Shirley Anne Papuga

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Summary

I am an internationally recognized leader in the hydrologic sciences with skills that have helped in securing funding for, maintaining productivity in, and generating enthusiasm around research and education related to ecohydrology and water resources. I tackle environmental problems using an interdisciplinary approach that engages multiple stakeholders with diverse perspectives. My goal is to use earth science as a platform to empower our youth with the skills and knowledge necessary to thrive and lead us through the complex and intertwined social, economic and environmental challenges of the 21st century.

Highlights

- Scientific leader in hydrological sciences with history of success in interdisciplinary research efforts
- Highly-respected research mentor and classroom instructor for undergraduate and graduate students
- Accomplished in securing and managing competitive grants
- Experienced and effective in oral and written presentation of scientific knowledge to a variety of audiences
- Expert in analyzing quantitative and qualitative data

Research Interests

ecohydrological processes | critical zone dynamics| land surface – atmosphere interactions | coupled human – natural systems |soil moisture | stable water isotopes | water sustainability and green infrastructure

Education

2006 PhD **Geological Sciences (Hydrology Focus)** **University of Colorado – Boulder, CO**
Relevant Coursework: *Vadose Zone Hydrology; Global Biogeochemical Cycles; Computational Modeling of Surface Processes; Hillslope Hydrology*

2000 - 2002 **Earth and Environmental Science** **New Mexico Tech – Socorro, NM**
Relevant Coursework: *General Physics 1; General Chemistry 1; General Chemistry 2; Plant-Water Dynamics; Surface Water Hydrology; Groundwater Hydrology; Groundwater Hydrology Lab; Hydrogeochemistry; Field Methods in Vadose Zone Hydrology; Flow and Transport in Hydrologic Systems; Contaminant Hydrology*

1998 - 2000 **Environmental Sciences** **University of Virginia – Charlottesville, VA**
Relevant Coursework: *Ecological Issues in Global Change with Lab; Hydrology & Transport Processes; Fluid Mechanics 1; Geomorphology; Numerical Methods in Hydrology; Current Research in Hydrology; Engineering Mathematics; Environment & Meteorology & Climate; Remote Sensing of the Land Surface*

1998 BA **Mathematics** **Kalamazoo College – Kalamazoo, MI**
Cum Laude
Relevant Coursework: *Calculus 1; Calculus 2; Linear Algebra and Vectors; Calculus 3; Intro to Computer Science with Lab; Topics in Pure and Applied Mathematics; Probability; Discrete Mathematics; Energy and the Environment; Automata, Formal Languages, and Computability; Intro to Programming with Lab; Real Analysis 1; Modern Algebra 1; Mathematical Statistics*

Professional Work Experience

Associate Professor	**Wayne State University**, Detroit, MI *Department of Geology* *Environmental Science Program*	08/2017 – present
Associate Professor	**University of Arizona**, Tucson, AZ *School of Natural Resources & the Environment* *Department of Hydrology & Water Resources* *Department of Soil, Water & Environmental Science*	07/2013 – 08/2017
Program Chair	**University of Arizona,** Tucson AZ *Watershed Management & Ecohydrology Program*	05/2013 – 05/2016

	School of Natural Resources & the Environment	
Assistant Professor	**University of Arizona,** Tucson AZ *School of Natural Resources & the Environment* *Department of Hydrology & Water Resources* *Department of Soil, Water & Environmental Science*	01/2007 – 06/2013
Post Doc	**University of Michigan,** Ann Arbor, MI *School of Natural Resources*	08/2006 – 10/2006
Research Assistant	**University of Colorado,** Boulder, CO *Department of Geological Sciences*	08/2002 – 08/2006
Research Assistant	**New Mexico Tech,** Socorro, NM *Department of Earth & Environmental Science*	08/2000 – 08/2002
Research Assistant	**University of Virginia,** Charlottesville, VA *Department of Environmental Sciences*	08/1998 – 08/2000
G Research Assistant	**Los Alamos National Lab,** Los Alamos, NM *Earth & Environmental Science*	05/1998 – 08/1998
U Research Assistant	**Los Alamos National Lab,** Los Alamos, NM *Earth & Environmental Science*	08/1997 – 12/1997

Honors and Awards

2014/2015/2016	Public Voices Fellowship Nominee
2015	SNRE Outstanding Faculty Award
2015	SNRE Outstanding Dissertation Award (*for Guido*)
2014	AGU 2013 Editor's Citation for Excellence in Refereeing (*Water Resources Research*)
2014	CALS Nominee for UA 1885 Society Distinguished Scholars Award
2014	SNRE Outstanding Dissertation Award (for Sanchez-Mejia)
2013	NSF Early Career Development (CAREER) Award in Hydrologic Sciences
2012	UA College of Ag and Life Sciences Research Career Development Award
2011	SNRE Outstanding Scholarly Achievement Award
2010	Nominated for the UA College of Ag and Life Sciences A+ Advisor Award
2010	Santa Fe Institute Global Sustainability School Fellow
2008	Wakonse Teaching Fellow

Teaching Experience (Courses)

In all of my courses I emphasize experiential and hands-on learning. I am acutely aware that people learn by different means and by different experiences. Furthermore, especially as environmental science problems become increasingly interdisciplinary, the diversity of students that we will have to educate becomes greater. We must be able to meet the needs of this diverse student population. As a teacher and mentor, I aspire to create a learning environment that offers multiple opportunities for students to see how components fit together.

My Current Course(s):

Global Change and the Ecohydrology of Cities, Wayne State University Instructor

A mixed graduate/undergraduate course using peer-reviewed literature to explore how the interrelated hydrology and ecology of cities are influenced by global change. We look at recent advances in how hydrology and ecology are studied and valued in urban ecosystems. We also look at how these advances are being developed in a way that can be understood by the general public to engage them in global change issues. While our readings may not be specific to Detroit, we relate each reading to Detroit-specific issues in our student-led discussions

Environmental Systems Analysis, Wayne State University Instructor

An undergraduate course emphasizing a systems thinking approach to environmental changes that occur on a variety of spatial and temporal scales and impact our intertwined Earth spheres. We engage with multiple examples of real world environmental issues. The goal of this course is to train students to be able to analyze environmental changes and to develop the skills to anticipate and respond to

management and policy issues that arise from these changes using an earth system approach.

