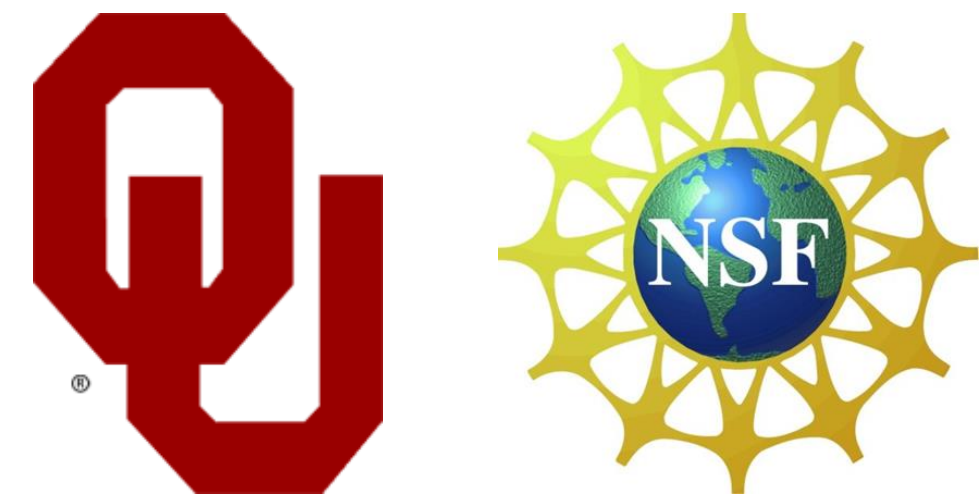


Responses of Evapotranspiration and Gross Primary Production of Forests and Grasslands to Drought in the Kiamichi Watershed of Southeast Oklahoma

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Introduction

- The forested Ouachita landscape of southeastern Oklahoma is suspected to play a significant role in Oklahoma's climate.¹
- There has been a dramatic reduction in Ouachita forest cover; for example, 93% of the Kiamichi watershed was forested in 1898 compared to 63% in 2006 (Figure 1).²
- A shift in species dominance has also occurred; what remains of the Kiamichi forest, once dominated by pure stands of shortleaf pine (*Pinus echinata*), is now about 62% deciduous forest (Figure 2).³
- Gross primary production (GPP) of vegetation is an important carbon flux and terrestrial ecosystems have the capacity to help offset anthropogenic carbon dioxide emissions.⁴
- 65% of precipitation on lands comes from terrestrial evapotranspiration (ET).⁵
- Has the reduction Oklahoma's forest cover and change in species dominance made Oklahoma more susceptible to drought?

Figure 1. Land cover types of the Kiamichi watershed in 1898 (A) and 2006 (B). County and state boundaries are included for reference².

