

Toby Maxwell, PhD
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Education

University of California at Davis, September 2012-March 2018

Ph.D., Agricultural and Environmental Chemistry, Advisor: William Horwath

State University of New York at Geneseo, Graduated 2011

Bachelor of Science in Chemistry, Magna Cum Laude

Research Areas

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

In review, JGR-Biogeosciences

Co-authors: William Horwath, Lucas Silva

In this study, we present the first evidence for predictable exchange of oxygen isotopes between water and lipid compounds. Using laboratory incubations with aliphatic alcohols, hexadecanol and eicosanol, and bulk soil lipid extracts in isotopically enriched water for up to 160 days, we determined the magnitude and direction of exchange rates for bulk lipid extracts. Our data show that $\delta^{18}\text{O}$ ratios of long-chain aliphatic lipids that persist in hydrophobic portions of soil organic matter may be used to reconstruct the plant water $\delta^{18}\text{O}$ values, which could help elucidate hydrologic shifts in terrestrial systems. Furthermore, as equilibrium was reached for the bulk lipid extract, we are able to calculate that only 22% of its content represents an exchangeable fraction, while the remaining portion efficiently exchanged with water with an exchange half-life of 0.13 years. Incubations the same of bulk lipid extract conducted in contact with the iron oxyhydroxide mineral limonite showed no difference in exchange rates, although the exchangeable fraction decreases to 19% of the total, suggesting that the mineral surfaces can inhibit oxygen exchange for some functional groups. In contrast, pure compounds showed no exchange under the same conditions. Taken together, these findings represent a significant development in the understanding of oxygen isotope exchange and common soil minerals, providing a path for using isotopically stable compound specific, or predictably exchangeable bulk analysis of soil organic matter in reconstructions of ecosystem water balance.

Efficiency-productivity tradeoffs in California cropping systems: how environmental gradients regulate responses to rising CO₂ 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 CO₂. By controlling for site based characteristics 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 threatened 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 N₂O and CO₂ fluxes in response to management. Enriched ¹⁵N 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.

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.

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 (CO₂). Further, I built a cryogenic leaf water extraction system allowing for isotopic analysis of leaf, stem, and soil water hydrogen and oxygen isotope values.

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 about 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](https://doi.org/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 conductance on water availability of young walnut trees (*Juglans regia L.*) under drought stress. *Sci. Hortic-Amsterdam*.

2. **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).
3. 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.

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 2016 Fall Meeting, AGU, San Francisco, Calif., Dec. 12-16.
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 teach 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.

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.

Extracurricular

Volunteer, Pacific Crest Trail Association, Winter 2016-Present

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.