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Education

University of California at Davis, September 2012-March 2018
Ph.D., Agricultural and Environmental Chemistry, Advisor: William Horwath
Dissertation Title: Advancing Molecular to Regional Understanding of Carbon-Water Relations in Managed and Natural Systems Across California

State University of New York at Geneseo, Graduated 2011
Bachelor of Science in Chemistry, Magna Cum Laude

Current Projects

The climate paradox: mapping resilience and vulnerability of montane forests
Trees can adjust to natural climate fluctuations by efficiently regulating leaf carbon and water exchange; however, the rapid pace of human induced climatic change threatens the ability of forests to sequester carbon and resist draught. While these limits are often characterized at the scale of an individual tree, or a plot, this research seeks to characterize regional scale drivers of forest productivity across the state of Oregon over recent decades. Recent research has found the most stressed forest ecosystems are mixed conifer forests where drought induced mortality has led to massive dieoffs. However, at high elevations in these same forests, tree lines are expanding, with longer growing seasons aiding forest expansion. This project seeks to develop of a risk index for dieoff of different regions based on characterizations of the impact of shifting climate. By measuring plant, site, and regional scale factors controlling productivity over time we will combine spatial and temporal data, generating a series of maps to inform land management, educate the general public, and direct future scientific efforts. To understand the range of impact of climate change, we identified regions in Oregon (Figure 1, attached) which are experiencing a variety of changes in climate. In the Northeast, the Wallowa mountains show increased moisture, while many Western locations are increasingly dry. By identifying factors which link spatial scales, we will also develop a tool to aid future efforts to model the impact of climate change and disturbance on forest evolution, and natural resources.

Probing for the role of fungal networks in nutrient transfer of novel plant communities across the PNW
The project will assess plant and soil community sensitivity to experimentally imposed drought across a 520 km latitudinal gradient in the PNW. A broad climatic gradient will be used to study typical prairie and pasture systems where increasingly severe seasonal differences, characterized by wetter winters and drier summers, have caused declines in productivity. General hypotheses pertaining to the role of fungal networks in maintaining diverse prairie and low-diversity pasture productivity will be tested to address a major challenge for sustainability in the region and in similar systems elsewhere. Specifically, the proposed tasks will identify plant and fungal species that best maintain primary productivity, plant water-use efficiency, and foster C and N exchange in communities under stress. This knowledge will be used to quantify thresholds of species

composition and soil resource availability beyond which intervention is needed to prevent loss of biodiversity and resilience to drought. Alterations of CMN-mediated transfer or retention of C and N will be monitored using pulse stable isotope labeling experiments to determine whether and how inter-specific connectivity increases community resilience and productivity under imposed stress. A replicated nested design across a latitudinal gradient will be used to characterize CMN behaviors that can be simplified to improve inter-specific connectivity and resource transfer in native and managed systems. Passive and active resource transport among different plant species and fungi will be distinguished through stable isotope probing of DNA sequences and used to develop a spatially-explicit mechanistic model for the scaling of local mutualistic and competitive interactions affecting composition and function of CMNs.

Connecting carbon and oxygen isotope ratios from plant cellulose to soil carobonates to improve understanding of past and future climates
In this project I am helping advise UO Geology student Adrian Broz in identifying a mechanism and mathematical transfer function to relate carbon and oxygen isotope ratios of soil carbonates as a reflection of cellulosic material. As soil microorganisms respire CO2, the soil atmosphere is in equilibrium with soil water, preserving that organically derived signal. Connecting these two pools will allow for soil carbonates in paleosols to be used to identify atmospheric conditions throughout geologic time, informing our understanding of how plant responses to past environmental conditions in order to better predict future responses.

Recent Research

Integrating effects of species composition and soil properties to predict shifts in montane forest carbon–water relations
Published, PNAS, 2018.
Co-authors: William Horwath, Lucas Silva
As a part of my Ph.D. I studied how plant, litter, and soil chemistry and stable isotope composition relate to the physiological performance of dominant species across large climatic and edaphic gradients. This study tracks these changes across elevation gradients and across varied geologic settings to develop an understanding of how specific species respond to climatic differences, and also to identify the role of soil properties in determining this status. New methods are being evaluated by tracking interactions between soil types and plant species to quantify the dynamic vs static aspects of ecosystem responses to climate change.

Predictable oxygen isotope exchange between plant lipids and environmental water: implications for ecosystem water balance reconstruction
Published, JGR-Biogeosciences, 2018
Co-authors: William Horwath, Lucas Silva
This work reports on the fundamental chemistry of compounds deposited into soil by plants. These compounds are interesting to us as measurements of their isotopic composition reveal water availability and stress level of plants that produced them. Thus, from these compounds, it is possible to gain understanding of water regime shifts over time and space in an ecosystem. However, this is only possible given some assumptions, primarily that these compounds retain their chemical and isotopic composition long after deposition. This research reports new data that

shows that some compounds of interest meet this assumption for practical applications paving the way for studying how natural systems respond to changes in environmental water.