Research Internship, Wayne State University Instructor

An undergraduate internship opportunity designed to get students active in research through development of an independent project. The students will learn to develop hypotheses, work with data to address those hypotheses, and convey their scientific findings to different audiences.

My Former Courses:

Watershed Hydrology (with Lab), University of Arizona Instructor

A mixed graduate/undergraduate lecture/lab combo course with field trips, emphasizing the practical aspects of hydrology. The lecture portion of this course is taught in a computer classroom to enable actively working with simple models and datasets. The lab portion of the course engages students in hands-on measurements.

Air and Water: Physics of Environmental Fluids, University of Arizona Instructor

A mixed graduate demonstration-oriented undergraduate course introducing environmental fluid mechanics and how the peculiar properties of air and water influence life in the watershed.

Using MATLAB® for Environmental Data Processing, University of Arizona Instructor

A graduate student course geared at helping students from multiple disciplines handle their large and often overwhelming data sets.

waterWRLD: water as a platform for Workforce Readiness and Leadership Development (Internship Program), University of Arizona Program Coordinator

A year-long experiential program designed to provide UA students with real world opportunities to develop workforce-relevant skills by engaging with the community on water-related issues in partnership with local Tucson 501(c)3 non-profit Watershed Management Group.
waterwrld.arizona.edu

Practical and Applied Hydrometeorology, University of Arizona Instructor

A graduate student course geared at helping students use data from eddy covariance and other micro-meteorological instruments to work on applied problems. For instance, we have installed flux towers in local pecan orchards to initiate the development of a region-specific empirical model for crop coefficients that account for the climate-triggered temporal dynamics in pecan phenology.

Other Teaching Experiences:

Summer 2011/2012	**Flux Measurements and Advanced Modeling** (Monson/Moore) University of Colorado Mountain Research Station	Co-Instructor
Spring 2011/2012/2013	**Soil Physics** SWES 470/570, University of Arizona	Guest Lecturer
Spring 2007	**Advanced Watershed Hydrology** WS M 467/567, University of Arizona	Guest Lecturer
Fall 2005	**Introduction to Physical Geology** University of Colorado	Teaching Assistant
Spring 2000	**Physical Hydrology** University of Virginia	Teaching Assistant
Spring 1999	**Environmental Fluid Mechanics** University of Virginia	Teaching Assistant

Teaching Experience (Advisees)

My current active research group consists of two MS students (at University of Arizona), five undergraduate students, and a web specialist (at University of Arizona). Since starting my academic career in 2007, I have served as the major advisor for five PhD students and eight MS students that successfully graduated; each of them is currently employed in a position for which their graduate degree played an important role in preparing them. I have also mentored several undergraduate students on independent projects, multiple of who have presented their projects at national meetings and gone on to graduate school. In addition to my own research lab, I have also

served and currently serve on multiple committees for MS and PhD students.

Graduated MS Students (8 Total):	Graduated PhD Students (5 Total):
Rotunno (2016), Szutu (2015), Kidder (2014), Nelson (2011), Bunting (2010), Martin (2009), Cavanaugh (2009), Benton (2009)	*Guido (2014), Cendrero-Mateo (2013), Sanchez-Mejia (2013), Neal (2012), Bunting (2012)*

Professional Service and Outreach

Appointed Boards and Advisory Committees:

Hydrologic Sciences Awards Committee — American Geophysical Union — 2018 - present
Member — *Washington, DC*

As part of the American Geophysical Union (AGU) Hydrology Section, the role of the Hydrologic Sciences Awards Committee is to review and evaluate nominations and letters of support for Hydrology Section awards.

Ecohydrology Technical Committee — American Geophysical Union — 2013 - present
Chair (2017); Deputy Chair (2015/16) — *Washington, DC*

As part of the American Geophysical Union (AGU) Hydrology Section, the Ecohydrology Technical Committee organizes and promotes ecohydrology sessions at AGU meetings and advances ecohydrology through conferences, publications and dissemination of new findings.

Board of Directors — Watershed Management Group, NGO — 2015 - 2016
Member, Governance Committee — *Tucson, AZ*

Watershed Management Group (WMG) develops community-based solutions to ensure long-term prosperity of people and health of the environment. They provide knowledge, skills, and resources for sustainable livelihoods. Board Members promote fundraising efforts and assist with strategic planning.

Student Engagement Committee — UA Office of Student Engagement — 2015 - 2016
Member — *Tucson, AZ*

This committee of faculty and staff evaluates and approves non-credit engaged learning experiences for University of Arizona students. It also oversees the distribution of central investments, expanding opportunities for students to graduate with "Engaged Learning Experience" notation on their transcript.

Internal Advisory Committee — UA Water, Environmental and Energy Solutions — 2014 - 2016
Member — *Tucson, AZ*

Established by the UA and the Arizona Board of Regents Water, Environmental, and Energy Solutions (WEES) is a funding initiative to support interdisciplinary and cross-sector collaborations concerning scientific, technological, and policy-related solutions to Arizona's water, environment, and energy issues.

Strategic Planning Committee — UA School of Natural Resources / Environment — 2013 - 2016
Tucson, AZ

Strategize for increasing student enrollment, generating new streams of revenue, and increasing potential for conducting cutting edge research. Evaluate potential in alternative educational programs, increased social media presence, strengthening alumni network, donor cultivation and marketing.

City of Tucson Citizen Task Force — Broadway Boulevard Improvement Project — 2012 - 2016
Member — *Tucson, AZ*

Use a "Context Sensitive Solutions" framework for public participation to understand diverse interests affected by project. Work with Project Team to design roadway concept that considers needs of all modes of transportation, maintains and strengthens a sense of community, and encourages economic vitality.

Neighborhood Board — Broadmoor-Broadway Village Neighborhood — 2010 – 2016
President (2010;2014; 2015) — *Tucson, AZ*

Hold monthly board meetings, bi-annual neighborhood meetings, meet with City officials, and work with volunteers to organize several neighborhood events and projects throughout the year. Organize the quarterly newsletter, manage the website, and assist with budgeting decisions.