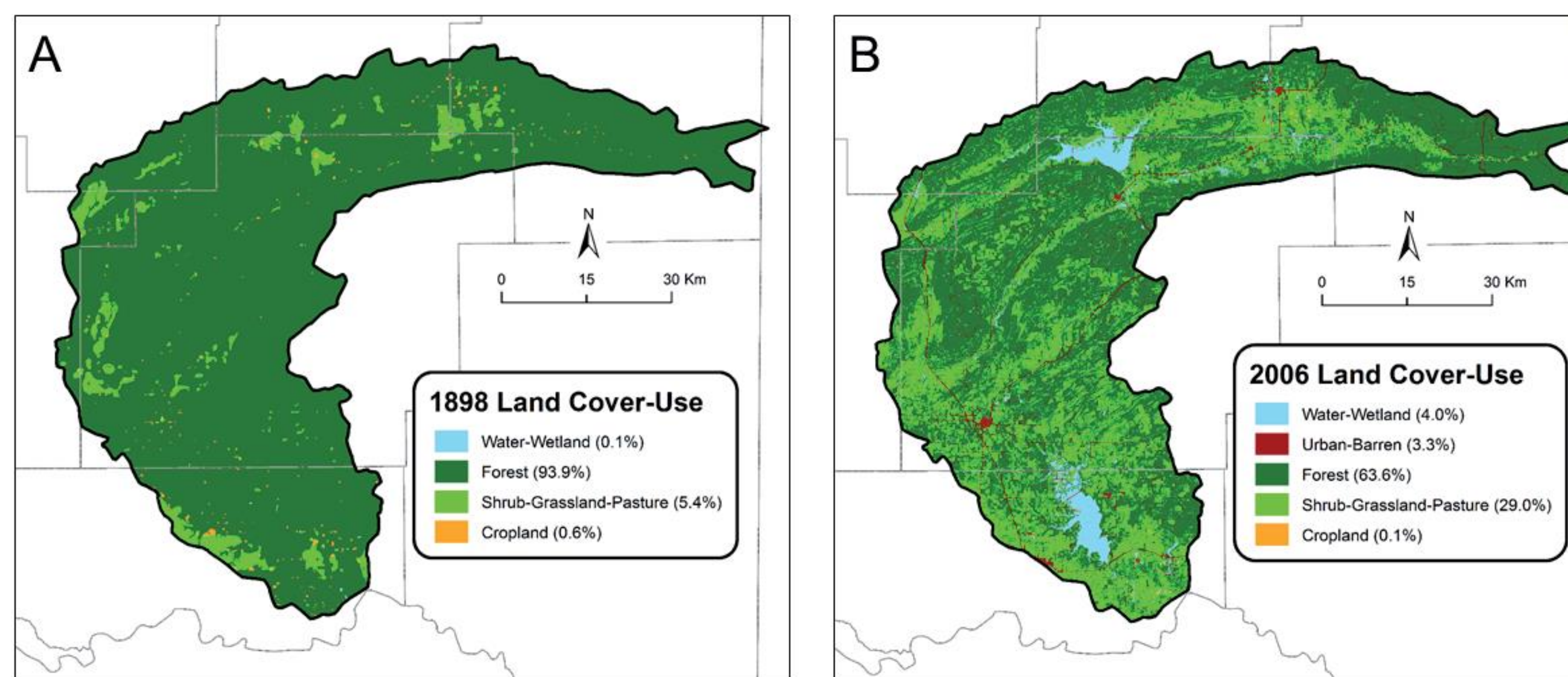
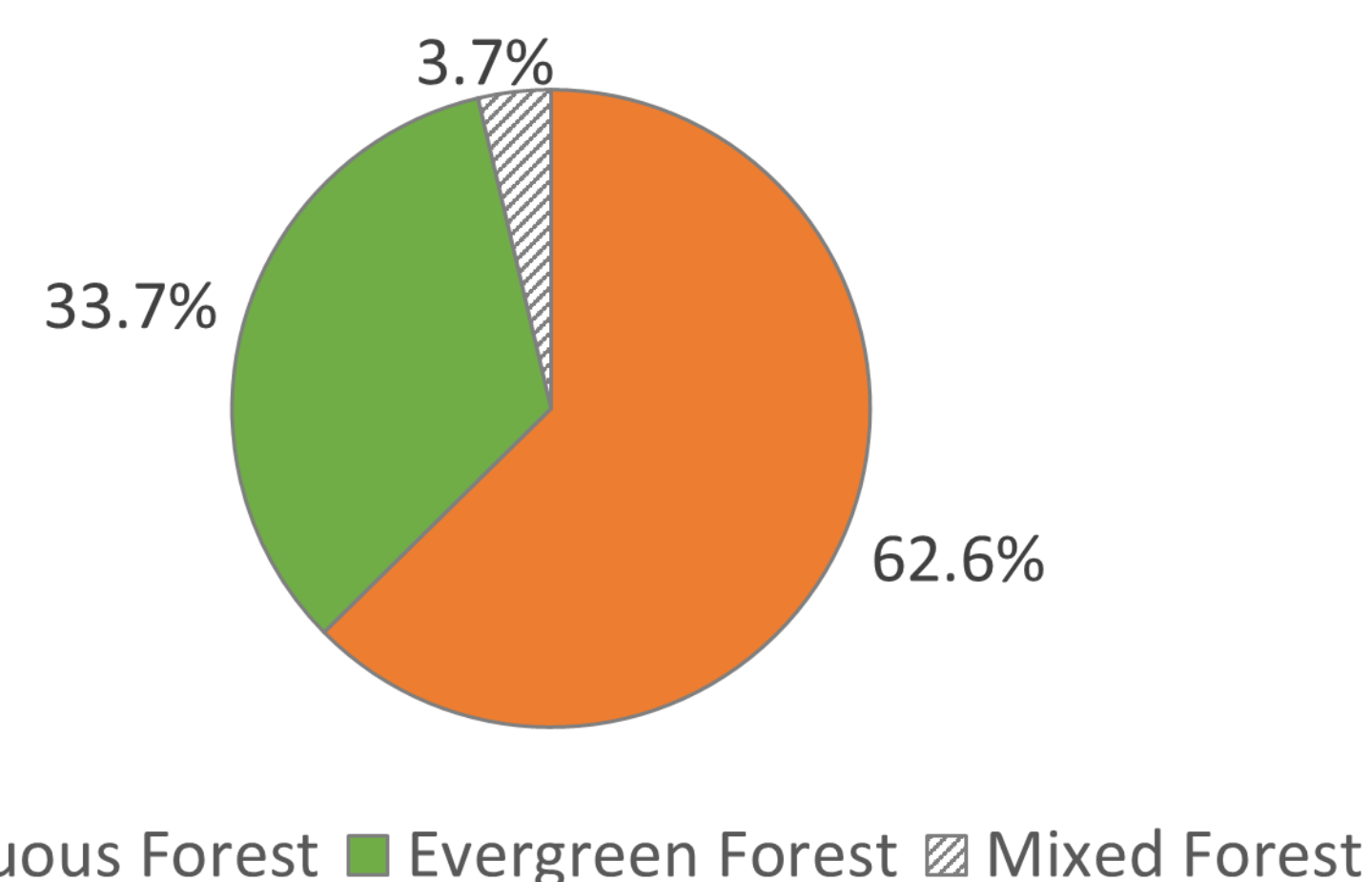


Figure 2. Forest cover types as a percentage of the total forest cover for the Kiamichi watershed in 2014.³ The basin was once dominated by shortleaf pine, but today the forest cover is primarily deciduous.



