions of the United States is lacking. Study of a switchgrass cropping ecosystem can be of great importance at a regional level since measured ecosystem level CO_2 fluxes can be extrapolated to estimate the regional carbon balance (Wofsy et al., 1993). Net ecosystem CO_2 exchange (NEE), the difference between gross primary production and ecosystem respiration, measured by eddy-covariance technique at a location is extrapolated to quantify carbon sequestration potential across potential switchgrass areas in Oklahoma. Study window was limited to the active growing season.

Objectives

1. To identify potential switchgrass production areas across the State of Oklahoma
2. To conduct seasonal (April to August) spatial modeling of net ecosystem exchange (NEE) of C across potential switchgrass production area.

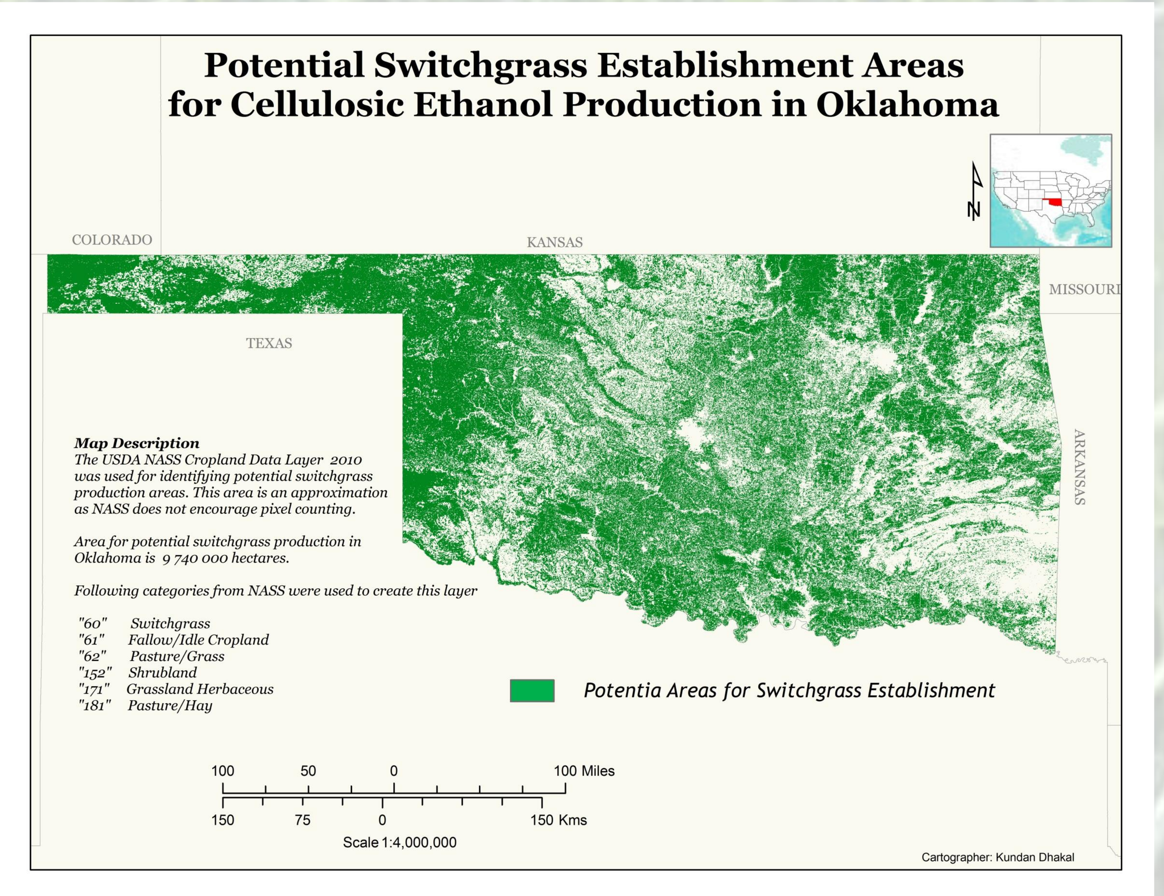

Fig. 1. Potential switchgrass production area estimated by reclassifying the USDA- NASS Crop Data Layer

