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Insights from a network of long-term measurements of biosphere-atmospheric exchanges of water vapor and carbon dioxide in a water-limited semiarid region

Russell Scott and Joel Biederman

United States Department of Agriculture, Agricultural Research Service, Tucson, AZ United States of America (russ.scott@ars.usda.gov)

Around one-third of Earth's land surface is classified as semiarid, and carbon dioxide exchange in these regions has been shown to be an important regulator of both the trend and interannual variability of the terrestrial carbon sink. Fifteen years ago, when we began making measurements of biosphere-atmospheric exchanges of energy, water vapor, and carbon dioxide using eddy covariance in southern Arizona USA, there was paucity of semiarid observations in flux networks like AmeriFlux and EuroFlux. We started by establishing riparian sites across a woody plant encroachment gradient to quantify the productivity and consumptive plant water use along a iconic and ecologically important desert river. Soon thereafter, we added semiarid grassland, shrubland, and savanna sites that do not have access to groundwater in order to better understand how water limitation and changes in vegetation structure affect ecosystem productivity. Here, we highlight the value of multiyear, multisite flux data for addressing regional to global scale problems associated with groundwater pumping, land cover change, drought, and climate change. For the riparian sites, we find that ecosystem water availability is altered by vegetation structure such that ecosystems with more deeply rooted trees have higher productivity but at a cost of greater groundwater use. For the non-riparian sites, precipitation strongly controls ecosystem water availability and the resultant productivity, but differences in ecosystem structure impact water use efficiency due to the partitioning of evapotranspiration into its component sources. Also, the productivity at sites with more grass, and less woody, plants responds more quickly to precipitation fluctuations including long-term drought conditions. In semiarid regions, variability in water and carbon fluxes is much larger than in more mesic climes. Across our riparian and non-riparian sites, access to more stable groundwater reserves reduces variability in water and carbon fluxes and can decouple ecosystem productivity from precipitation. Finally, we show that the 8% increase in carbon dioxide concentrations over the period of our measurements may be altering ecosystem water use efficiency, a result that is expected and has been reported for northeastern US forests.