Objectives

- To assess the drought-sensitivity of evapotranspiration and gross primary production in evergreen forest, deciduous forest, and grassland/pasture.

Methods

- The Kiamichi watershed was selected as the study area; it contains sizable portions of land types and the watershed is recognized internationally as an imperiled ecosystem due to its high biodiversity and plethora of endangered species.
- Satellite-based remote sensing data was used to analyze the entire Kiamichi landscape for the years for which data is available, 2007-2014, which includes periods of drought.
- Cropland Data Layers (CDLs) from USDA NASS were used to map forest cover types and grassland/pasture at 30m spatial resolution.
- Gross primary production was calculated using the Vegetation Photosynthesis Model (VPM, or GPP_{vpm}), at 500m spatial resolution and 8-day temporal resolution.⁶
- Evapotranspiration data is derived from MODIS satellite (MOD16A3) at 1km spatial resolution and 8-day temporal resolution.⁷

Results

Figure 3. Mean annual evapotranspiration by land type. Evergreen forest had higher evapotranspiration on average during the drought year 2011 than deciduous forest and grasslands/pasture.

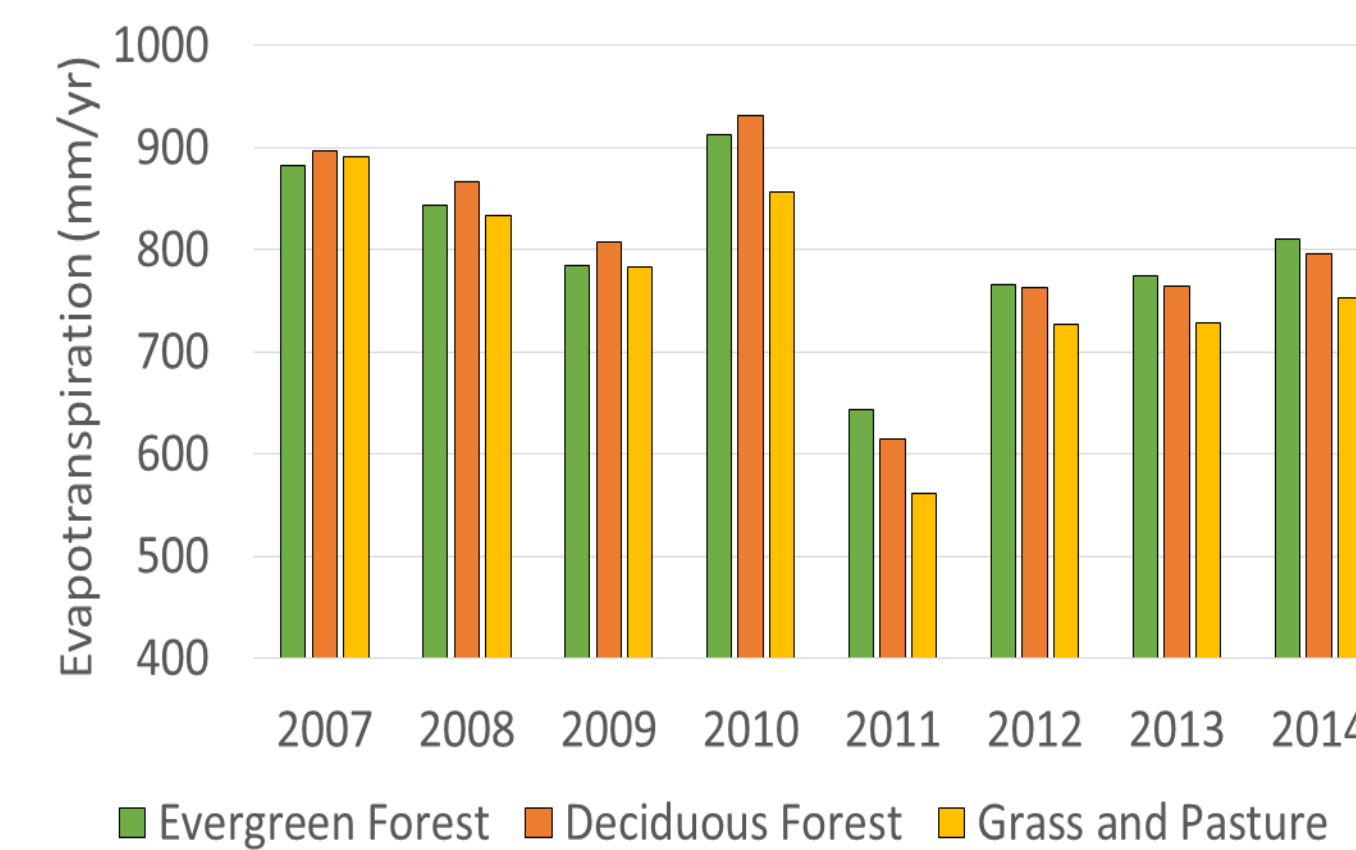


Figure 5. Standard deviation of annual evapotranspiration by land type, 2007-2014. The interannual variability of evapotranspiration for evergreen forest was much lower than other forest types and grasslands/pasture.

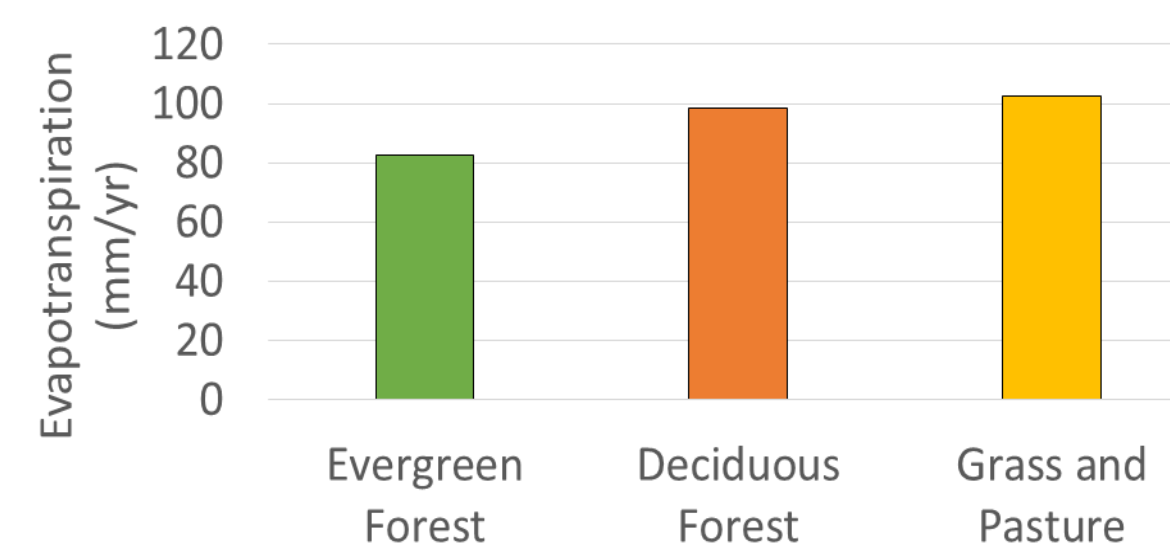


Figure 7. Total evapotranspiration in 2007.