Materials and Methods

- Potential switchgrass production areas in Oklahoma were identified from the USDA-NASS Cropland Data Layer (CDL). The raster data for 2011 were first imported into ArcGIS and reclassified to show only switchgrass, fallow cropland, pasture, shrub land, grassland, pasture, and hay.
- Weather data from 2008 to 2011 was acquired from the Oklahoma Mesonet (http://mesonet.org/). There are 110 automated stations that collect statewide weather data. A minimum of one site is located in each of Oklahoma's 77 counties.
- Mesonet data recorded at 5-minute intervals included the following observations: relative humidity, air temperature, wind speed, wind direction, rain, barometric pressure, solar radiation, and soil temperature at different depths. Data was checked thoroughly and processed to calculate 30-minute average values.
- Light–saturated net ecosystem CO_2 exchange as a function of air temperature was calculated (temperature ≥ 5.9 °C and PPFD ≥ 50 m mol m^{-2} s^{-1}).
- Daytime respiration (DR) was calculated using quadratic function of air temperature, whereas nighttime respiration (NR) was calculated using exponential function of soil temperature .
- Empirical equations: Temperature response curves were developed for NEEsat, apparent quantum efficiency (AQE), DR, and NR based on eddy-covariance measurements at Chickasha, OK in 2011. The 30 min NEE values were generated as a function of NEEsat, PPFD and AQE. We applied same equations from April through August to rest of the locations for the entire study period.
- Seasonal NEE average values were then interpolated using ordinary kriging (ArcGIS 10, ESRI, Redlands, California) across potential switchgrass growing sites.

