Title: **Integrating data and models to enhance our understanding of the effects and drivers of shrub encroachment in US tallgrass prairie**

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Project Abstract: Shrubs are encroaching upon and eradicating many grasslands across Earth, and we currently have very limited understanding about (1) why this is occurring, and (2) the resulting consequences for critical ecosystem services, such as carbon sequestration. Our project is designed to address both of these knowledge gaps through a combination of observational, experimental, and process-based modeling approaches in tallgrass prairie of eastern Kansas. More specifically, we have measured a wide range of above and belowground morphological and physiological characteristics of shrubs and grasses, as well as soil carbon turnover rates within the grass-shrub ecotone; we imposed a multi-year drought experiment to understand responses of grasses, shrubs, and carbon cycling to water stress; we are incorporating this empirical understanding into process-based models to test hypotheses about why shrub encroachment is occuring and to project impacts of encroachment on ecosystem carbon storage. In this Spark presentation, we will show findings associated with each of these approaches. Briefly, we found that shrubs had lower photosynthetic rates than grasses, but photosynthesis was more stable under drought, likely due to smaller yet more numerous conduits in roots. Instead of the expected increases in carbon storage by shrubs in deeper soils, we found less carbon storage across all depths under shrubs as well as carbon loss shrubs that have recently encroached on grasslands. By incorporating our empirical data into CLM-FATES and BiomeE, we are able to recreate historical (1983-current) patterns of shrub encroachment at our field site. We are using these models to test multiple drought-related mechanisms behind shrub encroachment, and find that drought events provide shrubs a foothold to advance into grass-dominated areas. Our initial model projections suggest that the consequences of shrub encroachment include a decadal reduction in soil carbon storage for these grasslands and that reversal back to grassland states is

difficult to achieve once shrub encroachment has occurred. In total, these findings highlight the importance of maintaining these grasslands into the future, especially as they are difficult to recover after being lost.