



AFRI and NIWQP Project Directors Meeting

Washington, D.C
October 12-13, 2016

United States Department of Agriculture
National Institute of Food and Agriculture



Agriculture and Food Research Initiative/National Integrated Water Quality

AFRI and NIWQP Annual Project Directors Meeting

United State Department of Agriculture
National Institute of Food and Agriculture
Washington D.C 20024

Welcome to the 2016 AFRI/NIWQP Annual Project Directors Meeting

The USDA National Institute of Food and Agriculture (NIFA) welcomes you to the FY 2016 *USDA-NIFA AFRI and NIWQP Annual Project Directors' Meeting*. The meeting brings together project directors, co- project directors, graduate students and collaborators from the National Integrated Water Quality Program (NIWQP, FY 2010-2014), the Agricultural and Food Research Initiative (AFRI), Water for Agriculture Challenge Area (FY 2014,-2015), AFRI Foundational RENRE (FY 2011- 2013) program and AFRI Foundational BENRE (FY2014 - FY2015). The purpose of the meeting is for NIFA staff to interact with awardees and learn more about the success of their projects, identify outcomes and learn about current research needs. It will also provide the opportunity for awardees to get the most recent updates on program priorities and new programs.

This year we have added additional breakout sessions for more interaction and networking opportunity. We expect that the interaction among awardees will provide the opportunity for collaboration that will help in the development of future NIFA awards.

We hope that everyone who attends will be enriched and impressed by the exciting science, innovation and productivity of your fellow awardees. Thank you for coming!

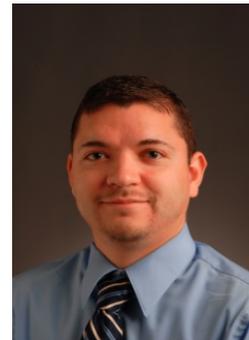
Sincerely,



James (Jim) Dobrowolski
Nat'l Program Leader
202-401-5016
jdobrowolski@nifa.usda.gov



Nancy Cavallaro
Nat'l Program Leader
202-401-5176
ncavallaro@nifa.usda.gov



Dewell Paez
Program Specialist
202-401-4141
dpaez@nifa.usda.gov

AGENDA

Wednesday, October 12, 2016

7:00 a.m. - 8:00 a.m.	Registration (2nd Floor-Junior Ballroom)
8:00 a.m. - 8:10 a.m.	Welcome and Opening Remarks to FY16 PD Meeting
8:10a.m. - 8:30 a.m.	NIFA Update Luis Tupas , Deputy Director Institute of Bioenergy, Climate, and Environment
8:30 a.m. - 9:10 a.m.	Program Updates & Future Direction Jim Dobrowolski , National Program Leader Division of Environmental Systems Nancy Cavallaro , National Program Leader Division of Global Climate Change
9:10 a.m.- 9:45 a.m.	<u>Communicating Your Impact Stories</u> Stephanie Pearl, NIFA Science Communicator/ Writer Katelyn Sellers, Management and Program Analyst Kelly Flynn, Public Affairs Specialist
9:45 a.m. - 10:00 a.m.	Break
10:00 a.m.- 12:00 p.m.	Oral Session I
10:00 a.m. - 10:15 a.m.	<u>Watershed Diagnostics for Improved Adoption of Management Practices: Integrating Biophysical and Social Factors</u> <i>Paul Leisnham - University of Maryland, College Park</i> p.2
10:15 a.m. - 10:30 a.m.	<u>Landscape-Scale Thresholds Of Early Successional Habitat: Reconciling Biodiversity, Public Perception, And Timber Yield In Managed Forests</u> <i>Susan Loeb - USDA Forest Service</i> p.3
10:30 a.m. - 10:45a.m.	<u>Downstream Water Quality and Quantity Impacts of Water Storage Systems in Porter Bayou Watershed</u> <i>Joel Paz - Mississippi State University of Agriculture & Applied Science</i> p.5
10:45 a.m. - 11:00 a.m.	<u>Developing a Web-based Forecasting Tool for Nutrient Management</u> <i>Anthony Buda on behalf of Patrick Drohan - Pennsylvania State University</i> p.7
11:00 a.m. - 11:15 a.m.	<u>Assessing The Impact Of Agricultural Practices On Phosphorous Availability And Loss Using Oxygen Isotopes Of Phosphate In Soil</u> <i>Adina Paytan - The Regents of the University of California, Santa Cruz</i> p.9
11:15 a.m. - 11:30 a.m.	<u>Watershed Scale Project in Oostanaula Creek</u> <i>Forbes Walker - University of Tennessee, Knoxville</i> p.10

11:30 a.m. - 11:45 a.m.	Variable Thinning Using Historical Stand Structure Data to Create Fire-Resilient Forests and Enhance Ecosystem Services in A Changing Climate <i>Eric Knapp - USDA- Forest Service</i> p.12		
11:45 a.m. - 12:00 p.m.	Physicochemical Controls On Transport of Veterinary Pharmaceuticals And Hormones To Surface Waters <i>Wei Zhang- Michigan State University</i> p.14		
12:00 p.m. - 1:00 p.m.	Lunch (On Your Own)		
1:00 p.m. - 2:00 p.m.	Breakout Group 1 (Sustainable Water Management)	Breakout Group 2 (Integrating Soil Health)	Breakout Group 3 (Nutrient & Contaminant Management)
2:00 p.m. - 2:30 p.m.	Breakout Reports		
2:30 p.m. - 2:45 p.m.	Break		
2:45 p.m. - 5:00 p.m.	Oral Session II		
2:45 p.m. - 3:00 p.m.	Water for Agriculture Challenge Area: Enhancing Climate Resiliency & Agriculture on American Indian Land <i>Maureen McCarthy- University of Nevada, Reno</i> p.49		
3:00 p.m. - 3:15 p.m.	An Integrated Approach to Foster Science-Based Management of Agricultural Drainage Channels in the Western Lake Erie Basin <i>Jonathan Witter - The Ohio State University</i> p.17		
3:15 p.m. - 3:30 p.m.	Enabling the Flow of Ecosystem Services from Agriculture to Improve Puerto Rico's Water Quality and Mitigate Global Climate Change <i>Kristin Fisher on behalf of Jonathan Winsten - Winrock International Institute for Agricultural Development</i> p.18		
3:30 p.m. - 3:45 p.m.	Consequences Of Stand Age And Structure On Forest Water Yield <i>Chelcy Ford Miniat- USDA Forest Service</i> p.19		
3:45 p.m. - 4:00 p.m.	Functional and Molecular Diversity in Nitrogen Cycle Enzymes under Contrasting Agricultural Management Systems <i>Jeanette Norton - Utah State University</i> p.20		
4:00 p.m. - 4:15 p.m.	Advancing Climate-Adaptive Decision Tools To Reduce Nutrient Pollution From Agricultural Fields <i>Aaron Ristow on behalf of Harold Van Es - Cornell University</i> p.22		
4:15 p.m. - 4:30 p.m.	Implementation of In-Stream, Streambank and Riparian Practices in Conjunction with Upland Practices for Conservation of Water Resources <i>Jason Vogel on behalf of Garey Fox - Oklahoma State University</i> p.24		