Peer Review:

Associate Editor — Water Resources Research — 2016 - present

Attract the best quality manuscripts for publication in one of the premier interdisciplinary journals focusing

on original research in natural and social sciences of water. Assure that these manuscripts receive prompt and thoughtful reviews.

Peer Reviewer	National Funding Agencies	*Ongoing*

Peer review of grant proposals national funding agencies including: the National Science Foundation (NSF) and US Department of Energy (DOE).

Peer Reviewer	Multiple Scientific Journals	*Ongoing*

Provide peer review of manuscripts for over 25 scientific journals including: Advances in Water Resources; Hydrological Processes; Journal of Applied Remote Sensing; Restoration Ecology; Functional Ecology; Journal of Geophysical Research – Atmospheres; Global Change Biology Journal; Journal of Geophysical Research – Biogeosciences; Tree Physiology; Geophysical Research Letters; Water Resources Research; Remote Sensing of the Environment; Oecologia; Journal of Arid Environments; New Phytologist; International Journal of Applied Earth Observation and Geoinformation; Plant Ecology; Applied Vegetation Science; Journal of the American Water Resources Association; Ecohydrology

Panel Member	NSF Graduate Research Fellowship Program	2008 – 2013/17

Review Graduate Research Fellowship applications on-site (2008 – 2012) and virtually (2013) and serve as Graduate Research Fellowship Resource Person at University of Arizona.

Peer Reviewer	Internal UA Funding Opportunities	*Ongoing*

Review proposals for internal funding opportunities ranging from student travel grants through the Institute for the Environment to faculty small grants through the Office of the Vice President for Research.

Diversity:

Instructor	UA Water Resources Technician Training Program	2012-2015

A summer outreach program for Native Americans with a GED or higher in collaboration with US Bureau of Indian Affairs. I teach about watersheds and the water, energy, and carbon budgets.

Tour Guide	UA Passport to High School	2012-2015

A summer outreach program for low-income 9th graders. I offer students a tour of my research lab where they learn about carbon sequestration.

Mentor	UA Arizona Assurance	2012

A program providing academic, financial and social support for low-income AZ residents to ensure success, retention and graduation. Meet with mentee formally and extracurricularly.

Synergistic Activities:

Co-Organizer	Research Insights in Semiarid Ecosystems Symposium *University of Arizona and the USDA-ARS*	*Ongoing*

Plan regional meeting, including inviting speakers and organizing student poster session focused on semiarid research, with emphasis on Walnut Gulch Experimental Watershed and Santa Rita Experimental Range (now a National Ecological Observatory Network Site).

Contributor/Investigator	Eddy Covariance Data Portals *Ameriflux and FLUXNET*	*Ongoing*

Actively participate in the Ameriflux and FLUXNET Networks, which are networks developed to coordinate regional and global observations from micrometeorological tower sites.

Convener/Chair	Oral and Poster Sessions *American Geophysical Union*	*Ongoing*

Plan multiple oral and poster sessions for the Annual Fall Meetings including "Plants as Builder and Plumbers of the Critical Zone", "Ecohydrology in the Critical Zone", "Predictive Understanding of Coupled Interactions Among Water, Life, and Landforms", and "Ecosystem Resilience to Changing Climate Patterns: The Role of Hydrology".

Professional Publications

NOTE: NAME WAS CHANGED FROM KURC TO PAPUGA AFTER MARRIAGE IN 2009.

I have authored or co-authored 34 peer-reviewed publications which, according to ISI Web of Science, have been cited well over 900 times, or an average of 26 citations per publication. A large fraction of these publications have

been written with my graduate students. I have also published with three of my undergraduate students. My first publication that lists me as the lead author (in Water Resources Research 2004) has been cited over 150 times. My first publication that lists one of my graduate students as the lead author (in Ecohydrology 2011) has already been cited over 50 times. Currently I have one publication in review, six publications in revision, and several more in preparation for submission as outlined below.

Refereed Journal Articles (published or accepted):

Note: underline indicates a student for whom I serve(d) as the major advisor with the superscript denoting the student degree seeking status at the time of initial manuscript preparation.