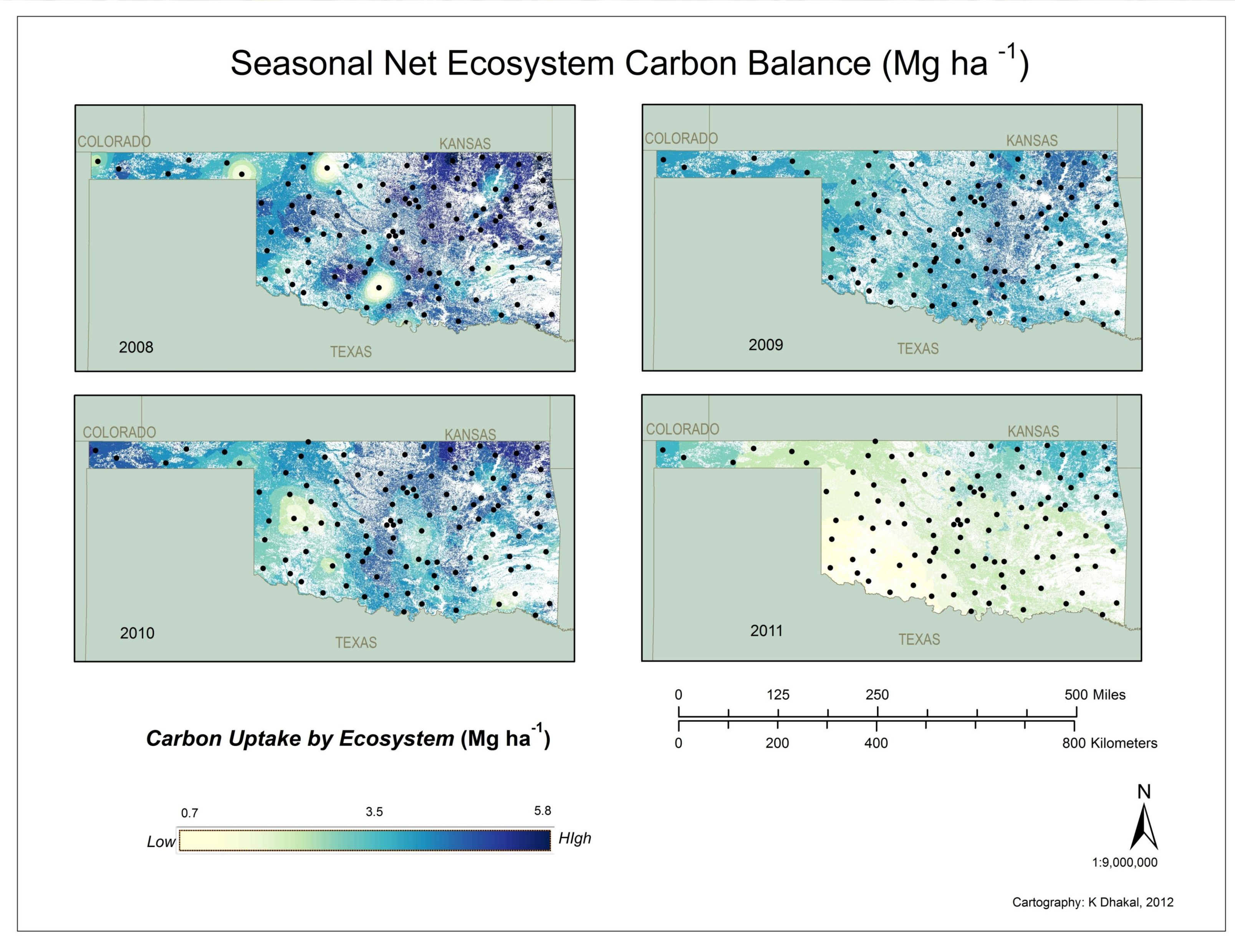

Fig. 2. Seasonal carbon uptake by switchgrass from 2008 to 2011. Seasonal net ecosystem carbon balance (Mg ha^{-1}) ranged from 0.7 to 5.8 Mg ha^{-1}. The highest carbon uptake by switchgrass was observed in 2008 and the lowest in 2011 due to an exceptional drought.

Results and Discussion

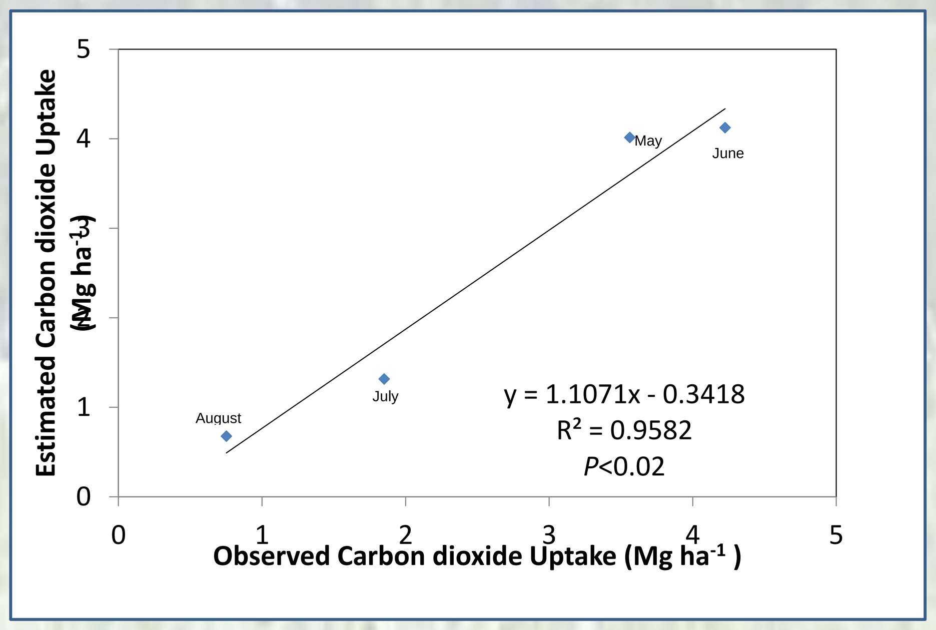

Fig. 3. Comparison of estimated and observed carbon dioxide uptake for May to August, 2011 at Chickasha, Oklahoma. The model showed great agreement (R^2 = 0.95)