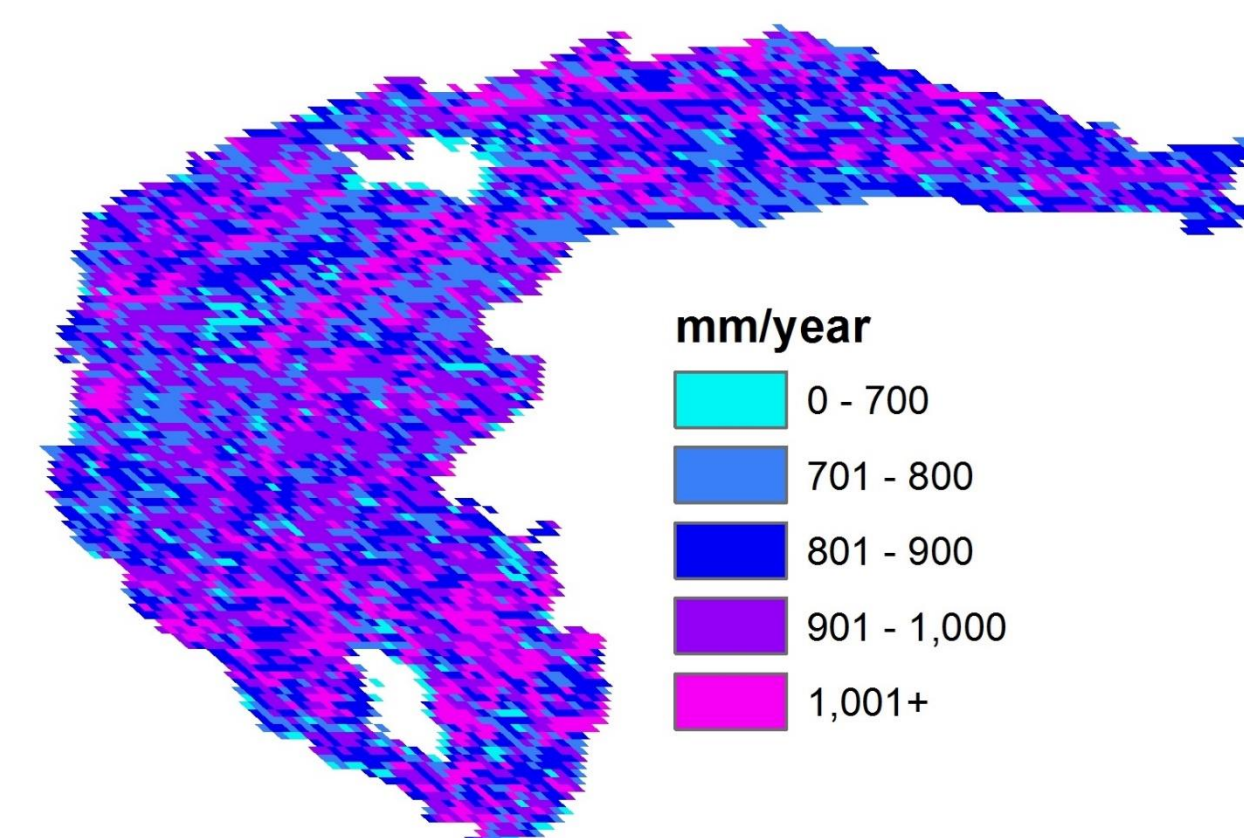


Figure 9. Total gross primary production in 2007.

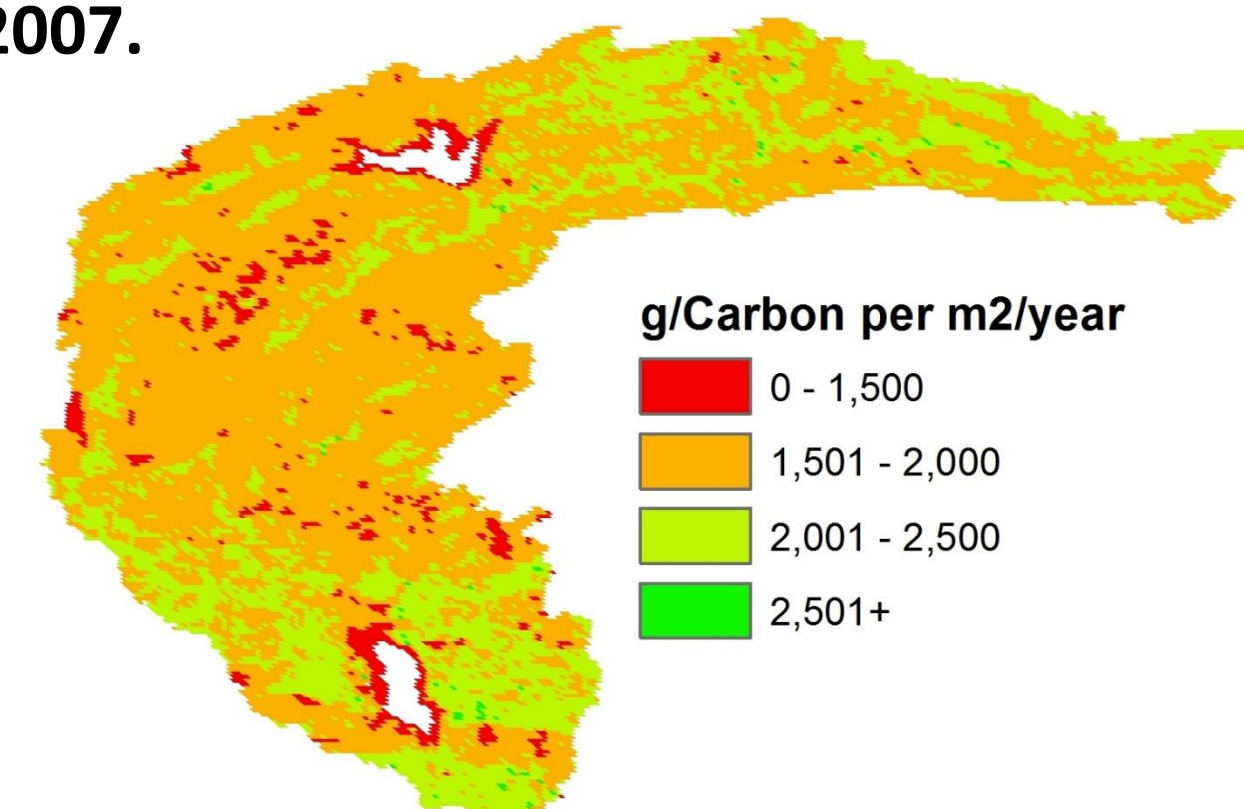


Figure 4. Mean annual gross primary production by land type. Evergreen forest had higher gross primary production on average during the drought year 2011 than deciduous forest and grasslands/pasture.