<p>4:30 p.m. - 4:45 p.m.</p>	<p><u>Water Quality Implications of Unique Transformation Processes of Synthetic Steroids Used As Agricultural Pharmaceuticals</u> <i>Edward Kolodziej- University of Washington</i> p.26</p>
<p>4:45 p.m. -5:00 p.m.</p>	<p><u>Hydrological-Microbial Interactions Controlling Landscape Phosphorus Mobility</u> <i>Anthony Buda on behalf of John Regan- The Pennsylvania State University</i> p.160</p>
<p>5:00 p.m. – 6:30 p.m. Poster Session I & Networking Reception</p>	
<p><u>Water Quality and Productivity Enhancement in an Irrigated River Basin through Participatory Conservation Planning and Analysis</u> <i>Timothy Gates - Colorado State University</i> p.29</p>	
<p><u>Innovative Policies to Optimize the Allocation of Water Quality and Conservation Investments and Maximize Multiple Benefits</u> <i>Kelly Grogan - University of Florida Board of Trustees</i> p.31</p>	
<p>Integrated plan for drought preparedness and mitigation, and water conservation at the watershed scale <i>Sandeep Kumar - South Dakota State University</i> p.33</p>	
<p>NIFA-BARD: Enhanced Resilience of Local Agricultural Water Supplies through the Reuse of Municipal and Agricultural Wastewater: A Dynamic Economic Analysis of Technological and Policy Options <i>Kurt Schwabe - University of California</i> p.35</p>	
<p><u>A Water Quality Valuation Approach To Strategic Planning</u> <i>Nathan Howell - West Texas A&M University</i> p.37</p>	
<p><u>Increasing the Resilience of Agricultural Production in the Tennessee and Cumberland River Basins through More Efficient Water Resource Use</u> <i>Forbes Walker - University of Tennessee, Knoxville</i> p.39</p>	
<p>Impacts of Prescribed Fire on Polycyclic Aromatic Hydrocarbon Production and Contaminant Photo-transformation Reductions in Coastal Plain <i>Alex Chow - Clemson University</i> p.40</p>	
<p>Stability In Rangeland Production With Increased Precipitation Variability: Linking Functional Diversity And Nutrient Retention <i>Katharine Suding - University of Colorado, Boulder</i> p.41</p>	
<p>Assessing Threshold Benefits Of Conservation Tillage During Drought Years: Implications For Nutrient Use Efficiency And Water Quality <i>Pierre- Andre Jacinthe - Indiana University</i> p.43</p>	

<u>The Value of Water Quantity versus Quality: Assessing the Tradeoffs between Agricultural Yields and Downstream Uses of Water Resources</u>	<i>Kevin Meyer on behalf of David Keiser - Iowa State University of Science and Technology</i>	<i>p.44</i>
Using Hydro-Economic Modeling to Optimally Allocate Water in the Humid Southeastern U.S.	<i>Shawn Hawkins on behalf of Christopher Clark- The University of Tennessee</i>	<i>p.45</i>
<u>A Synthesis of the NIFA Water Portfolio (2000-2013)</u>	<i>Michael O' Neill- University of Connecticut</i>	<i>p.46</i>
Determining the Potential Mitigation of Triclosan Accumulation in Commercial Onion Plants Using Plant-Growth Promoting Rhizobacteria	<i>Monica Mendez- Texas A&M International University</i>	<i>p.47</i>
<u>NIFA-BARD Collaborative: Rapid Hydrophobicity Sensing and Computing through MAV-based Hyperspectral Imaging</u>	<i>ZhiQiang Chen - University of Missouri-Kansas City</i>	<i>p.48</i>
goCrop: Integration of Mobile Technology to Enhance Nutrient Management Program Implementation	<i>Heather Darby - University of Vermont and State Agricultural College</i>	<i>p.16</i>
<u>ThinkWater II: Growing Knowledge to Solve Water Problems</u>	<i>Jennifer Kushner- University of WI System, UW-Extension</i>	<i>p.51</i>
<u>Towards a Near Real-time Agricultural Drought Monitoring and Forecasting</u>	<i>Ashok Mishra- Clemson University</i>	<i>p.53</i>
Sustainable Water Resources For Irrigated Agriculture In A Desert River Basin Facing Climate Change And Competing Demands: From Characterization To Solutions	<i>William Hargrove - The University of Texas at El Paso</i>	<i>p.54</i>
<u>Colloid Mobility in Soils, Fundamental Pore Scale Mechanisms, Simplifications and Practical Relevance for Risk Analysis</u>	<i>Marcel Schaap- University of Arizona</i>	<i>p.55</i>
<u>Improved N Retention Through Plant-Microbe Interactions</u>	<i>Larry Halverson - Iowa State University of Science and Technology</i>	<i>p.56</i>
Nitrogen Synchrony at The Crop-Soil Interface: Optimizing Root-Microbe Interactions To Minimize Environmental Nitrogen Losses	<i>Stuart Grandy - University of New Hampshire</i>	<i>p.57</i>
<u>Unveiling Fungal Contributions to Agricultural Soil Nitrogen Cycling Following Application of Organic and Inorganic Fertilizers</u>	<i>Bongkeun Song - Virginia Institute of Marine Science</i>	<i>p.59</i>

