Responses of daytime net ecosystem carbon and water exchange to increased seasonal precipitation in a sotol-grassland at Big Bend National Park, Texas

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INTRODUCTION

Changes in the global climate system due to increased levels of CO_2 and other greenhouse gases are predicted to significantly impact the Earth's terrestrial ecosystems. These anthropogenic emissions have been linked to an increase in both air and soil temperatures, thereby affecting patterns of global air circulation and hydrologic cycling, including regional precipitation regimes. In particular, the Hadley Global Climate Model 2 predicts a 3°C increase in air temperature by 2100 which is expected to increase summer and winter precipitation by 25% in Big Bend National Park (BBNP). Since water is the critical limiting factor in desert ecosystems, alterations in the timing or magnitude of precipitation could significantly affect plant and soil communities through altering the relative contribution of each component of the ecosystem carbon and water balance (e.g. plant photosynthesis and respiration, soil respiration, evaporation and transpiration). The degree of change in these parameters following a rain event will depend on the length and severity of the interpulse period as well as the magnitude of the pulse. In this poster, we discuss the responses of the dominant C_3 shrub ecosystem at our study site in BBNP to a 25% increase in winter rainfall during 2005. Since changes in the fluxes of water and carbon to the ecosystem can be related to net ecosystem productivity, the alteration of this plant's physiological processes due to changes in precipitation patterns could significantly impact the composition of arid plant communities.

SITE DESCRIPTION

Research was conducted at the sotol-grassland within the Pine Canyon watershed at Big Bend National Park in the Chihuahuan Desert. The Chihuahuan Desert range extends from southern New Mexico and Texas into much of northern Mexico. Due to the rain-shadow effect of the Sierra Madre ranges, the Chihuahuan Desert receives little precipitation, usually averaging about 360 mm annually, although this can fluctuate from 76 to 508 mm. About 65-80% of this annual rainfall occurs from mid-June to mid- September. At an elevation of 1526 m, the dominant plant species in the sotol-grassland of Pine Canyon are: *Dasylirion leiophyllum* (sotol, C3), *Bouteloua curtipendula* (side-oats grama, C4), and *Opuntia phaeacantha* (brownspine prickly pear, CAM).

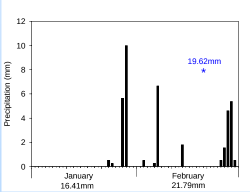


Figure 1: Daily precipitation at study site in BBNP in 2005. Time and magnitude of supplemental water addition is indicated by the star.

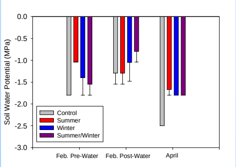


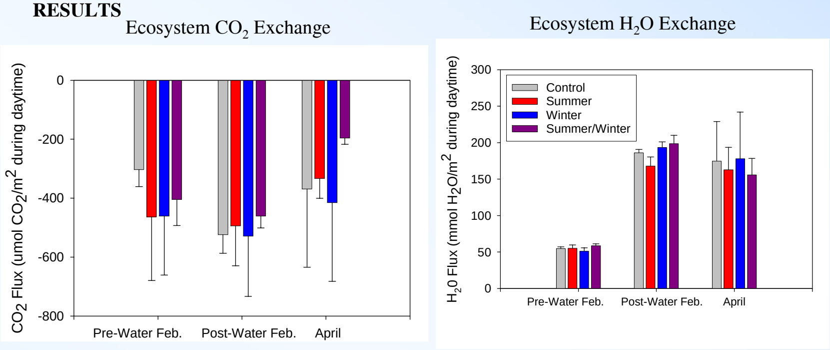
Figure 2: Soil moisture data for all plots during the time of ecosystem flux measurements. Soil moisture increased in watered plots post-water in Feb.