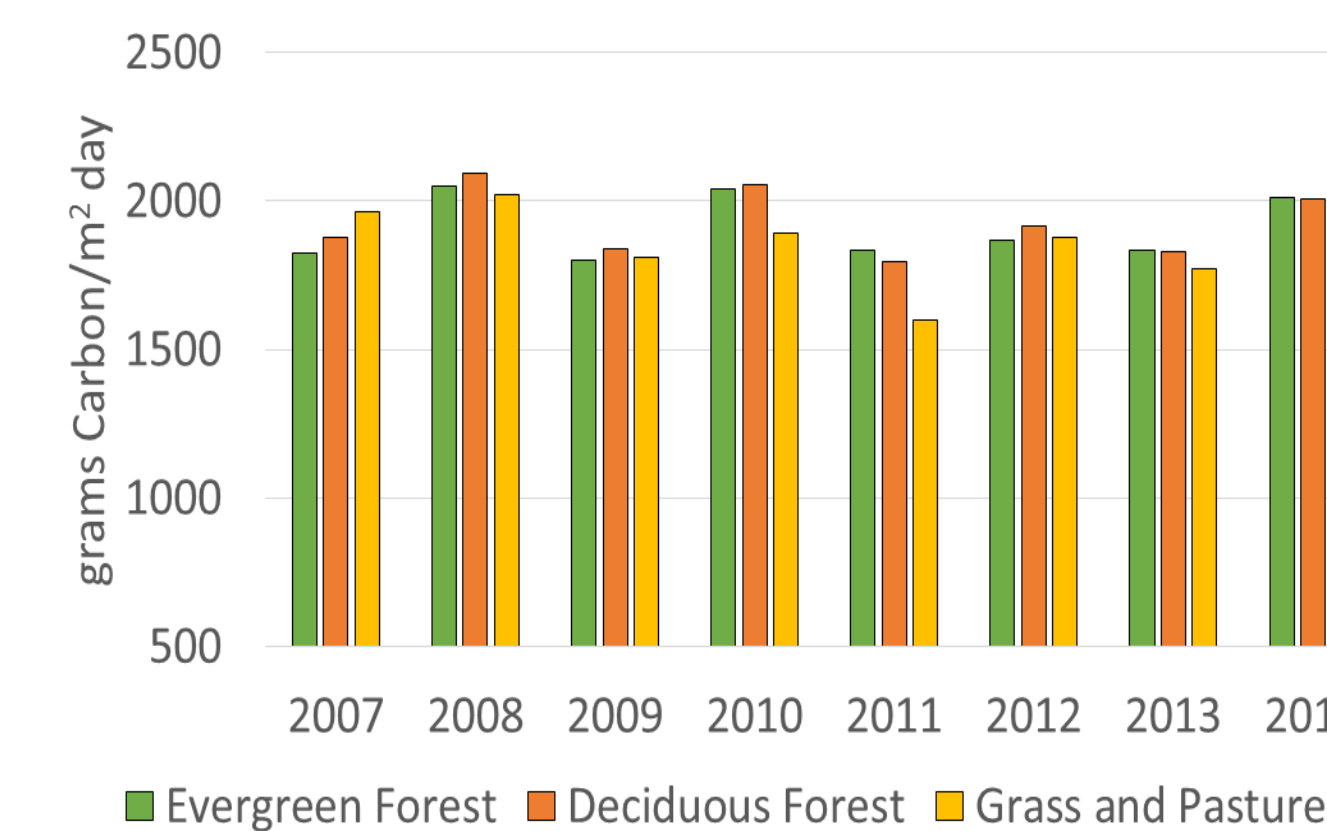


Figure 6. Standard deviation of annual gross primary production by land type, 2007-2014. The interannual variability of gross primary production for evergreen forest was lower than other forest types and grasslands/pasture.