Lake Ontario Basin Agriculture in the Coming Decades: Room for Expansion or Imminent Future Water Conflict	<i>Stephen Shaw – SUNY State University of New York</i>	<i>p.60</i>
Developing And Promoting Water-, Nutrient-, And Climate-Smart Technologies To Help Agricultural Systems Adapt To Climate and Societal Change	<i>Bruno Basso - Michigan State University</i>	<i>p.61</i>
Evaluating the Presence of Pathogenic Bacteria in Fecal Sample of Feral Pigs and Their Transport to Surface Waters	<i>Dave Bachoon- Georgia College & State University</i>	<i>p.63</i>
2015 Healthy Soils for Healthy Waters Symposium	<i>Andrew Ward- Ohio State University</i>	<i>p.65</i>
6:30 p.m.	Adjourn	

Thursday, October 13, 2016

7:30 a.m. - 8:00 a.m.	Poster set-up	
8:00 a.m. - 8:10 a.m.	Welcome	
8:10 a.m. - 9:30 a.m.	Poster Session II	
Adaptive Management For Phosphorus To Improve Economic And Water Quality Outcomes	<i>Peter Scharf- University of Missouri</i>	<i>p.67</i>
Nitrogen Emissions Associated With Nutrient Management Practices: Measurements, Modeling, And Microbial Communities	<i>Julie Zilles- Board of Trustees of the University of Illinois</i>	<i>p.68</i>
Mitigating Nutrient Losses from Agroecosystems: Biotic And Abiotic Mechanisms Of Nitrogen Cycling Under Conservation Agriculture Management Practices	<i>Sean Schaeffer- The University of Tennessee</i>	<i>p.69</i>
Linking Topography, Changing Snow Regimes, Nitrogen Dynamics, And Forest Productivity	<i>Yuriko Yano on behalf of Jia Hu - Montana State University</i>	<i>p.71</i>
Bioavailability And Fate Of Articulate And Colloidal Phosphorus Released From Agricultural Sources: A Case Study In The Chesapeake Bay Watershed	<i>Deb Jaisi- University Of Delaware</i>	<i>p.72</i>
Large Runoff Flux And Transformation of Particulate Nitrogen (Pn) Following Large Storms: A Critical But Unexplored Component Of N Cycling	<i>Inamdar Shreeram - University of Delaware</i>	<i>p.73</i>
Impacts Of Tree Species And Harvest Regimes on N Retention In Northeastern U.S. Forests	<i>Gary Lovett - Cary Institute of Ecosystem Studies</i>	<i>p.74</i>

<u>Process-Based Nutrient Modeling Of Integrated Beef Cattle Finishing And Crop Production Systems In The Northern Great Plains</u> <i>Erin Cortus - South Dakota State University</i>	<i>p.75</i>
Managing N and C cycling processes at multiple scales to improve nitrogen use efficiency in grains <i>Laurie Drinkwater- Cornell University</i>	<i>p.76</i>
Measuring and modeling denitrification hot spots on agricultural landscapes <i>Miki Hondzo - University of Minnesota</i>	<i>p.77</i>
A New Landscape Based Approach To Optimize Riparian Zone Nitrogen And Phosphorus Management In Glaciated Settings <i>Philippe Vidon - SUNY College of Environmental Science & Forestry</i>	<i>p.79</i>
<u>Improving Life-Cycle Nitrogen Use Efficiency And Environmental Performance Of Corn Production Through Improved Fertilizer Timing And Rate</u> <i>Robert Anex - University of Wisconsin System</i>	<i>p.80</i>
Reducing Nitrogen Losses from Agricultural Systems: Incorporating Biochar into Farmstead Management Strategies <i>Rebecca Larson - University of Wisconsin System</i>	<i>p.81</i>
<u>N2-Fixing Cyanobacteria Harnessed For Biosolar Production Of Nitrofertilizer</u> <i>Ruanboa Zhou - South Dakota State University</i>	<i>p.82</i>
New Awardees*	
Enhancement of Nitrogen Usage Efficiency and Mitigation of Nitrous Oxide Emission in Agricultural Fields <i>Gang Chen - Florida A&M University*</i>	<i>p.84</i>
<u>Conference: Extreme Climate Event Impacts On Aquatic Biogeochemical Cycles And Fluxes</u> <i>Shreeram Inamdar- University of Delaware*</i>	<i>p.85</i>
Sustaining Agriculture through Adaptive Management to Preserve the Ogallala Aquifer under a Changing Climate <i>Reagan Waskom on behalf of Meagan Schipanski - Colorado State University*</i>	<i>p.86</i>
<u>Understanding The Hydrologic and Socioeconomic Impacts of Water Use and Resource Allocation Under Different Climate and Policy Scenarios</u> <i>Marco Maneta-Lopez -University of Montana*</i>	<i>p.88</i>
Municipal Wastewater Application to Forests: Participatory Science to Understand Human Exposure and Risks to Contaminants of Concern. <i>Elizabeth Nichols - North Carolina State University*</i>	<i>p.90</i>

Addressing Community Perceptions and Concerns on Wastewater Use for Agriculture in Puerto Rico: The Conference <i>Maria Ortiz- Universidad Metropolitana*</i>	<i>p.91</i>
Rhizosphere Priming Effects on Legacy Organic Phosphorus (Po) In Winter Wheat/Corn Rotation Systems <i>David McNear - University of Kentucky*</i>	<i>p.93</i>
Can Induced Rhizosphere Hydraulic-Redistribution be Engineered to Enhance Macronutrient Uptake Efficiency? <i>Teamrat Ghezzehei - UC Merced*</i>	<i>p.94</i>
Combining Electrical Resistivity Imaging and Conservative Tracers to Characterize and Model Subsurface Phosphorus Losses from Drained Soils <i>Amy Shober - University of Delaware*</i>	<i>p.95</i>
Translating On-farm Research into Farmer-Relevant Nutrient Risk Assessments Using Advanced Hierarchical Methods <i>John Lory - The Curators of the University of Missouri*</i>	<i>p.96</i>
CONSERVE: A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health <i>Amy Sapkota- University of Maryland*</i>	<i>p.97</i>
The 3rd International Conference on Hydropedology: Promoting Breakthrough Collaborations among Agro-,Hydro-,Geo-,and Bio-Sciences <i>Hangsheng Lin - The Pennsylvania State University*</i>	<i>p.99</i>
Sustainable Use Of Dairy Farm Anaerobic Digestate: From Environmental Pollutant To New Source Of Water, Energy, And Nutrients <i>Sharon Walker, University of California*</i>	<i>p.100</i>
Mitigating Human Health Risks and Enhancing Water Sustainability: Evaluating Antibiotic Resistance in Anaerobic Wastewater Treatment <i>Adam Smith- University of Southern California*</i>	<i>p.102</i>
Transforming Denitrifying Bioreactor Research and Applications: Unveiling The Inside of The Blackbox <i>Francois Birgand- North Carolina State University*</i>	<i>p.103</i>
Enhancing The Nutrient Use Efficiency In Crop Plants By Tailoring The Nitrogen and Phosphorous Release Rates From Rendered Animal Materials <i>Nishanth Tharayil - Clemson University*</i>	<i>p.104</i>
Reducing Gaseous Nitrogen Losses from High Temperature Agricultural Systems <i>Jenerette Darrel - University of California*</i>	<i>p.105</i>
Phosphorus Management in Forested Ecosystems	