Efficiency-productivity tradeoffs in California cropping systems: how environmental gradients regulate responses to rising CO_2 levels and climatic variability in California
Manuscript in Prep.
Co-authors: William Horwath, Lucas Silva, Mark Lundy
This project focused on understanding long-term changes in physiological performance and agricultural efficiency of the wheat in CA. Two main responses were considered: productivity (yield) and efficiency (water and nitrogen). We observed a declining trend in efficiency despite improved technology and rising atmospheric CO_2. By controlling for site based characteristcs we found a remarkably trivial link between climate and yield, and further find that economic and agronomic stressors combined with rising quality demands may be the cause of declining efficiency. On top of this, we identified regions of CA where yield is threated by such factors, in an attempt to help guide future management and market directions.

Greenhouse Gas Monitoring on Agricultural Fields, UC Davis, 2012 – 2014
Advisors: William Horwath, Martin Burger
Exploring the impact of various farming and fertilization methods on greenhouse gas emissions and nitrogen mineralization rates in agricultural wheat production. Studies have been conducted on by monitoring N_2O and CO_2 fluxes in response to management. Enriched ^{15}N fertilizers were applied allowing for a mass balance analysis, separating fertilizer and soil nitrogen contributions to better understand how specific fertilizers contribute to plant nutrition.

Lab Experience and Data Analysis

R
Extensive experience with efficient data management of large datasets, multivariate linear modeling, non-linear and process based models, time series analysis, structural equation modeling, multi-model inference.

Isotope Biogeochemistry
I am an expert in stable isotope biogeochemistry and have run experiments observing shifts in natural abundance over environmental gradients, and additionally probing with enriched isotopes both as dissolved soil amendments (N), and via gaseous uptake (CO_2). Further, I built a cryogenic leaf water extraction system allowing for isotopic analysis of leaf, stem, and soil water hydrogen and oxygen isotope values.

GIS
I am experienced in working with spatial data, including both descriptive and predictive techniques to help determine appropriate interpolation methods in R. A basic knowledge of ArcGIS allows me to perform basic tasks including mapping, merges, calculations, and integration of satellite data.

Analytical Chemistry

Extensive experience troubleshooting methodology and working with GC/MS and HPLC data, significant experience maintaining and troubleshooting instrument software and hardware. Also familiar with extraction, purification, and derivatization procedures for many compound classes from soil and plant material.

Organic Chemistry
Extensive experience with organic separations and purifications. I am comfortable working with volatile, flammable, and toxic chemicals. I have extensive experience with flash column chromatography, extraction from complex matrices, and method calibration.

Relevant Coursework

University of Utah Summer Course in Stable Isotope Ecology and Biogeochemistry, June 2014
The course is a multi-instructor lecture and lab short course offered to graduate students concerning the application of stable isotopes to environmental and ecological studies.

Completed Graduate Coursework: GEO200: Quantitative Geography, ETX 220/L Analysis of Toxicants, SSC 205 Field Studies of Soils in California Ecosystems, SSC 208 Plant Soil Interrelations, PLS 205 Experimental Design and Analysis, PLS 206 Multivariate Statistical Modeling, SSC 202 Environmental Soil Chemistry, CHE 226 Transition Metal Chemistry, SSC 120 Soil Genesis and Classification, SSC 111 Soil Microbiology, SSC 109 Soil Physics

Completed Undergraduate Coursework: CHEM 340/L Modern Analytical Chemistry, CHEM 313 Lab Techniques in Organic Chemistry, CHEM 330/L Inorganic Chemistry, CHEM 302/304/L Biochemistry, CHEM 211/213/L Organic Chemistry, CHEM 320/322 Physical Chemistry, GEO 200 Environmental Geology

Honors/Awards
National Geographic Exploration and Research - $5000, award #:EC-422R-18
Jastro Shields Research Award, 2015 - $3000
William and Linda Sullivan Graduate Research Fellowship, 2014 - $1240
Gamma Sigma Epsilon National Chemistry Honor Society

Publications

1. **M Maxwell, T. M.,** Silva, L. C. R. & Horwath, W. R. Integrating effects of species composition and soil properties to predict shifts in montane forest carbon–water relations. Proc. Natl. Acad. Sci. 201718864 (2018). doi:10.1073/PNAS.1718864115

2. **Maxwell, T.M.**, Silva, L. C. R., Horwath, W.R., Predictable oxygen isotope exchange between plant lipids and environmental water. *In review (JGR Biogeosciences).*

3. Jerszurki, D., Couvreur, V., **Maxwell, T.M.**, Silva, L. C. R., Matsumoto, N., Shackel, K., Souza, J. L. M., Hopmans, J. Impact of root growth and hydraulic condiuctance on water availability of young walnut trees (*Juglans regia L.)* under drought stress. *Sci. Hortic-Amsterdam.*

4. **Maxwell, T. M.**, Silva, L. C. R. & Horwath, W. R. Using multielemental isotopic analysis to decipher drought impacts and adaptive management in ancient agricultural systems. *Proc. Natl. Acad. Sci.* 2–3 (2014).