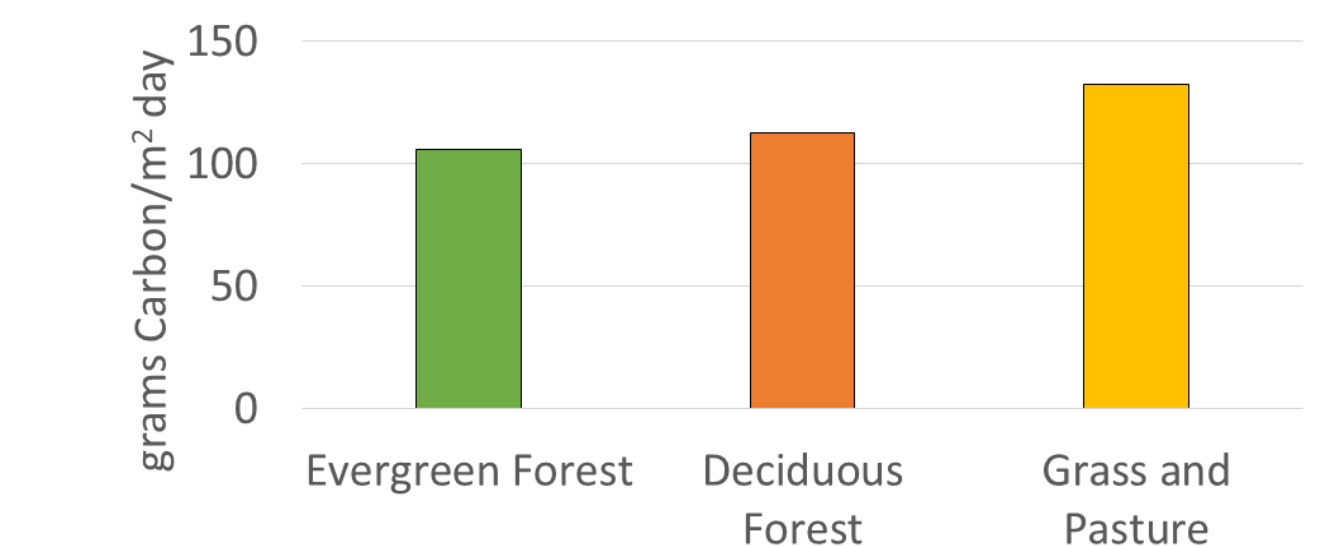


Figure 8. Total evapotranspiration in 2011.