<i>Mariana Dobre - University of Idaho*</i>		<i>p.106</i>
On-Farm Research on Drainage Water Management to Reduce Nitrogen and Phosphorus Leaching: Trade-offs with N ₂ O and CH ₄ Emissions <i>Eric Davidson - University of Maryland Center for Environmental Science*</i>		<i>p.107</i>
Sources And Transport of Phosphorous In Tile Drained Agricultural Watersheds Using Advanced Chemical Analysis <i>Mark David - University of Illinois*</i>		<i>p.108</i>
Decadal Nitrogen Partitioning and Retention: Insights From Whole-Ecosystem, Laboratory And Molecular Studies <i>Carmen Martinez - Cornell University*</i>		<i>p.109</i>
Influence of Preferential Flow on Coupled Colloid, Nitrogen, and Phosphorus Transport through Riparian Buffers* <i>Garey Fox - Oklahoma State University*</i>		<i>p.111</i>
Reactive Nitrogen Cycling And Impacts On U.S. Dairy Farms: The Feasibility of Sustainable Milk And Agro-Ecosystems <i>Peter Vadas - Texas A&M AgriLife Research*</i>		<i>p.112</i>
Quantitative Approach for Recovering Legacy Phosphorus while Minimizing Crop Nutrient Deficiency Risk <i>Vimala Nair - University of Florida*</i>		<i>p.113</i>
Biochar and Poultry Litter Amendments In Highly Weathered Soils: Phosphorus Availability, Transformation And Dynamics <i>Thilini Ranatunga - Alabama A&M University*</i>		<i>p.114</i>
Implementing California's Sustainable Groundwater Management Act: Farmer Perceptions And The Balance Of Groundwater And Economic Sustainability <i>Charles Young- Stockholm Environment Institute U.S.*</i>		<i>p.115</i>
Future Water Quality Challenges to Aquaculture and Influences on Product Safety <i>Jeremy Conkle- Texas A&M University-Corpus Christ*</i>		<i>p.116</i>
9:30 a.m. - 9:40 a.m.	Oral Session III	
	Oral Session (Salon I & II)	Oral Session (Salon III)
9:30 a.m.- 9:45 a.m.	<u>Algae For Conversion of Manure Nutrients to Animal Feed: Evaluation Of Advanced Nutritional Value, Toxicity, And Zoonotic Pathogens</u> <i>Murinda Shelton- California State Polytechnic University</i> <i>p.118</i>	<u>Grazing Management Effect on Micro- and Macro-Scale Fate of Carbon and Nitrogen in Rangelands</u> <i>Mamo Martha- University of Nebraska-Lincoln</i> <i>p.146</i>

<p>9:45 a.m.- 10:00 a.m.</p>	<p><u>Farms, Floods And Fluvial Geomorphology: Making The Most of Our Natural Resources</u> <i>Christine Hatch- University of Massachusetts Amherst p.120</i></p>	<p><u>Denitrification within Saturated Riparian Buffers Re-designed to Remove Nitrate from Artificial Subsurface Drainage</u> <i>Thomas Isenhardt- Iowa State University of Science and Technology p.147</i></p>
<p>10:00 a.m. - 10:15 a.m.</p>	<p><u>Advancing Agricultural Water Security and Resilience Under Nonstationarity and Uncertainty: Evolving Roles Of Blue, Green And Grey Water.</u> <i>Paula Rees- University of Massachusetts Amherst p.121</i></p>	<p><u>Seed Grant To Determine Molecular Speciation Of Phosphorus In Soils From A Long-Term Dairy Manure Amendment Trial In Idaho</u> <i>Daniel Strawn- University of Idaho p.148</i></p>
<p>10:15 a.m. – 10:30 a.m.</p>	<p><u>Characterizing The Fate And Transport Of Chemicals Of Emerging Concern (CEC’s) From Animal Manures During Waste To Energy Processes</u> <i>Lance Schideman- University of Illinois p.122</i></p>	<p><u>Processes Controlling the Source, Movement, and Release of Soil Phosphorus in Midwestern Streams from Pasture and Crop Land</u> <i>Thomas Insehart on behalf of Richard Schultz- Iowa State University of Science and Technology p.149</i></p>
<p>10:30 a.m. – 10:45 a.m.</p>	<p><u>Fate CEC’ in Animal Manure Amended Soils-Soil Processes</u> <i>Xia Kang- Virginia Polytechnic Institute and State University p.123</i></p>	<p><u>Soil Health and Water Quality Impacts of Growing Energy Beets for Advanced Biofuel Production in North-Central United States</u> <i>Zhulu Lin- North Dakota State University p.150</i></p>
<p>10:45 a.m. – 11:00 a.m.</p>	<p><u>Chemicals of Emerging Concern in the Eastern Snake River Plain of Idaho: A Threat to Irrigated Agriculture, Dairy, and Aquaculture?</u> <i>Morra Mathew- University of Idaho p.125</i></p>	<p><u>Biogeochemical Iron Cycling in Subalpine Wetlands with Different Hydraulic Connectivity: Impact on Fate and Transport of Organic C and N</u> <i>Thomas Borch-Colorado State University p.152</i></p>
<p>11:00 a.m. – 11:15 a.m.</p>	<p><u>Managing Water for Increased Resiliency of Drained Agricultural Landscapes</u> <i>Jane Frankenberger- Purdue University p.127</i></p>	<p><u>Nitrogen Transformations in Aquaponic Systems</u> <i>Samir Khanal- University of Hawaii at Manoa p.154</i></p>