34. Biederman, J., Scott, R.L., Arnone III, J.A., Jasoni, R.L., Litvak, M.E., Moreo, M.T., **Papuga, S.A.**, Ponce-Campos, G.E., Schreiner-McGraw, A.P., and E.R. Vivoni. (2017) Shrubland carbon sink depends upon winter water availability in the warm deserts of North America. *Agricultural and Forest Meteorology* http://dx.doi.org/10.1016/j.agrformet.2017.11.005.
33. Brantley, S.L., Eissenstat, D.M., Marshall, J.A., Godsey, S.E., Balogh-Brunstad, Z., Karwan, D.L., **Papuga, S.A.**, Roering, J., Dawson, T.E., Evaristo, J., Chadwick, O., McDonnell, J.J., and K. Weathers. On the role of trees in building and plumbing the Critical Zone, *Biogeosciences* 14, 5115–5142.
32. Sanchez-Mejia, Z.[PhD] and **S.A. Papuga**. Empirical modeling of planetary boundary layer dynamics under multiple precipitation scenarios using a two-layer soil moisture approach: an example from a semiarid shrubland, *Water Resources Research* 53. https://doi.org/10.1002/ 2016WR020275.
31. Yao, Y., Liang, S., Li, X., Zhang, Y., Chen, J., Jia, K., Zhang, X., Fisher, J.B., Wang, X., Zhang, L., Xu, J., Shao, C., Posse, G., Li, Y., Magliulo, V., Varlagin, A., Moors, E.J., Boike, J., Macfarlane, C., Kato, T., Buchmann, N., Billesbach, D.P., Beringer, J., Wolf, S., **Papuga, S.A.**, Wohlfahrt, G., Montagnani, L., Ardö, J., Paul-Limoges, E., Emmel, C., Hörtnagl, L.H., Sachs, T., Gruening, C., Gioli, B., López-Ballesteros, C., Steinbrecher, R., and B. Gielen. (2017). Estimation of high-resolution terrestrial evapotranspiration from Landsat data using a simple Taylor skill fusion method. *Journal of Hydrology* 553:508-526.
30. Biederman, J., Scott, R.L., Bell, T.W., Bowling, D.R., Dored, S., Garatuza-Payane, J., Kolb, T., Krishnanf, P., Krofcheck, D.J., Litvak, M., Maurer, G.E., Meyers, T.P., Oechel, W.C., **Papuga, S.A.**, Ponce-Camposa, G.E., Rodriguez, J.C., Vargas, R., Watts, C.J., Yepez, E.A., and M.L. Goulden. (2017) CO_2 exchange and evapotranspiration across dryland ecosystems of southwestern North America. *Global Change Biology:* DOI: 10.1111/gcb.13686.
29. Wang, Z., C.B. Schaaf, Q. Sun, J. Kim, A.M. Erb, F. Gao, M.O. Román, Y. Yang, S. Petroy, J.R. Taylor, J.G. Masek, J.T. Morisette, X. Zhang, and **S.A. Papuga**. (2017) Monitoring land surface albedo and vegetation dynamics using high spatial and temporal resolution synthetic time series from Landsat and the MODIS BRDF/NBAR/albedo product. *International Journal of Applied Earth Observation and Geoinformation* 59:104-117.
28. Johnson, J.E., Hamann, L.[MS], Dettman, D.L., Kim-Hak, D., Leavitt, S.W., Monson, R.K., and **S.A. Papuga.** (2017) Performance of induction module-cavity ring-down spectroscopy (IM-CRDS) for measuring $\delta^{18}O$ and $\delta^{2}H$ values of soil, stem, and leaf waters. *Rapid Communications in Mass Spectrometry*: 31:547-560.
27. Guido, Z.[PhD], McIntosh, J.C., **Papuga, S.A.**, and T. Meixner. (2016) Seasonal glacial meltwater contributions to surface water in the Bolivian Andes: A case study using environmental tracers. *Journal of Hydrology: Regional Studies* 8: 260-273.
26. Novick, K.A., Ficklin, D.L., Stoy, P.C., Williams, C.A., Bohrer, G., Oishi, A.C., **Papuga, S.A.**, Blanken, P.D., Noormets, A., Sulman, B.N., Scott, R.L., Wang, L. and R.P. Phillips. (2016) The increasing importance of atmospheric demand for ecosystem water and carbon fluxes. *Nature Climate Change*: 6:1023-1027.
25. Cendrero-Mateo M.P.[PhD], Moran, M.S., **Papuga, S.A.**, Thorp. K.R., Alonso, L., Moreno, J., Ponce-Campos, G., Rascher, U. and G. Wang. (2016) Plant chlorophyll fluorescence: active and passive measurements at canopy and leaf scales with different nitrogen treatments, *Journal of Experimental Botany:* 67 (1): 275-286.
24. Cendrero-Mateo, M.P.[PhD], Carmo-Silva, A.E., Nearing, G.S., Porcar-Castell, A., Hamerlynck, E.P., **Papuga, S.A.** and M.S. Moran. (2015) Dynamic response of plant chlorophyll fluorescence to light, water and nutrient availability, *Functional Plant Biology*: http://dx.doi.org/10.1071/FP15002.

23. Field, J.P., Breshears, D.D., Law, D.J., Villegas, J.C., López-Hoffman, L. Brooks, P.D., Chorover, J., Barron-Gafford, G.A., Gallery, R.E., Litvak, M.E., Lybrand, R.A., McIntosh, J.C., Meixner, T., Niu, G.-Y., **Papuga, S.A.**, Pelletier, J.D., Rasmussen, C.R., and P.A. Troch. (2015) Critical zone services: Expanding context, constraints, and currency beyond ecosystem services. *Vadose Zone Journal*.
22. Bunting, D.P.[PhD], **Kurc, S.A.**, Glenn, E., Nagler, P., and R.L. Scott. (2014) Insights for empirically modeling evapotranspiration influenced by riparian and upland vegetation in semiarid ecosystems, *Journal of Arid Environments*.
21. Biederman, J.A., A.A. Harpold, D. Gochis, B.E. Ewers, D.E. Reed, **S.A. Papuga**, P.D Brooks. (2014) Increased evaporation following widespread tree mortality limits streamflow response, *Water Resources Research,* 50: 5395-5409.
20. Sanchez-Mejia, Z. M.[PhD], **S.A. Papuga**, J.B. Swetish[BS], W.J.D. van Leeuwen, D. Szutu[MS], and K. Hartfield (2014), Quantifying the influence of deep soil moisture on ecosystem albedo: The role of vegetation, *Water Resources Research*, 50: 4038-4053.
19. Sanchez-Mejia, Z.[PhD] and **S.A. Papuga** (2014) Observations of a two-layer soil moisture influence on surface energy dynamics and planetary boundary layer characteristics in a semiarid shrubland, *Water Resources Research,* 50: 306–317.
18. Nelson, K.[MS], **Kurc, S.A.**, John, G.P.[BS], Minor, R., and G.A. Barron-Gafford (2014) Influence of snow cover duration on soil evaporation and respiration efflux in mixed-conifer ecosystems, *Ecohydrology*, 7: 869–880.
17. Rosolem, R., Shuttleworth, W.J., Zreda, M., Franz, T., Zeng, X. and **S.A. Kurc** (2013) The effect of atmospheric water vapor on the cosmic-ray soil moisture signal, *Journal of Hydrometeorology,* 14:1659–1671.
16. Pelletier, J.P., Barron-Gafford, G.A., Breshears, D.D, Brooks, P.D., Chorover, J., Durcik, M., Harman, C.J., Huxman, T.E., Lohse, K.A., Lybrand, R., Meixner, T., McIntosh, J.C., **Papuga, S.A**., Rasmussen, C., Schaap, M., Swetnam, T.L., and and P.A. Troch (2013) Coevolution of nonlinear trends in vegetation, soils, and topography with elevation and slope aspect: A case study in the sky islands of southern Arizona, *Journal of Geophysical Research – Earth Sciences*, 118:741–758.
15. Bunting, D.P.[PhD], **Kurc, S.A.**, and M.R. Grabau. (2013) Long-term vegetation dynamics after high-density seedling establishment: implications for riparian restoration and management, *River Research and Applications*, 29:1119–1130.
14. Martin, J.[MS], **Kurc, S.A.**, Zaimes, G., Crimmins, M., Hutmacher, A., and D. Green (2012) Elevated air temperatures in riparian ecosystems along ephemeral streams: The role of housing density. *Journal of Arid Environments* 84:9-18.
13. Royer, P.D., Breshears, D.D., Zou, C.B., Villegas, J.C., Cobb, N.S., and **S.A. Kurc** (2012) Density-dependent ecohydrological effects of piñon-juniper woody canopy cover on soil microclimate and potential soil evaporation. *Rangeland Ecology and Management* 65: 11-20.
12. Cavanaugh, M.L.[MS], **Kurc, S.A.**, and R.L. Scott (2011). Evapotranspiration partitioning in semiarid shrubland ecosystems: a two-site evaluation of soil moisture control on transpiration. *Ecohydrology* 4:671-681.
11. Bunting, D.P.[MS], **Kurc, S.A.**, and M. R. Grabau (2011) Using existing agricultural infrastructure for restoration practices: Factors influencing successful establishment of *Populus fremontii* over *Tamarix ramosissima*. *Journal of Arid Environments* 75:851-860.
10. Chorover, J., Troch, P.A., Rasmussen, C., Brooks, P.D., Pelletier, J.D., Breshears, D.D., Huxman, T.E., **Kurc, S.A.**, Lohse, K.A., McIntosh, J.C., Meixner, T., Schaap, M.G., Litvak, M.E., Perdrial, J., Harpold, A., and M. Durcik (2011) How Water, Carbon, and Energy Drive Critical Zone Evolution: The Jemez-Santa Catalina Critical Zone Observatory. *Vadose Zone Journal* 10:884-899.
9. Neal, A.L.[MS], Gupta, H.V., **Kurc, S.A.**, and P.D. Brooks (2011) Modeling moisture fluxes using artificial neural networks: can information extraction overcome data loss? *Hydrology and Earth System Sciences* 15:359-368.
8. Royer, P.D., Breshears, D.D., Zou, C.B., Cobb, N.S., and **S.A. Kurc** (2010) Ecohydrological energy inputs in semiarid coniferous gradients: Responses to management- and drought-induced tree reductions. *Forest Ecology and Management* 260:1646-1655.
7. **Kurc, S.A.**, and L.M. Benton[MS] (2010) Digital image-derived greenness links deep soil moisture to carbon uptake in a creosotebush-dominated shrubland, *Journal of Arid Environments* Volume 74, Issue 5: 585-594.
6. Jardine, K., Abrell, L., **Kurc, S.A.**, Huxman, T., Ortega, J., and A. Guenther (2010) Volatile organic compound emissions from *Larrea tridentata* (creosotebush). *Atmospheric Chemistry and Physics* 10:12191-12206.

