Can crop rotations facilitate surface water – groundwater connectivity to maximize yield during drought?

Adam Schreiner-McGraw, Jeffrey Wood, Lori Abendroth

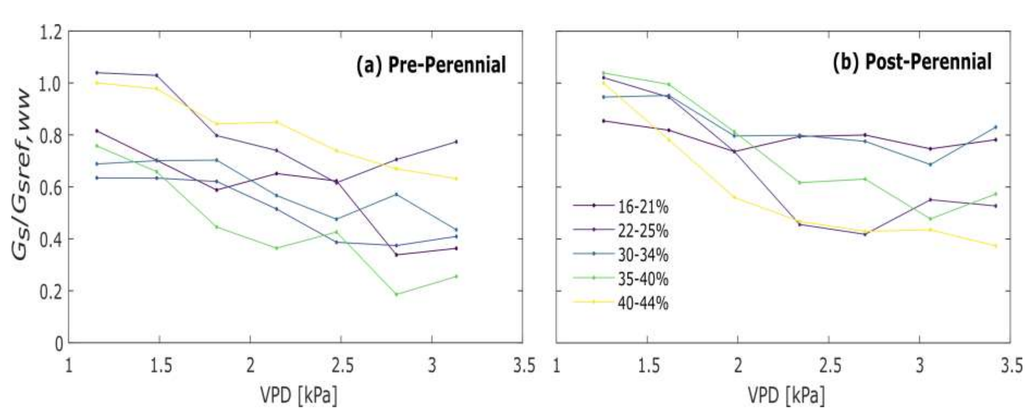
Introduction

- Crops in shallow soils are susceptible to drought.
- Shallow soils are common in the U.S. Corn Belt in Missouri and Illinois due to restrictive clay layer.
- Perennial hay crops with deep roots may create root channels and allow water to pass through clay layer.
- We evaluate the effectiveness of perennial crop in improving soil function and crop resilience to drought.

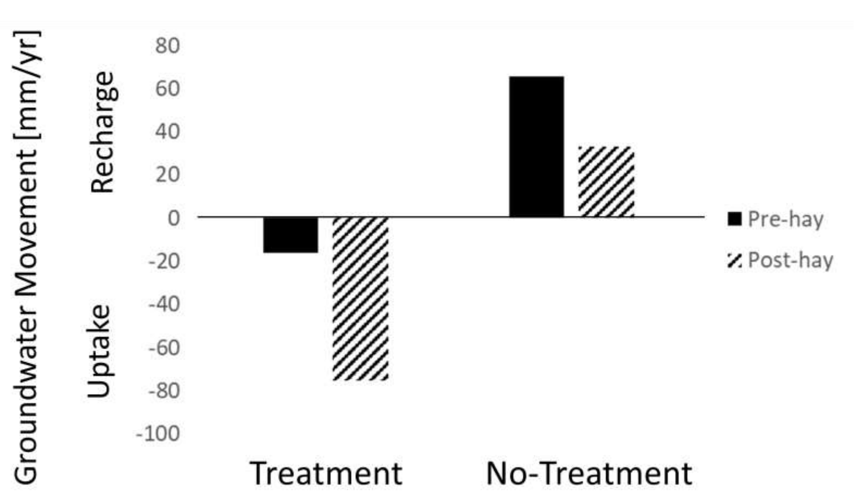
Methods

1. We use eddy covariance measurements of *ET* from before and after planting a perennial hay crop to quantify crop water use.
2. By inverting the Penman-Monteith equation we calculate the surface conductance (G_s) to water vapor.
3. A relatively constant relation between VPD and G_s across different soil moisture classes would suggest that the plants are using water that is stored beneath the surface soil zone, in the region that the hay roots have remediated.
4. Additionally, water balance measurements demonstrate that $ET+Q > P$ after the hay crop.

Results



- Following the perennial crop, soil moisture limitations on surface conductance are reduced, even though 2022 was a drought year.



- Water balance non-closure suggests significant uptake of groundwater (75 mm/yr) in the field after the hay treatment.