11:15 a.m. – 11:30 a.m.	Persistence and Transport of Veterinary Antibiotics and Antibiotic-Resistant Bacteria in Midwestern Farming Systems <i>Thomas Moorman- USDA- Agricultural Research Service</i> p.129	Colloid Mobilization and Biogeochemical Cycling of Organic Carbon, Nitrogen and Phosphorous in Wetlands <i>Bruce Vasilas- University Of Delaware</i> p.155
11:30 a.m. – 11:45 p.m.	Evaluation Of Downstream And Ecosystem Water Quality And Quantity Through Targeting Conservation Practices In Mississippi <i>Prem Parajuli- Mississippi State University</i> p.130	Integrating Soil Carbon Stabilization Concepts and Nitrogen Cycling <i>Michael Castellano- Iowa State University of Science and Technology</i> p.156
11:45 a.m. – 12:00 p.m.	Moving Forward on Agricultural Water Conservation in the Colorado River Basin <i>Reagan Waskom- Colorado State University</i> p.131	Regional-Scale Assessment of N2O Emissions within the US Corn Belt: The Impact of Precipitation and Agricultural Drainage on Indirect Emissions <i>Timothy Griffis- University of Minnesota</i> p.157
12:00 p.m. 1:30 p.m.	Lunch (On Your Own)	
1:30 p.m. - 1:45 p.m.	Interactions Between Antibiotic Resistance In Soil Microbial Communities And Coupled Elemental Cycles <i>Michael Strickland- Virginia Polytechnic Institute & State University</i> p.132	Application of phosphate oxygen isotope ratios to detect sources and cycling of phosphorus in the White Creek, a Chesapeake Bay Watershed <i>Deb Jaisi- University of Delaware</i> p.158
1:45 p.m. – 2:00 p.m.	Smart Phone Apps: Scientific Validation Quantification of Water Conservation <i>Kelly Morgan- University of Florida Board of Trustees</i> p.134	Toward Sustainable Nitrogen and Carbon Cycling on Diversified Horticulture Farms Serving Community Food Systems <i>Ole Wendroth on behalf of Krista Jacobsen- University of Kentucky</i> p.159
2:00 p.m. – 2:15 p.m.	Improved Assessment of Nitrogen and Phosphorus Fate and Transport for Irrigated Agricultural Watersheds in Semi-Arid Regions <i>Bailey, Ryan on behalf of Mazdak Arabi- Colorado State University.</i> p.136	Impacts of Nitrogen Deposition on Microbial Community Carbon Dynamics in Forest Soils <i>Daniel Buckley- Cornell University</i> p.163
2:15 p.m. – 2:30 p.m.	An Integrative Decision Support System for Managing Water	Biologically Based Fertilizer Recommendations to Meet Yield

	Resources under Increased Climate Variability <i>Glenn O'Neil on behalf Jon Bartholic- Michigan State University</i> p.137	Expectations and Preserve Water Quality <i>Alan Franzluebbers- USDA- Agricultural Research Service</i> p.164
2:30 p.m. – 2:45 p.m.	Twenty-First Century Development Of 21st Century Precision Agriculture For Water Quality Protection <i>Michael Walter- Cornell University</i> p.139	Measuring Success of Targeted BMP Implementation, and Getting Smarter about Ephemeral Gully Sediment and Nutrient Sources and BMPs <i>Aleksey Sheshukov- Kansas State University</i> p.165
2:45 p.m.- 3:00 p.m.	Expanding Consumer and Community Water Protection Efforts Through Innovative and Integrated Mobile Technologies <i>Michael Dietz- University of Connecticut</i> p.140	Practical Benefits of Biochar Amendment to Agricultural Systems: Linking Soil and Microbial Processes to Economic Feasibility And Sustainability <i>Susan Crow- University of Hawaii, Manoa</i> p.166
3:00 p.m. – 3:15 p.m.	Break	
3:15 p.m. – 3:30 p.m.	Coupling Solid-Aqueous-Gas Phases Of Carbon And Nitrogen Across Topographic Gradients And Extreme Weather Events <i>Rodrigo Vargas- University of Delaware</i> p.141	Peptide/Protein Stabilization and C and N Sequestration in Soils: Contributions of Mineralogy in Native and Agro-managed Soils <i>Mark Williams – Virginia Polytechnic Institute and State University</i> p.168
3:30 p.m. – 3:45 p.m.	Biological and Biologically Mediated Abiotic Transformation of Contaminants of Emerging Concern in Anaerobic Soils <i>Timothy Strathmann- Colorado School of Mines</i> p.142	Impact of Agricultural Stream Restoration on Riparian Hydrology and Biogeochemistry <i>Sara McMillan- Purdue University</i> p.169
3:45 p.m. - 4:00 p.m.	Multi-Scale Investigation of Winter Runoff and Nutrient Loss Processes in Actively Managed Dairy Agroecosystems <i>Melanie Stock on behalf of KG Karthikeyan- University of Wisconsin System</i> p.143	
4:00 p.m. – 4:30 p.m.	General Discussion and Wrap up (Salon I &II)	

Oral Session I

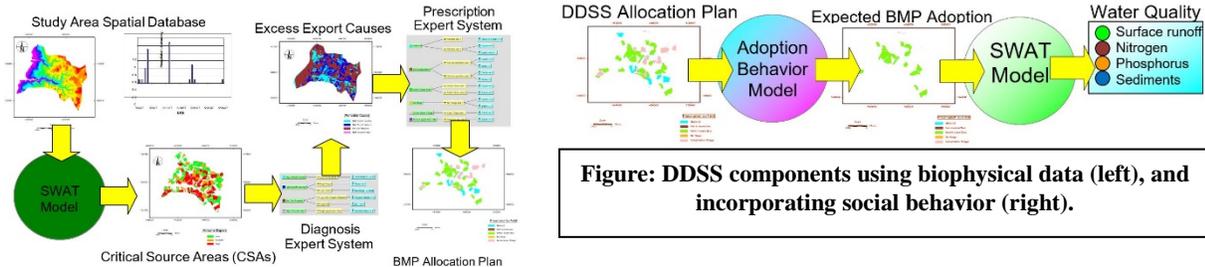
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Watershed Diagnostics for Improved Adoption of Management Practices: Integrating Biophysical and Social Factors

Paul T. Leisnham¹, H. Montas², A. Shirmohammadi¹, T. Hutson³, D. Lansing⁴, J. Renkenberger¹

1. Environmental Science & Technology, University of Maryland; 2. Bioengineering, University of Maryland; 3. University of Maryland Extension; 4. Geography & Environmental Systems, University of Maryland Baltimore County.