5. **Kurc, S.A.** and E.E. Small (2007), Soil moisture control on ecosystem scale fluxes of water and carbon in semiarid grassland and shrubland*, Water Resources Research* 43(6): W06416, doi:10.1029/2006WR005011.
4. Turner, D.P., Ritts, W.D., Zhao, M., **Kurc, S.A.,** Dunn, A.L., Wofsy, S.C., Small, E.E., and S.W. Running (2006), Assessing interannual variation in MODIS-based estimates of gross primary production. *IEEE Transactions on Geoscience and Remote Sensing* 44(7): 1899 - 1907.
3. Turner, D.P., Ritts W.D., Cohen W.B., Maeirsperger T.K., Gower S.T., Kirschbaum A.A., Running S.W., Zhao M.S., Wofsy S.C., Dunn A.L., Law B.E., Campbell J.L., Oechel W.C., Kwon H.J., Meyers T.P., Small E.E., **Kurc S.A.** and J.A. Gamon (2005), Site-level evaluation of satellite-based global terrestrial gross primary production and net primary production monitoring, *Global Change Biology*, 11(4): 666-684.
2. **Kurc, S.A.** and E.E. Small (2004), Dynamics of evapotranspiration in semiarid grassland and shrubland during the summer monsoon season, central New Mexico, *Water Resources Research*, 40, W09305, doi:10.1029/2004WR003068.
1. Small, E., and **S. Kurc** (2003), Tight coupling between soil moisture and the surface radiation budget in semiarid environments: Implications for land-atmosphere interactions, *Water Resources Research*, 39(10), 1278, doi: 10.1029/2002WR001297.

Other Scholarly Publications (*not peer-reviewd)*:

4. **Papuga, S.** (2010). Supporting Generation "E": Teaching and Research is Not Enough. *The Journal of Sustainability Education*. October, 2010.
3. **(Kurc) Papuga, S.A.** (2009), Highlight FLUXNET site Santa Rita Creosotebush, *FluxLetter: The Newsletter of FLUXNET*, Vol. 2 No. 4, December*,* 2009.
2. **Kurc, S.A.** (2008), Extreme makeovers: Crossing critical thresholds into desertification, *Arid Lands Newsletter*, 60, ISSN: 0277-9455, E-ISSN: 1092-5481.
1. Small, E.E. and **Kurc, S**. (2001). The influence of soil moisture on the surface energy balance in semiarid environments. *NM Water Resources Research Institute Technical Completion Report* No. 318.

Manuscripts in Review (*in alphabetical order by first author*):

1. Szutu, D.[MS] and **S.A. Papuga**. Differential use of shallow and deep soil moisture in a semiarid shrubland: Linking sap flow and stable isotope techniques to quantify temporal variability in evapotranspiration dynamics, *in review at Water Resources Research.*

Manuscripts in Revision (*in alphabetical order by first author*):