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A deep-rooted perennial crop created connectivity between soil water and groundwater in a shallow soil agricultural field.

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Extra Figures & Tables

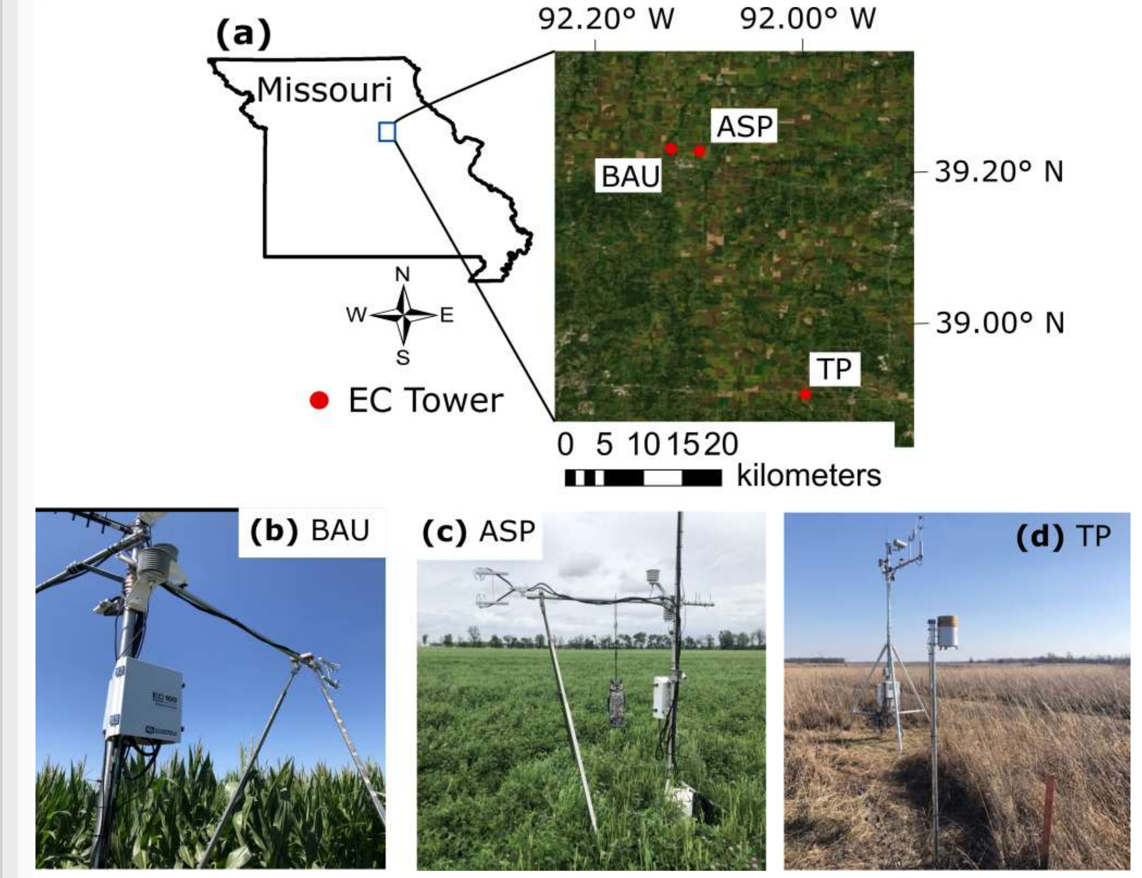

Figure 2: The (a) three study sites located within central Missouri, USA including photographs of the EC deployments at (b) the business-as-usual (BAU) field (July 24, 2020), (c) the aspirational management (ASP) field (May 25, 2021) , and (d) tallgrass prairie (TP; December 9, 2021).