Summary: The goal of this proposal is to develop new GIS-based assistive tools that integrate biophysical and social factors to support the adoption and maintenance of targeted Best Management Practices (BMPs) on Critical Source Areas (CSAs) of constituent pollutants (surface runoff, sediments, nitrogen and phosphorus). We are achieving this goal through three objectives: 1. Social science research evaluating the attitudes and behaviors of farmers and other watershed citizens towards water quality and BMP adoption. 2. Developing a Diagnostic Decision Support System (DDSS) that integrates biophysical and social data to prescribe appropriate BMPs on CSAs, under different carbon emission / climate scenarios. 3. Extension and education of stakeholders in ecologically oriented water-quality assessment, environmental stewardship and DDSS application.



Impact: We used the Soil Water and Assessment Tool (SWAT), in combination with ArcGIS, to identify constituent CSAs in the agricultural Choptank watershed of the Chesapeake Bay drainage basin. Under current conditions, CSAs occupy 11-21% of the watershed but contribute 31-45% of constituents suggesting clear advantages of targeted control, and SWAT models were generally well correlated with macroinvertebrate indicators of stream health. Under high emission scenarios, constituent yields were predicted to increase by 1.8-2.3 times from a 30% increase in annual rainfall, and CSA areas are predicted increase by 2-3 times leading to much lower advantages of targeted BMPs. Much larger CSAs suggest that stakeholder involvement and community-oriented participatory approaches will be increasingly important for achieving Bay TMDLs with climate change. Unfortunately, social science instruments revealed substantial current social barriers to BMP adoption. Q-sort interview data showed sharp polarization in attitudes on the causes of nutrient runoff and the effectiveness of BMPs between farmers vs. environmental science professionals, with farmers largely believing that agricultural land users were not responsible for excessive runoff and highly suspicious of BMP effectiveness. Survey results confirmed these general divisions but also showed meaningful variation in farmer knowledge and attitudes, which were predicted by demographic factors and associated with actual BMP implementation. Further, farmers identified University Extension as a highly desired source of information, suggesting that targeted education approaches using University Extension could improve farmer knowledge, attitudes, and adoption of BMPs. Preliminary findings from adult and 4-H outreach events indicate success at improving BMP knowledge of diverse stakeholder groups. Ongoing research involves completing DDSS development, including filtering BMP implementation likelihoods based on social data, and introducing the DDSS to larger number of critical decision makers.



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Landscape-Scale Thresholds of Early Successional Habitat: Reconciling Biodiversity, Public Perception, and Timber Yield in Managed Forests

S.C. Loeb, B. Collins, L.E. DeWald, J. Hyman, E.D. Baldwin, T.J. Straka

USFS Southern Research Station, Clemson, SC; Western Carolina University, Cullowhee, NC and
Clemson University, Clemson, SC

Summary: Early successional habitats in the eastern U.S. have been declining over the past several decades due to farm abandonment, urban and suburban development, and suppression of natural disturbances such as fires, beaver activity, and flooding. Consequently, many species that depend on early successional habitats, including several species of conservation interest in the southern Appalachians, have also declined. Hence, restoration of early successional habitat in the southern Appalachians has been designated as a priority management goal.

Our objective is to determine if changing the size and aggregation of early succession habitat created by timber harvest can more effectively increase abundance of early successional species at the stand and landscape levels while retaining acceptable timber yield and forest interior habitat, and creating favorable public perception. At the landscape level, we hypothesize that aggregating the harvest areas will 1) increase connectivity among early successional patches while maintaining larger tracts of interior forest, thus creating a ‘habitat mix’ that can sustain early successional diversity and maintain forest interior species at lower overall harvest intensity; and 2) maintain acceptable timber yield while being perceived more favorably by the public than a single large-scale harvest.

Impact: We have examined the effects of size and aggregation of early successional habitat on biodiversity in several ways: 1) Vegetation structure and plant functional traits (seed mass, shade tolerance, wood density) are being compared across young (5-15 yr) and older (> 30 yr) past harvests that range in size from 2 to 14 ha to determine if larger and more recent harvests promote early successional forest structure. 2) Vegetation, avian diversity, bat activity and diversity, insect pollinator species composition, and soil respiration are being compared among 1-acre patches that were recently (spring, summer 2016) slashed and are either ‘aggregated’ (patches close together) or ‘dispersed’ to determine if aggregation of small openings promotes early successional habitat or species. 3) The effects of early successional patch size, edge, landscape characteristics, and environmental factors on bat activity and diversity were examined using existing forest cuts ranging in size from 0.2 ha to 18.5 ha. We have also developed a model of incremental benefit/cost values due to silvicultural framework modification to effect a change in the aggregation of harvests to increase early successional species at the stand and forest levels. The model addresses the economic and financial trade-offs between the various harvesting schemes.

Preliminary comparisons among past harvests show no effect of harvest size or open canopy on plant traits or the diversity of vegetation height. However, vegetation was shorter and denser closer to the ground in smaller and younger openings. Among large past harvests, younger forests had higher density and diversity of canopy trees. These results confirm that younger forests have early successional characteristics (higher density, shorter and dense closer to the ground) and suggest that small harvests may be as effective as larger harvests in creating early successional habitat. We also found no effect of harvest size on bat activity or diversity. However, activity was greater at opening edges suggesting that creating early successional patches that maximize the amount of edge may benefit bats.

