Plant Water Use in Owens Valley, CA: Understanding the Influence of Climate and Depth to Groundwater

Diane E. Pataki
Departments of Earth System Science, and Ecology and Evolutionary Biology
University of California, Irvine

There is a long standing controversy in Owens Valley, California about the role of water exports in local vegetation change, particularly the loss of grasslands and the expansion of shrublands. While previous studies have focused on water availability as a primary mechanism of shrub expansion, our measurements of soil organic matter and nitrogen availability indicate that nutrient cycling may be a key variable linking ecology and hydrological processes in the valley.

Owens Valley, California has been the site of redistribution of groundwater for almost 100 years. There is a long standing controversy in the region surrounding the potential influence of groundwater exports on the local vegetation of the valley, which is at the transition between the Mojave and the Great Basin Deserts. In 1991, Inyo County, where Owens Valley is located, and the Los Angeles Dept. of Water and Power signed an agreement stating a goal of water management in the valley must be to avoid changes in local vegetation cover that cannot be acceptably mitigated. To reach this goal, the linkage between hydrology and ecological processes in semi-arid but shallow groundwater ecosystems must be greatly improved, as the impacts of altered hydrology on vegetation is still quite poorly understood.

In this study, we evaluated plant access to groundwater in both grass and shrub species at grass-dominated and meadow-dominated sites in Owens Valley near Bishop, CA. Of particular concern is the loss of grasslands due to encroachment of shrub species such as *Atriplex torreyi* (Torrey's saltbush), *Sarcobatus vermiculatus* (greasewood), and *Ericameria nauseosa* (rubber rabbitbrush). It is has long been assumed that grass species in the valley are more shallowly rooted than shrub species, and are out-competed by shrubs when the water table is lowered beyond the rooting zone. However, the maximum rooting depth of the common species in Owens Valley is unknown. In addition, woody encroachment is a global phenomenon that has been documented in many ecosystems worldwide that do not have shallow water tables. Rather, grazing and climate change are commonly cited reasons for the expansion of shrubs into grasslands. It is not clear if altered hydrology has or will in the future cause a loss of grasslands in Owens Valley.

The isotopic composition of plant stem water can be used to determine if plant water sources are dominated by deep soil/ groundwater or shallow surface water. This is because shallow surface water is isotopically enriched (meaning it contains more of the heavy vs. light isotope) due to evaporation. We measured the isotopic composition of grass and shrub stem water along a gradient of decreasing grass cover. We found that grasses do indeed appear to lose contact with the water table in late summer, which corresponds to a reduction in grass transpiration. However, the correlation between access to groundwater and

transpiration is not as great as we expected. Grass transpiration is low at our shrub-dominated site regardless of access to groundwater, and shrub transpiration shows spatial and temporal pat-terns that do not correspond well to access to groundwater. Clearly, factors other than groundwater depth and plant access are limiting transpiration in Owens Valley.

Our measurements of soil organic matter (SOM) and nutrient availability indicate that nutrient cycling may be a key variable linking ecology and hydrological processes in the valley. There is a large gradient of soil carbon (C) and nitrogen (N) content across our grass to shrub gradient, with the highest SOM and total N at the grassland site and the lowest as the shrub site (Figure 1). This corresponds well to the pattern of gas exchange at the three sites. It is known that N availability may strongly limit gas exchange due to the high N re-quirement in synthesizing photosynthetic enzymes. For the shrub species at our sites, it appears that plants have constant access to groundwater but have less access to N at the end of the season and at more shrub-dominated sites.

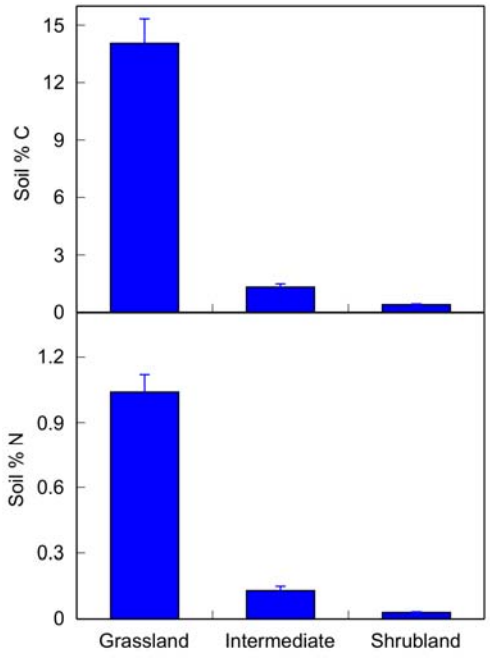

Figure 1. Soil C and N content in the top 5 cm at a grassland, mixed grass-shrubland, and shrub dominated site in Owens Valley.

This finding has led to a new direction in our work. We would like to quantify the link between groundwater depth, vegetation composition, and N cycling in Owens Valley. Nutrient cycling is rarely incorporated into hydrologic models, yet it is likely to be a primary limitation for transpiration. Our results imply that N cycling and availability may improve hydrologic modeling, which is critically important for water resource management. In addition, to explore the management implications of these findings we would like to address the question: does woody encroachment cause a reduction in N availability or do shrubs encroach sites that are already N limited? The answer will provide information about the causes and possible mitigation strat-egies for vegetation changes in Owens Valley.

Collaborative Efforts

We are collaborating with S. Trumbore at UC Irvine to further explore differences in how grasses and shrubs allocate biomass belowground to roots. We are also collab-orating with S. Billings at the University of Kansas to study the biogeochemistry and N cycling in soils from our sites to determine the underlying reasons for differences in N availability. We have written a proposal (currently pending) to NSF with Trumbore, Billings, and J. Famiglietti at UC Irvine to incorporate an improved understanding of ecosystem dynamics into a full hydrologic model of inflows, outflows, and groundwater depth in Owens Valley. The study would contribute to the field of ecohydrology at the interface between the two disciplines.

The Los Angeles Department of Water and Power (LADWP) gave us permission to establish study sites on their property. LADWP, their primary contractor MWH, Inc., and the County of Inyo have all been very helpful and have shared the results of their previous studies in the valley with us.

For further information please contact:

Diane E. Pataki
dpataki@uci.edu
(949) 824-9411
http://www.ess.uci.edu/~dpataki/