Diversity and Stability in Experimental Fields of Perennial Bioenergy Crops

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In this project our goal was to determine the effect of species richness on productivity and its change through time in perennial cropping systems designed for bioenergy production. For growers of biofuel feedstocks, yield stability may be an important secondary ecosystem service of diverse plantings, especially in the context of climate change and inter-annual variability in growing conditions. Experiments in community ecology have identified several mechanisms linking higher diversity to increased stability, yet these have not been tested in agro-ecosystems, which differ in many important ways from the communities used in these experiments. The strength of a relationship between plant diversity and stability may also vary with environmental context, thus comparing multiple sites is critical. By testing the importance of ecological mechanisms for achieving stable yields at two replicate sites, we will generate general recommendations for feedstock production.

Evidence from both community ecology and studies of candidate bioenergy crops suggests that diverse plantings may not outperform the most productive monocultures in terms of yield. Mixtures of many different species, however, may offer benefits for long-term sustainability that may offset smaller yields. One such ecosystem service is stability, or the consistency of production over time. The presence of multiple species intrinsically reduces temporal variance in the same way that grouping stocks together in funds reduces risk to investors; a phenomenon termed the portfolio effect in ecology. In addition to this statistical mechanism, however, the biological interactions between species can enhance stability. For example, different species (or functional groups) may respond in alternate ways to environmental change such that one may dominate in some conditions, and another in others. This niche complementarity between species increases stability. Lastly, in mixtures that are highly dominated by one species, the response of this species can determine the pattern over time. By examining biofuel plantings for evidence of these mechanisms, we aim to understand where and when diversity is stabilizing.

This project is a part of the Great Lakes Bioenergy Research Center’s biofuel cropping systems experiment (BCSE), which has two replicate sites at Kellogg Biological Station (Michigan) and Arlington Agricultural Research Station (Wisconsin). In this experiment, eight managed agroecosystems were established for candidate crops whose biomass may be used as feedstock for biofuel production. Several of these candidate cropping systems included perennial plants that are native to the Midwest region of the USA. Following establishment, small plots in these fields have been sub-sampled in July to determine ANPP (annual net primary productivity) and plant composition. These data are used for our analysis of temporal change and diversity.

In this poster we present results from the first five years of biomass production. Over this period, switchgrass was the most productive crop, although this was more dramatic at the Wisconsin site compared to Michigan. Each perennial cropping system developed a distinct plant community composition which differed from all others within a site, and across sites. We also observed significant change in the plant communities over time as the abundances of different species shifted. During the initial five years, the most diverse cropping system in terms of species richness (a mix of native prairie species) was not necessarily the most stable overall. Species richness, however, did have a weakly positive effect on stability at the Michigan site. By contrast, negative covariance between functional
groups (a measure of niche complementarity) always increased stability. Plots with a dominant species that produced a consistent amount of biomass year after year were also very stable overall. This suggests that including multiple functional groups and a stable dominant will be important for achieving stability in yield.

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