6. Benton, L.M.[MS], **Papuga**, **S.A.,** and K. Nelson[BS]. Automated repeat digital photography for continuous monitoring of shrubland flowering phenology, *rejected from Global Change Biology and New Phytologist, now in prep for submission to International Journal of Biometeorology.*
5. Cendrero-Mateo, M.P.[PhD], Moran, M.S., **Papuga, S.A.**, Laparra, V., Rascher, U., Rivera, J.P., Ponce-Campos, G. and J. Moreno. Seasonal variation of net photosynthesis, optical vegetation indices, and chlorophyll fluorescence under different nitrogen availability in wheat, *in revision for Agricultural and Forest Meteorology.*
4. Guido, Z.[PhD], **Papuga, S.A.**, Ward, D., and S. Slayback. An empirical approach to quantifying temperature-driven area changes of alpine glaciers: Andean glaciers under CMIP5 warming scenarios, *in revision for Global and Planetary Change*.
3. Mitra, B., **Papuga, S.A.**, Alexander, M.R., Swetnam, T.L., and N. Abramson. Allometric relationships of primary size measures to sapwood area for six common southwestern USA tree species, *rejected from Trees – Structure and Function; now in prep for Journal of Forestry Research*.
2. Neal, A.L.[PhD], **Papuga, S.A.**, Brooks, P.D., and R.L. Scott. Soil moisture and vegetation controls on ecosystem respiration in drylands, *rejected from Journal of Geophysical Research – Biogeosciences, now in prep for submission to Journal of Arid Environments.*
1. **Papuga, S.A.** and Z. Sanchez-Mejia[PhD]. Simplifying the soil moisture influence on dryland ecohydrology: a two-layer bucket approach, rejected from *Advances and Water Resources and Ecohydrology, now in prep for Arid Land Research and Management*.

Manuscripts in Prep (*in alphabetical order by first author*):

8. Kidder, A.[MS], **Papuga, S.A.**, Breshears, D.D., and D.J. Law. Classification tree estimation of the climate change velocity gap for little-studied, slow-dispersing endangered species, *in prep for submission to Conservation Biology*.
7. Kidder, A.[MS], **Papuga, S.A.**, Breshears, D.D., and D.J. Law. Ecohydrological controls on cactus flowering phenology and plant reproductive characteristics: a two year observational study of an endangered species, *in prep for submission to Ecohydrology*.
6. Mitra, B., **Papuga, S.A.**, and T. Swetnam. Observations of species-specific shifts from energy-limited to water-limited transpiration in subalpine mixed-conifer: a seasonal analysis, *in prep for submission to Water Resources Research*.
5. **Papuga, S.A.**, Krell, N.[BS], Kipnis, E.[BS], Nelson, K.[MS], Crimmins, T., and D. Bertelsen. Differential controls on repeat flowering events in a semiarid shrubland. *in prep for submission to New Phytologist.*
4. Neal, A.L.[PhD], Brooks, P.D., and **S.A. Kurc**. Lateral hydrologic redistribution subsidizes carbon flux in semiarid landscapes, *in prep for submission to Advances in Water Resources*.
3. Neal, A.L.[PhD], **Kurc, S.A.**, Brooks, P.D., and W.J.D. van Leeuwen. Soil moisture controls on remote sensing-based upscaling of carbon fluxes in a semiarid shrubland. *in prep for submission to Remote Sensing of the Environment.*
2. Swetish, J.B.[BS], **Papuga, S.A.**, Litvak, M.E., Mitra, B. and D. Wilcox[BS]. Influence of understory greenness on trace gas and energy exchange in forested ecosystems, *in prep for submission to Geophysical Research Letters.*
1. Wehr, R.[BS] and **S.A. Papuga.** Long-Term Precipitation Trends of Two Uniquely Water-Limited Ecosystems: Implications for Future Soil Moisture Dynamics, *in prep for submission to Water Resources Research.*

Scholarly Presentations

Note: underline indicates a student for whom I serve(d) as the major advisor with the superscript denoting the student degree seeking status at the time of the abstract submission.

Oral Presentations

(INVITED) **Papuga, S.A.** 2015. Importance of deep soil moisture in dryland land surface – atmosphere interactions. *Research Insights in Semiarid Ecosystems Symposium*, University of Arizona, Tucson, AZ.

(INVITED) **Papuga, S.A.** 2015. Toward quantifying pecan water use in Arizona. *Annual Meeting of the Arizona Pecan Growers Association*. Tucson, AZ.

(INVITED) **Papuga, S.A** 2015. It's not easy being green - linking phenology and climate change at the Santa Rita Experimental Range. *Discovery Saturday Illustrated Talk at the Santa Rita Experimental Range*. Green Valley, AZ.

(INVITED) **Papuga, S.A** 2014. A two-layer soil moisture conceptual framework for exploring land surface-atmosphere interactions in water-limited ecosystems. Fall Meeting of the American Geophysical Union. San Francisco, CA.

(INVITED) **Papuga, S.A.** 2014. Toward quantifying pecan water use in Arizona. *Annual Meeting of the Arizona Pecan Growers Association*. Tucson, AZ.

(INVITED) **Papuga, S. A.** 2014. Ecohydrological controls on land-atmosphere interactions in water-limited ecosystems. *Department of Soil, Water and Environmental Science Spring Colloquia*. University of Arizona, Tucson, AZ.

Sanchez-Mejia, Z.M.[PhD] and **S.A. Papuga**. 2013. Empirical relationships between soil moisture, albedo, and the planetary boundary layer height: a two-layer bucket model approach. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

(INVITED) **Papuga, S. A.** 2012. Feedbacks between vegetation and the water and energy cycles in semiarid regions. *Arid Lands Resources Sciences Spring Colloquia*. University of Arizona, Tucson, AZ.

Papuga, S.A., Sanchez-Mejia, Z.M.[PhD], and A.L. Neal[PhD]. 2011. Feedbacks between vegetation and the water and energy cycles in semiarid regions. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

Pelletier, J.D., Swetnam, T., **Papuga, S.A.**, Nelson, K.[MS], Brooks, P.D., Harpold, A.A. and J. Chorover. 2011. Distinguishing grass from ground using LiDAR: Techniques and applications. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

Chorover, J., Troch, P.A., Pelletier, J.D., Rasmussen, C., Brooks, P.D., McIntosh, J.C., Breshears, D.D., Huxman, T.E., **Papuga, S.A.**, Lohse, K.A., Meixner, T., Schaap, M.G., Litvak, M.E., Harpold, A.A., Perdrial, J.N., and M. Durcik. 2011. Carbon, water and weathering limitations in the semi-arid critical zone. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

(INVITED) **Papuga, S. A.** 2010. It's not easy being green: linking hydrology, phenology, and climate change. *Southwest Watershed Research Center Brown Bag Series*, USDA-ARS, Tucson, AZ.

(INVITED) **Kurc, S.** 2009. The nature of the pulse: hydrologic triggers of phenological activity in creosotebush dominated ecosystems. *Research Insights in Semiarid Ecosystems Symposium*, University of Arizona, Tucson, AZ.