Neither species richness nor abundance of early successional plant species differed strongly between aggregated and disaggregated sites or between cut and forest interiors. However, opening up the canopy resulted in the expected micro-environment differences among open, edge, and forested areas of the cut patches. Abundance of insect pollinators did not differ between aggregated (average 10.8 pollinators/observation) and disaggregated (average 9.3 pollinators/observation) sites, but there was a weak trend ($P = 0.08$) of a greater number of pollinator species in the open (average 6.8 species/observation) compared to edge (average 5.9 species/observation) areas of the cut patches. In all sites surveyed, the majority of bird species detected were forest interior species. Bat data are still being analyzed.

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Downstream Water Quality and Quantity Impacts of Water Storage Systems in Porter Bayou Watershed

Joel O. Paz¹, Mary Love M. Tagert¹, Jonathan W. Pote¹, Charles L. Wax²

¹Department of Agricultural and Biological Engineering,

²Department of Geosciences

Mississippi State University, Mississippi, MS

Summary: The declining groundwater levels in the Mississippi Delta Shallow Alluvial Aquifer and nutrient loads into the Mississippi River and the Gulf of Mexico are the two most important issues affecting the sustainability of agroecosystems in the Mississippi Delta region. Numerous on-farm water storage (OFWS) systems have been installed across the region primarily with support from the Mississippi River Basin Healthy Watersheds Initiative and other funding assistance programs. An OFWS system includes a tailwater recovery (TWR) canal and storage pond, and offers the dual benefits of providing irrigation water and capturing nutrient-rich tailwater from irrigated fields. The placement of these systems throughout a watershed can be better targeted if we can quantify the downstream nutrient reduction and water quantity effects of this BMP. The goal of this project is to determine the impacts of water storage systems on water quality and quantity in Porter Bayou Watershed, Mississippi.

We monitored two OFWS systems, one on Metcalf Farm and one on Pitts Farm in Porter Bayou Watershed, Mississippi through our partnership with NRCS and other stakeholders. Water samples from different points (inlet, outlet, mid-canal, and storage pond) within the OFWS were collected for analysis every three weeks throughout the growing season from March-October and every six weeks through the off-season. Cumulative readings were also taken on flow meters to measure water use both from the storage pond and groundwater wells.

Comparing nutrient concentrations in the TWR canal and at the outlet over the entire study period, we observed a reduction of 67% and 50% in nitrate nitrogen (NO₃-N) at Pitts Farm during winter and spring, respectively (Table 1), while Metcalf farm had slightly lower reduction in NO₃-N in the winter (54%). Reductions in total phosphorus at Pitts Farm were 31% and 10% during winter and spring, respectively. Based on median NO₃-N concentrations and volume discharge from the Metcalf farm for a three-month period, a 54% reduction translated into 289 kg of NO₃-N that was retained within the OFWS system. Results provide evidence of significant seasonal water quality changes among the different monitored locations, and more importantly, highlight downstream nutrient reduction. Equally important were the significant water savings by utilizing surface water storage for irrigation activities. Pitts Farm used 163.3 million gallons (501.1 acre-ft) of water from 2012 to 2015 growing seasons, while Metcalf Farm used 96.9 million gallons (297.4 acre-ft) of water from its storage pond during the same period (Figure 1). These amounts reflect savings in groundwater that was not pumped from the Mississippi Delta Shallow Alluvial Aquifer.

Impact: Farmers, commodity groups, and other stakeholders in other parts of the state are very interested in adopting this best management practice for water conservation and nutrient reduction. We have relayed the results of this project to local NRCS staff, as well as the NRCS Regional Engineer who designs most of these systems in the Mississippi Delta. We have leveraged this project and received support from the Mississippi Soybean Promotion Board for a new project (which started in May 2014) to monitor an OFWS system outside of the Mississippi Delta region and perform a

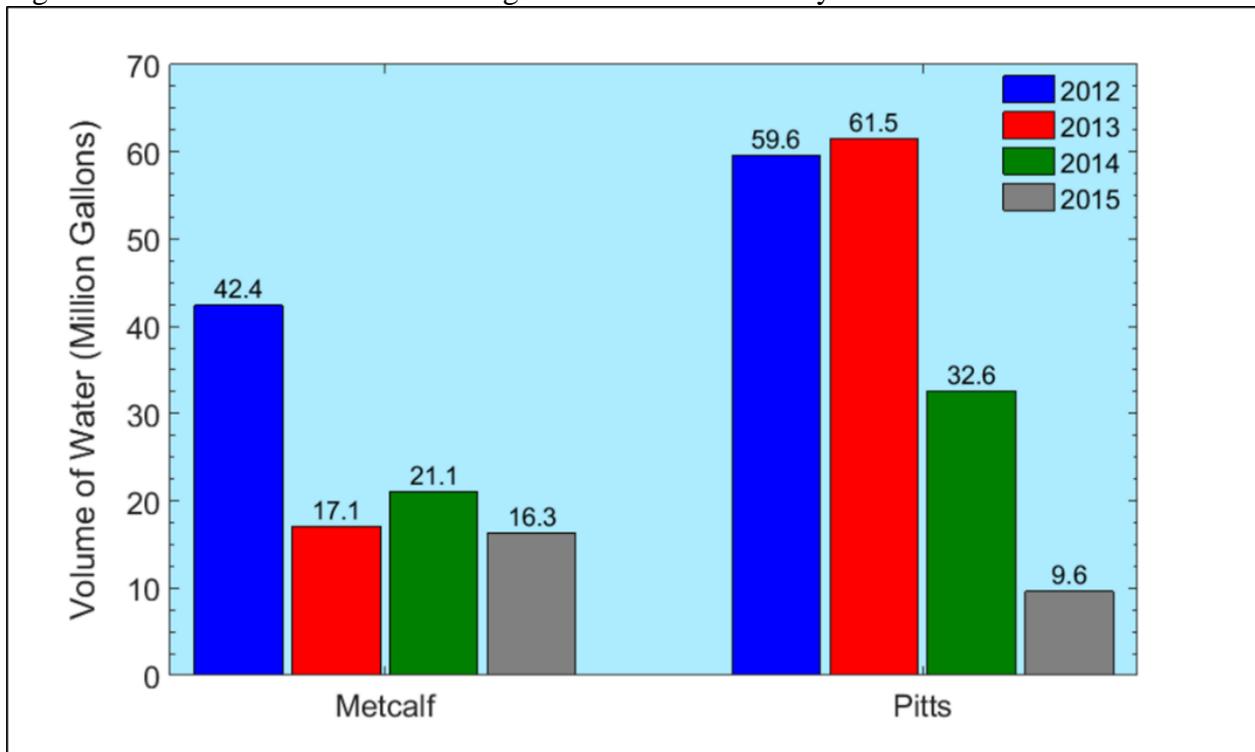
cost/benefit analysis of these systems. We have also shared results of this work with fellow scientists and government employees from Bosnia Herzegovina (through a Cochran Fellowship) and will continue to share the benefits of using and recycling surface water with a Borlaug Fellow from Algeria.