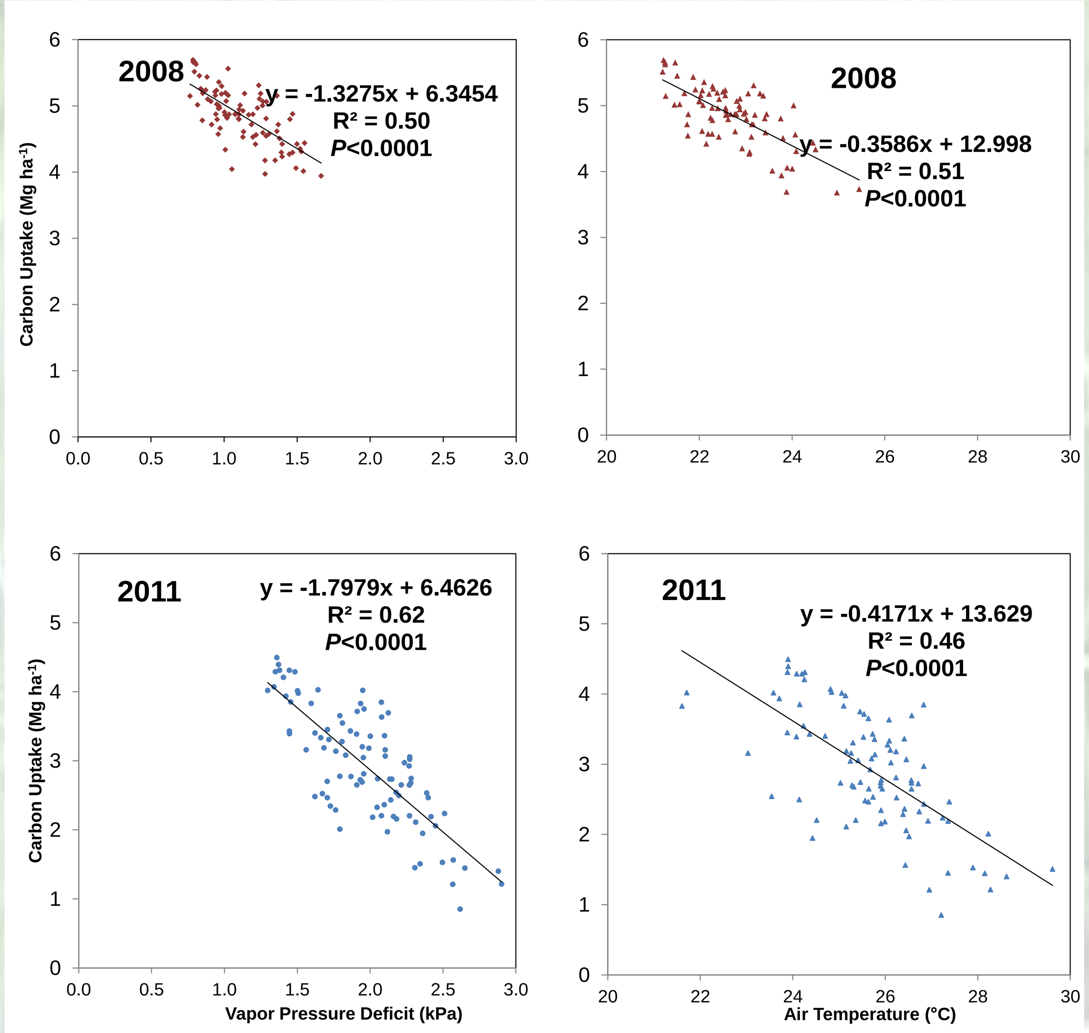

Fig. 4. Influence of vapor pressure deficit (VPD) and air temperature on carbon uptake by the switchgrass ecosystem in 2008 and 2011. Carbon uptake showed negative relationship with increasing VPD and air temperature.

Conclusion

Our results illustrate the importance of carbon balance model development on temporal and spatial scale. The tempo spatial simulations demonstrate the effect of microclimate variability on the carbon balances is captured well for carbon budget related studies in switchgrass ecosystem on a regional scale.

Potential impact of this study would be on regional level understanding of carbon sequestration since switchgrass acreage is in expansion phase for biofuel feedstock production.

Future Work

In order to make reliable predictions of carbon balance and better understand regional NEE

- We will explore the existing algorithmic techniques for filling gaps in the current data.
- We will calculate carbon budget for entire growing season.

Reference

Wofsy SC, Goulden ML, Munger JW, Fan SM, Bakwin PS, Daube BC, et al. Net exchange of CO2 in a mid-latitude forest. Science 1993;260(5112):1314-7.

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