Site	Year	Crop	Site	Year	Crop
ASP	**2016**	**Corn**	BAU	**2016**	**Soybean**
	2017	**Soybean**		**2017**	**Corn**
	2018	Wheat		2018	Soybean
	2019	**Soybean**		**2019**	**Soybean**
	2020	Wheat		2020	Corn
	2021	**Hay**		**2021**	**Soybean**
	2022	**Corn**		**2022**	**Soybean**

Table 1: Crop rotations used at the ASP and BAU sites during the study period. Bold years are used as "pre-perennial crop" years, bold and blue years are "post-perennial crop" years.

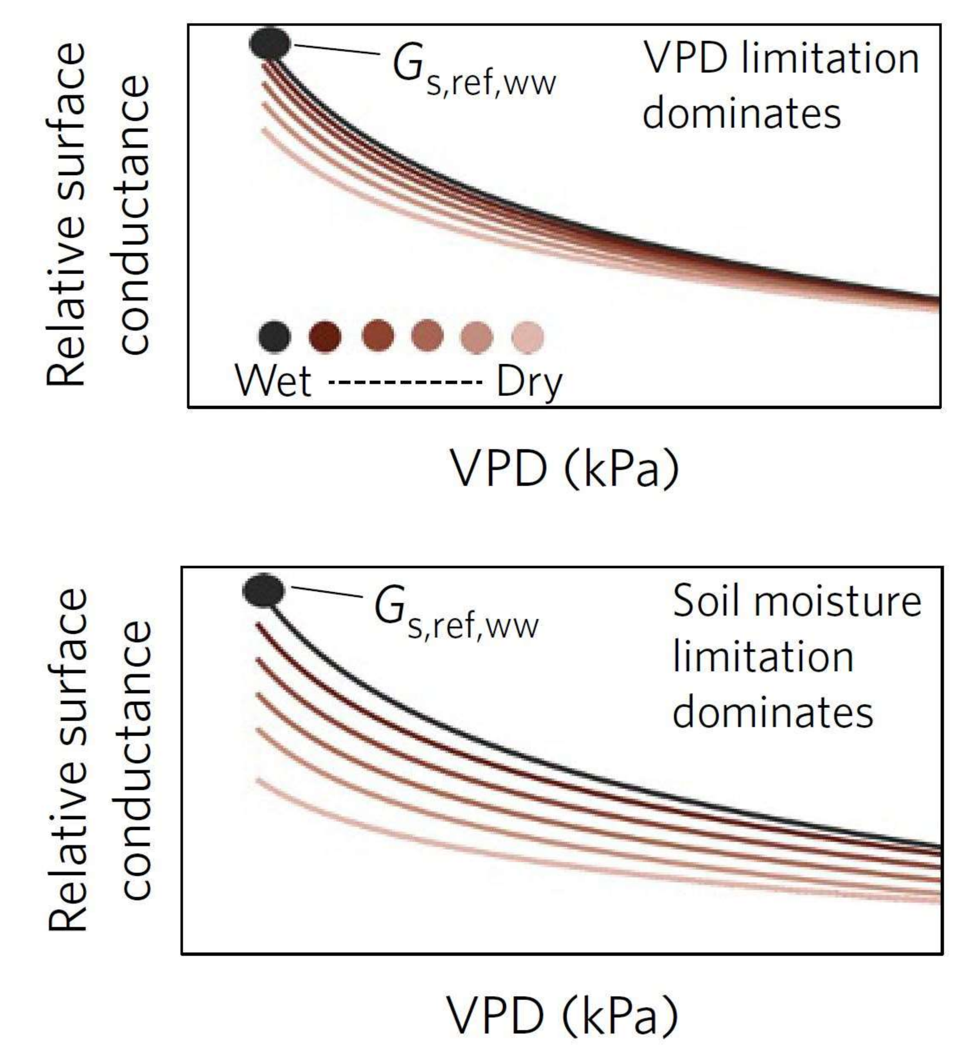

Figure 3: Adapted from *Novick et al. (2016), Nature Climate Change*. Predicted changes in the relationship between G_s and *VPD* as soil dries at a site where *VPD* limitations dominate (top), and where soil moisture limitations dominate (bottom).