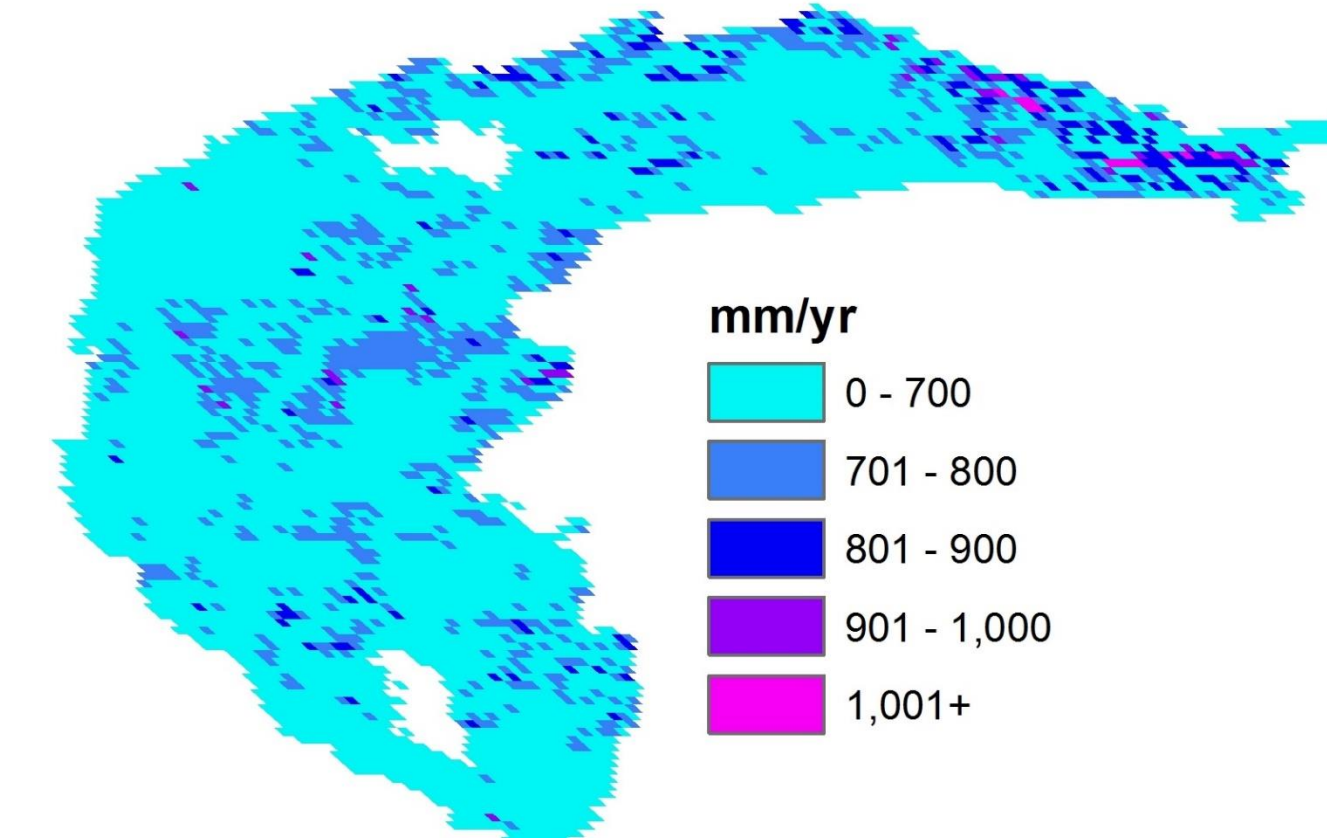
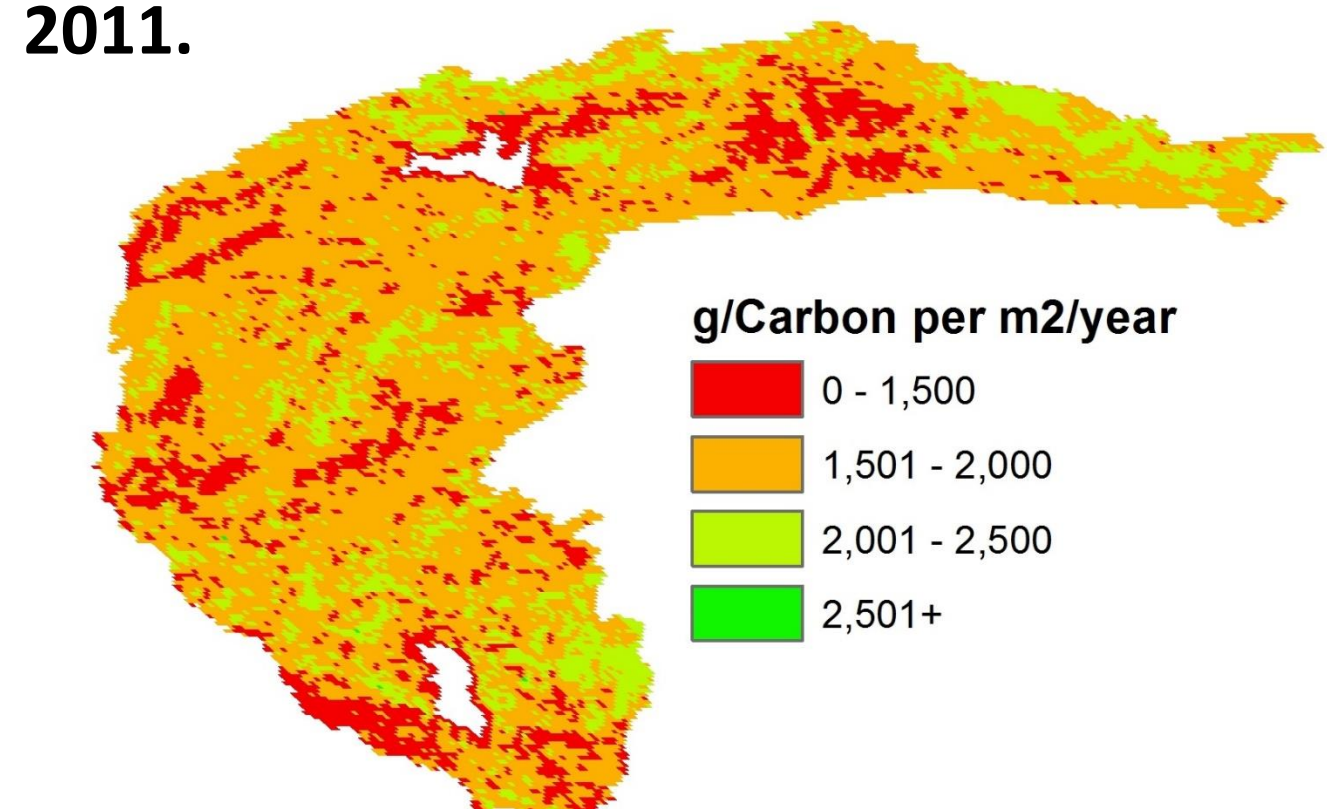


Figure 10. Total gross primary production in 2011.



Conclusions

- Evergreen forest in the Kiamichi watershed is more resilient to drought than deciduous forest and grassland/pasture.
- During drought, evergreen forest of the Kiamichi watershed has higher annual average evapotranspiration and gross primary production than deciduous forest and grassland/pasture.
- Evergreen forest has less inter-annual variability of evapotranspiration and gross primary production than deciduous forest and grassland/pasture.

Social Impact

- Oklahoma's highly variable climate is expected to become more extreme in the future.⁸ The state legislature and land managers are seeking for methods to make Oklahoma more resilient to future drought and changes in climate. The results of this study can help guide the state legislature and land managers make the most appropriate decision when selecting policy options and land management regimes.
- Future research on the potential benefit of increased evapotranspiration in the region on cloud formation, precipitation and temperature is encouraged. Analysis on the differences in seasonal canopy and surface temperatures between forest types would also help guide policy and land management decisions.

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