QUESTIONS

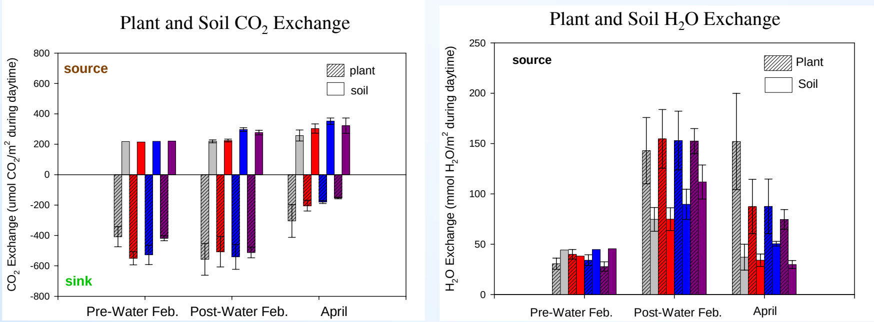
❖ How will a 25% increase in winter rainfall affect total ecosystem carbon and water exchange in the sotol-grassland of Big Bend National Park?

❖ Can individual plant and soil responses be scaled to the ecosystem level to predict ecosystem carbon and water exchange?

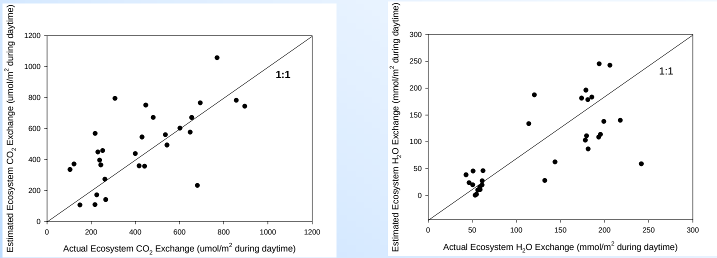
RESULTS



Figures 3a and 3b: Average ecosystem carbon and water exchange for all *Dasylirion* ecosystem plots. Negative values indicate carbon or water uptake by the ecosystem (sink), while positive values indicate carbon or water loss by the ecosystem (source).



Figures 4a and 4b: Average plant and soil carbon and water exchange during daytime for all *Dasylirion* ecosystem plots. Negative values indicate carbon or water uptake by the ecosystem (sink), while positive values indicate carbon or water loss by the ecosystem (source).



Figures 5a and 5b: Measured ecosystem carbon and water exchange compared with calculated values (scaled leaf photosynthesis, leaf transpiration, soil respiration and soil evaporation). Values above the 1:1 line indicate overestimation, while values below represent underestimation.

METHODS

• Twelve plots (1 m by 0.5 m) contain one individual of *Dasylirion leiophyllum*. Each year for the past three years, water has been added to the plots to simulate a 25% increase in precipitation: 1) no water addition (C), 2) summer water addition only (S), 3) winter water addition only (W), and 4) summer and winter water additions (SW).

• In February 2005, 19.6 mm of water (25% of ambient rainfall for Nov, Dec, Jan) was added to the winter addition and summer/winter addition plots. Measurements were taken over the course of 12 hours during the day both pre- and post-watering in Feb. and also in April.

• Whole-plot CO_2 and H_2O exchange were measured inside the chamber with a LI-7500 and instantaneous measurements of leaf gas exchange (photosynthesis, respiration, stomatal conductance, transpiration) were measured using a LI-6400. Soil surface fluxes of CO_2 and H_20 were measured using the Li-6400-09 Soil Flux Chamber.

• In order to scale leaf-level measurements to the ecosystem level, leaf area index was measured with a portable PAR/LAI ceptometer. Total daytime fluxes of CO_2 and H_20 on both individual and ecosystem scales were calculated by integration in SigmaPlot.

•Ecosystem carbon flux = Plant photosynthesis/respiration + Soil respiration

•Ecosystem water flux = Plant transpiration + Soil evaporation

CONCLUSIONS

• During the daytime, these ecosystems are a carbon sink, where plant photosynthesis > soil respiration.

•Ecosystem carbon and water exchange are not affected by the watering event. In April, however, more CO_2 is being lost to the atmosphere in SW plots.

• Plant photosynthesis is not affected by the watering event, while soil respiration does increase in supplementally watered plots the day after watering in February.

• Plant transpiration is not affected by the watering event, but both soil respiration and soil evaporation increase in supplementally watered plots the day after watering.

• Overall ecosystem responses to watering are primarily driven by soil respiration.

• Scaling plant and soil processes from the individual plant and soil level to the ecosystem level is possible in the sotol-grassland ecosystem.

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