5. Culman, S.W., Haden, V.R., **Maxwell, T.M.**, Waterhouse, H., and William Horwath. 2014. Greenhouse Gas Mitigation Opportunities in California Agriculture: Review of California Cropland Emissions and Mitigation Potential. NI GGMOCA R 3. Durham, NC: Duke University.

In review

Liles, GC, **Maxwell T.M.**, Silva L, Zhang, J, Horwath WRH (*In review*) Two decades of experimental manipulation reveal mechanisms for enhanced growth potential of Ponderosa Pine plantations across climate gradients. J. Geophys. Res Biogeosciences.

In prep

Maxwell T.M., Silva LCR, Horwath WRH (*In prep*) Observed and projected climate change impacts on productivity and efficiency of common wheat (Triticum aestivum L.) across California: A case study in production from 1981 to 2070.

Broz, A., Retallack, G.J., **Maxwell T.M.**, Silva, LCR (In prep) Paleoproxy for vapor pressure deficit (VPD) from fossil cellulose and pedogenic carbonate. Geology

Presentations

1. Maxwell, T.M., Silva, L.C.R., Horwath, W.R. (2017), Dynamic and inertial controls on forest carbon-water relations. Abstract PP31D-2311, presented at 2017 Fall Meeting, AGU, New Orleans, LA, Dec. 11-15.
2. Maxwell, T.M., Silva, L.C.R., Horwath, W.R. (2016), Predictable oxygen isotope exchange of plant lipids improves our ability to understand hydrologic shifts and partition evapotranspiration across scales. Abstract PP31D-2311, presented at 2016 Fall Meeting, AGU, San Francisco, Calif., Dec. 12-16.
3. Maxwell, T.M., Silva, L.C.R., Horwath, W.R. (2016), Soil Properties Drive Carbon-Water Relations Across a Climate Gradient in Sierra Nevada Forests. Abstract 60315, presented at 2017 Annual Meeting, ESA, Ft. Lauderdale, FL, Aug. 7-12.
4. Maxwell, T.M., Silva, L.C.R., Horwath, W.R. (2015), Soil Properties Drive Changes in Water Use Efficiency Across a Climatic Gradient. Abstract 68367, presented at 2015 Fall Meeting, AGU, San Francisco, Calif., Dec. 14-18.
5. Maxwell, T.M., Silva, L.C.R., Horwath, W.R. (2014), Expanding lipid proxies to the next dimension: Developing methods for the measurement of oxygen isotopes in plant waxes, Abstract 30432, presented at 2014 Fall Meeting, AGU, San Francisco, Calif., Dec. 15-19.
6. Maxwell, T.M., Silva, L.C.R., Pedroso, G., Doane, T.A., Mukome, F.N.D., and Horwath, W.R. (2014), Quantifying Water Balance-Carbon Storage Relationships Using Oxygen Isotope Ratios of Plant Lipids, Poster 27, presented at 2014 Soil's Role in Restoring

Ecosystem Services Conference, Soil Science Society of America, Sacramento, Calif., Mar. 7-9.

Teaching Experience

Teaching Assistant for Science and Society 5, Forests in Society, Spring 2014, 2015, 2016
Professor: William Horwath
I taught 3x1 hour sessions each week including classroom introductions to various topics associated with the importance of forests as a natural resource. Additionally, taught lab components using field trips, and gave 2 lectures in the main class.

Teaching Assistant for CHEM 313 Lab Techniques in Organic Chemistry, Fall, 2010
Professor: Christina Geiger
I helped students with troubleshooting in using NMR and GC-MS to elucidate structures from their products. Additionally, I taught lab techniques in organic synthesis, such as basic reflux reactions, liquid extractions and use of TLC to determine if reactions had gone to completion.

Teaching Assistant for CHEM 324, Principles of Physical Chemistry, Spring, 2010
Professor: Kazushige Yokoyama
Offered support to students for studying and understanding material for tests.

Lab Assistant for CHEM 119 Freshman Introductory Chemistry Lab, Fall, 2009
Professor: James McGarrah
Helped explain set up processes for basic titrations and reactions. I helped to develop understanding of the principles of lab techniques and report writing skills.

Peer Review Contributions

I have worked as a referee for the following journals
Nature Scientific Reports
Global Change Biology
Journal of Geophysical Research: Biogeosciences
PLOS-ONE
Plant and Soil

Extracurricular

Volunteer, Pacific Crest Trail Association, Winter 2016-Spring 2018
I wrote scientific blog posts and aid in office work for the Pacific Crest Trail association. See link below.
http://www.pcta.org/2016/desert-survives-keys-natures-success-californias-vibrant-desertscape-38536/

Mentor at Center for Land Based Learning SLEWS program, Spring 2013-2017

I assisted middle and high school programs to create compost buckets, harvest crops and understand the study of soil as a resource. We participate in ecological restoration projects at reclaimed wilderness sites through organizations partnered with the Center.