Shrubland Carbon Sink Depends Upon Winter Water Availability in the Warm Deserts of North America

Joel A. Biederman1, Russell L. Scott1, John A. Amone II2, Richard L. Jasoni3, Marcy E. Litvak3, Michael T. Moreo3, Shirley A. Papuga3, Guillermo E. Ponce-Campos3, Adam P. Schreiner-McGrav4 and Enrique R. Vivoni5

1USDA-ARS Southwest Watershed Research Center, 2Desert Research Institute, 3University of New Mexico, 4USGS Nevada Water Science Center, 5Wayne State University, 6Arizona State University

**Water and Carbon in Shrublands**
- Open shrubland is the most abundant land cover type on Earth ~ 14%
- Water availability is the strongest driver of shrubland Net Ecosystem Production (NEP)
- Evergreen desert shrubs can have both winter/spring and summer growing seasons

**Study Questions**
1. Does net carbon uptake in shrublands differ between summer and winter growing seasons?
2. How has the 21st-Century drought, with reduced winter precipitation, affected the net carbon uptake of shrublands in the Southwest?

**Water balance**
- NEP = Net Ecosystem Production
- GEP = Gross Ecosystem Photosynthesis
- \( R_{\text{eco}} \) = whole-ecosystem respiration

**Seasonality of 3 Deserts**
- Some precipitation (P) is lost to runoff (R) and drainage (D)
- Most of the remaining water recharges soil moisture (SM)
- SM is depleted by Evaporation and Transpiration (ET)
- Over seasonal to annual scale, ET is a metric of ecosystem-available water

**Study Design**
- 3 Deserts with different mean precipitation and winter/summer precipitation blend
- 6 Eddy Covariance sites with 2-8 years of data each
- Separate into winter (Nov-May) and summer (Jun-Oct)
- Winter/summer sums of P, ET, GEP, \( R_{\text{eco}} \), NEP

**3 Deserts Climate and Shrubland Extent**

**Lower Respiration Makes Winters Critical for Net C Sequestration**
- Water availability drives the same amount of gross photosynthesis in winter and summer
- Same WUE = GEP/ET in summer/winter

**Lower Winter P since 1999 Reduced Southwest Desert C Sequestration**
- Less winter P & ET in all 3 deserts
- Summers same or wetter
- NEP declines in winter, little change in summer
- Lower 21st-Century winter precipitation reduced net C sequestration of the 3 deserts by ~20% or 7 Tg C yr\(^{-1}\)

**Water and Carbon Fluxes Across Sites and Deserts**
- Mean GEP and ET are well-correlated (\( r = 0.73 \) to 0.89) suggesting similar water use efficiency WUE = GEP/ET
- Sites with significant winter rainfall (Src and Mgc) have greater NEP in winter than summer
- NEP differences result when Reco returns less C to the atmosphere in winter

**Water Balance using Eddy Covariance ET and Watershed Runoff and Drainage**
- Winter ET = P, all precipitation available
- Summer ET sometimes << P due to runoff and drainage
- Where available, independent measures of runoff and drainage close the water balance
- Supports the idea that seasonal ET indicates ecosystem-available water

**Thank You**
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