Jardine, K., **Kurc, S.A.**, Guenther, A., Scott, R., Huxman, T., and Abrell, L. 2009. Net ecosystem exchange rates of carbon dioxide and volatile organic compounds between the Sonoran desert and the atmosphere during the North American Monsoon. *GEIA-ACCENT Open Conference* Oslo, Norway.

(INVITED) **Kurc, S.** 2007. How the west was won: an eco-hydrological perspective on woody plant encroachment. *NSF ADVANCE Environmental Sustainability Data Blitz*, University of Arizona, Tucson, AZ.

Kurc, S. and Small, E. 2007. Simple hydro-ecological models: Is root zone average soil moisture an adequate driver in the functions for evapotranspiration and assimilation? *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

Kurc, S. 2007. Patience is a virtue and other valuable principles: the tao of vegetation in dryland ecosystems. School of Natural Resources. Fall Brown Bag Series, University of Arizona, Tucson, AZ.

(INVITED) **Kurc, S**. 2007. Hydrological triggers of ecological activity: Days in the lives of desert shrubs and grasses. *Soil, Water and Environmental Science Fall Colloquia*, University of Arizona, Tucson, AZ.

(INVITED) **Kurc, S**. 2007. Dynamics of water, carbon, and energy cycling at semiarid grassland and shrubland. *Agricultural and Biosystems Engineering Spring Colloquia*, University of Arizona, Tucson, AZ.

Poster Presentations (national conference only)

Luketich, A.[MS], **Papuga, S.A.** and M. Crimmins. Differential impact of passive versus active irrigation on urban forests in semiarid regions. 2017. *Fall Meeting of the American Geophysical Union*. New Orleans, LA.

Papuga, S.A. and L. Hamann[MS]. Temporal dynamics of tree source water in sky island ecosystems with ephemeral snow pack: a case study using *Pseudotsuga menziesii* (Douglas Fir). 2017. *Fall Meeting of the American Geophysical Union*. New Orleans, LA.

Meixer, T., **Papuga, S.A.**, Luketich, A.M.[MS], Rockhill, T., Gallo, E.L., Anderson, J., Salgado, L., Pope, K., Gupta, N., Korgaonkar, Y., and D.P. Guertin. Green infrastructure increases biogeochemical responsiveness, vegetation growth and decreases runoff in a semi-arid city, Tucson, AZ, USA. 2017. *Fall Meeting of the American Geophysical Union*. New Orleans, LA.

Biederman, J., Scott, R., Goulden, M., Litvak, M., Kolb, T., Yepez, E., Oechel, W., Meyers, T., **Papuga, S.**, Ponce-Campos, G., Crofcheck, D., Maurer, G., Dore, S., Garatuza, J., Bell, T., and P. Krishnan. Ecosystem carbon balance in a drier future: land-atmosphere exchanges of CO2, water and energy across semiarid southwestern North America. 2015. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

Szutu, D.[MS] and **S.A. Papuga**. Differential use of shallow and deep soil moisture in a semiarid shrubland: Linking sap flow and stable isotope techniques to quantify temporal variability. 2015. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

Szutu, D.[MS] and **S.A. Papuga**. Using stable water isotopes in a two-layer soil moisture conceptual framework to understand transpiration dynamics in a semiarid shrubland. 2014. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

Krell, N.[BS], **Papuga, S.A.**, Kipnis, E.[BS], and K. Nelson[MS]. Dynamic Pulse-Driven Flowering Phenology in a Semiarid Shrubland. 2014. *Fall Meeting of the American Geophysical Union*. San Francisco, CA.

Swetish, J.[BS], **Papuga, S.A.**, Litvak, M., Barron-Gafford, G. and B. Mitra. 2012. Influence of understory greenness on trace gas and energy exchange in forested ecosystems. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Sanchez-Mejia, Z[PhD]. and **S.A. Papuga**. Quantifying the influence of deep soil moisture on ecosystem albedo: the role of vegetation. 2012. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Mitra, B. and **S.A. Papuga.** Toward an improved understanding of the role of transpiration in critical zone dynamics. 2012. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Lowry, F.[BS] and **S.A. Papuga**. 2011. Vegetation-infiltration relationships along an elevational gradient in the semiarid southwestern United States. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Nelson, K.[MS], **Papuga, S.A.**, John, G.P.[BS], Minor, R., and G.A. Barron-Gafford. 2011. Influence of snow cover duration on soil evaporation and respiration efflux in mixed-conifer ecosystems. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Bunting, D.B.[PhD], Glenn, E., **Kurc, S.A.**, Scott, R.L, and P. Nagler. 2010. Estimating large-scale evapotranspiration in arid and semi-arid systems: a multi-site study linking MODIS and Ameriflux data. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Nelson, K[BS] and **S.A. Kurc**. 2010. Continuous monitoring of dynamic pulse-driven phenological phases in a semiarid shrubland. *AGU* Fall Meeting, *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Neal, A.L.,[PhD] **Kurc, S.A.**, and P.D. Brooks. 2010. Environmental controls on soil respiration in semiarid ecosystems: the role of the vertical distribution of soil moisture. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

John, G.P.[BS], **Papuga, S.A.**, Wright, C.L., Nelson, K.[MS], and G.A. Barron-Gafford. 2010. Investigating the impact of temporal and spatial variation in spring snow melt on summer soil respiration. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Sanchez-Mejia, Z.[PhD], and **S.A. Kurc.** 2010. Influence of temporal variation in the vertical distribution of soil moisture on the surface energy budget: implications for semiarid land-atmosphere interactions. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Kurc, S. and Benton, L[MS]. 2008. Identifying hydrological triggers of green-up in the resilient and widespread creosotebush. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Neal, A. L.[MS], **Kurc, S.A**., and Huxman, T. 2008. Practical use of eddy covariance in non-ideal landscapes: pilot study on a small, enclosed turfgrass setting. *AGU* Fall Meeting, San Francisco, CA.

Cavanaugh, M.[MS], **Kurc, S. A.**, Scott, R., and Bryant, R. 2008. Two-site comparison of transpiration by *Larrea tridentata*. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Benton, L.[MS] and **Kurc, S. A.** 2008. Digital image analysis of flowering in the repeat-blooming creosotebush (*Larrea tridentata*) in relation to climatic factors. *Fall Meeting of the American Geophysical Union.* San Francisco, CA.

Grants and Contracts

Currently, I am lead or co-PI on grants totaling nearly $13.5 million. The majority of this funding ($12.1 million) is associated with large multi-investigator interdisciplinary projects through the National Science Foundation (NSF) opportunities that include the Critical Zone Observatory Network, Sustainability Research Networks, and Coupled Human-Natural Systems. However, I also was awarded a large (>$500,000) sole-investigator NSF CAREER award in the Hydrologic Sciences.

- *Toward Quantifying the Risk of VOC Exposure via Vapor Intrusion in Post-Industrial Cities.* $50,000. 2018. CoI with C Miller and L Lemke. WSU, Office of the Vice President for Research.
- *NSF Career-Life Balance Supplemental Funding.* $22,668. 2016. Sole PI. National Science Foundation - CAREER.
- *Eddy Covariance System for Quantifying Water Use of AZ Pistachio Orchards.* $25,711. 2016. CoI with P Brown and J Walworth. UA Water, Environmental and Energy Solutions (WEES) Competitive Equipment Grants Program.
- *Acquisition of a Shared Benchtop Hyperspectral Imaging System.* $43,000. 2016. CoI with M Tuller, J Chorover, C Rasmussen, and P Troch. UA Water, Environmental and Energy Solutions (WEES) Competitive Equipment Grants Program.

- *Quantifying Variability in Arizona Pecan Water Use*. $47,513. 2015 – 2017. CoI with P Brown and J Walworth. Arizona Department of Agriculture (ADA) Specialty Crop Block Grant Program.
- *Coupled Networks in Urbanized Landscapes: Linking Ecosystem Services and Governance for Water Sustainability*. $1,798,784. 2015 – 2020. CoI with M Crimmins, E Gallo, A Gerlak, P Guertin, A Henry, T Meixner, M Pavao-Zuckerman, G Pivo, and A Sanderford. NSF Coupled Human-Natural Systems.
- *Urban Water Innovations Network (U-WIN)*. $1,074,788 – UA Portion. ($12,000,000 total across 14 institutions) 2014 – 2019. Pivo is Lead UA PI with UA CoPIs M Crimmins, P Guertin, T Meixner, and S Papuga. National Science Foundation – Sustainability Research Networks.
- *waterWRLD: Water as a Platform for Workforce Readiness and Leadership Development*. $12,086. 2015-2016. Papuga is PI in partnership with local NGO Watershed Management Group. 100% Student Engagement Initiative: UA Vice Provost of Digital Learning and Student Engagement.
- *Transformative behavior of Energy, Water and Carbon in the Critical Zone II: Interactions between Long- and Short-Term Processes that Control Delivery of Critical Zone Services*. $5,000,000. 2013-2018. CoI with PIs J Chorover, J Pelletier, D Breshears, J McIntosh, C Rasmussen and CoIs G Barron-Gafford, P Brooks, M Durcik, T Ferre, R Gallery, M Litvak, M Losleben, T Meixner, G-Y Niu, B Parmenter, V Rich, M Schaap, P Troch. NSF-CZO.
- *Ecohydrological Controls on Land-Atmosphere Interactions in Water-Limited Ecosystems: A Framework for Education and Research.* $523,270. 2013 – 2017. Sole PI. National Science Foundation - CAREER.
- *Quantifying Pecan Water Use in Arizona.* $94,112. 2012 – 2015. Co-I with P Brown and J Walworth. Arizona Department of Agriculture (ADA) Specialty Crop Block Grant Program.
- *Transformative Behavior of Energy, Water and Carbon in the Critical Zone: An Observatory to Quantify Linkages among Ecohydrology, Biogeochemistry, and Landscape Evolution*. $4,271,856. 2009-2014. Papuga is CoI with PIs P Troch, J Chorover, P Brooks, J Pelletier, C Rasmussen and CoIs D Breshears, T Huxman, K Lohse, J McIntosh, T Meixner, M Schaap. NSF-CZO.
- *Ecohydrological Controls on Water, Energy, and Carbon Cycling in Water-Limited Ecosystems.* $14,988. 2012. Sole PI. SAHRA NSF STC, the SAHRA center of the UA Water Sustainability Program, and State of Arizona TRIF Support for WEES.
- *The Santa Rita Creosote Site: Representing Water, Carbon, and Energy Cycling in Arizona, the Southwestern US, and Water-Limited Ecosystems Worldwide.* $4,651. 2011. PI. UA Water Sustainability Program.
- *Soil Moisture Controls on Water, Energy, and Carbon Cycling in Water-Limited Ecosystems.* $10,927. 2011. Sole PI. SAHRA NSF STC, the SAHRA center of the UA Water Sustainability Program, and State of Arizona TRIF Support for WEES.
- *Water Resource Adaptation Strategies in Developing Countries: Climate Change "Realities"*. $9,150. 2010-2011. Sole PI. UA-VPR Faculty Small Grant.
- *Ecological Implications of Climate Change in Dryland Ecosystems: Sensitivity of Carbon Uptake to Intra-Annual Variability of Plant-Available Moisture*. $10,000. 2009-2010. Sole PI. UA-Institute for the Environment Faculty Exploratory Grant - TRIF.
- *Restoration of Managed Marsh Units to Benefit California Black Rails and Other Marsh Birds: An Adaptive Management Approach*. $327,401. 2008-2010. Co-PI with PI C Conway. United States Department of the Interior, Bureau of Reclamation.
- *Fingerprinting Water: Tracking Flow Paths and Residence Times from Mountain Catchment to Aquifer Extraction in the Tucson Basin*. $50,000. 2008-2009. Co-PI with PIs P Troch and J Chorover and Co-PIs P Brooks, C Rasmussen, J Pelletier, T Huxman, J McIntosh, D Breshears, T Meixner, M Schaap, D Goodrich, C Unkrich. TRIF-WSP proposal FY 2009.
- *Vegetation Controls on Water, Energy, and Carbon Cycling in Water-Limited Ecosystems*. $6,000. 2007 – 2011. Sole PI. The University of Arizona Agriculture Experiment Station.