We have presented results from this project at various scientific and stakeholder meetings, including the Yazoo Basin Team, the Mississippi Chapter of the American Society of Agronomy, and others. This project has also been used to provide research opportunities for junior and senior high school students attending the Mississippi School for Mathematics and Science. In addition, information and results provided through this project were used to train participants attending an Adopt-A-Stream workshop, who were interested in monitoring their watershed and largely consisted of teachers and environmental professionals.

Table 1. Seasonal nutrient reduction (%) of OFWS systems installed on two farms in Porter Bayou Watershed, Mississippi.

Season	Nitrate-Nitrogen		Total Phosphorus	
	Metcalf Farm	Pitts Farm	Metcalf Farm	Pitts Farm
Winter	54	67	-	31
Spring	50	50	-	10
Autumn	-	32	22	-

Figure 1. Volume of water used for irrigation from the OFWS systems.





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Developing a Web-based Forecasting Tool for Nutrient Management

Drohan, P.; Miller, D. A.; Knight, P. G.; Beegle, D. B.; Lin, H.; Crawford, S. R.; Bills, B. W.

Summary: US and state nutrient management planning provides strategic guidance that, in the best cases, educates farmers and others involved in nutrient management to make prudent management decisions. The strategic guidance provided by nutrient management plans does not provide the day-to-day support required to make operational decisions, particularly when and where to apply nutrients over the short term. These short-term decisions on when and where to apply nutrients can make the difference between whether the nutrients impact water quality or are efficiently utilized by crops. Infiltrating rainfall events occurring on the heels of broadcast nutrient application are beneficial, as they will wash soluble nutrients into the soil where they are used by crops. Rainfall events that generate runoff shortly after nutrients are broadcast will wash off applied nutrients, producing the largest losses of nutrients possible from that site. Our goal is to develop a research driven support tool for nutrient management, the Fertilizer Forecaster, which identifies the relative probability of runoff or infiltrating events in Pennsylvania (PA) landscapes. This tool will support field specific decisions by farmers on when and where to apply fertilizers and manures over 24, 48 and 72 hour periods. Our objectives are to: (1) monitor agricultural hillslopes in watersheds representing four of the five Physiographic Provinces of the Chesapeake Bay basin; (2) validate a high resolution mapping model that identifies soils prone to runoff; (3) develop an empirically based approach to relate state-of-the-art weather forecast variables to site-specific rainfall infiltration or runoff occurrence; (4) test the empirical forecasting model against alternative approaches to forecasting runoff occurrence; and (5) recruit farmers from the four watersheds to use web-based forecast maps in daily manure and fertilizer application decisions. Data from on-farm trials will be used to assess farmer fertilizer, manure, and tillage management decisions before and after conscientious use of the Fertilizer Forecaster, and will help to understand not only the effectiveness of the tool, but also characteristics of farmers with the greatest potential to benefit from such a tool. Feedback from on-farm trials will be used to refine a final tool for delivery to the PA Conservation Commission. We hope that the Fertilizer Forecaster will serve as the basis for state (PA), regional (Chesapeake Bay), and national changes in nutrient management planning. The proposed project is central to the objectives of AFRI's Management of Agroecosystems program area. Specifically, this project develops an innovative management practice that is designed to enhance the services of aquatic ecosystems by improving water quality and enhance the services of terrestrial ecosystems by increasing the efficiency of nutrient use by targeted crops.

Impact: What was accomplished under these goals? Postdoctoral Scholar Jasmeet Lamba worked with our research group for just under one year. NIFA support for Jasmeet was leveraged with USDA-ARS funds. We held several meetings (informally by phone and formally in person) with members of the runoff forecasting project team, including representatives from Penn State, USDA-ARS, and NOAA's Middle Atlantic River Forecast Center (MARFC). The two formal (face-to-face) meetings were held on September 3, 2015 and March 24, 2016. The goals of these meetings were to discuss optimal ways for portraying runoff risk in our runoff forecasting prototype. Based on the outcome of the most recent meeting in March, we decided to depict maps of watershed scale runoff risk using a set of soil saturation and runoff contributing area thresholds that enable 2×2 km forecast cells from the SAC-SMA model to be color-coded green for low risk, yellow for moderate risk, and red for high risk. By zooming in on a 2×2 km cell, one can then obtain a field-scale view of the forecast runoff contributing area, which is mapped spatially using simple depth-to-water indices created from LiDAR digital elevation models. Future iterations of these field-level maps will incorporate information from the digital soil mapping efforts led by Lauren Vitko, PhD student in Ecosystem Science and

Management. Drs. Buda and Lamba (postdoc on the Fertilizer Forecaster project) were invited to attend a meeting on runoff forecasting tools organized by the leadership of USDA NRCS and NOAA's North Central River Forecasting Center in St. Paul, Minnesota. The meeting was held at the USDA South Building in Washington, D.C. on April 16, 2015. Drs. Buda and Lamba gave a brief presentation on the Fertilizer Forecaster and contributed to a discussion on developing, testing, and expanding runoff risk tools in nutrient management. Drs. Buda, Kleinman, Drohan, and Lamba were invited to participate in the development of a national NRCS Conservation Innovation Grant (CIG) on runoff forecasting tools led by Whatcom Conservation District in Lynden, Washington. The proposed research involves qualitatively and quantitatively comparing several of the most prominent runoff forecasting tools across the US, including the Runoff Risk Advisory Forecast (Wisconsin), Application Risk Management System (Washington), Fertilizer Forecaster (Pennsylvania), and Saturated Area Forecast Tool (Virginia). The grant was successful, and work on the project began this in spring 2016. Initial progress includes a qualitative comparison of the four runoff tools, which addresses and expands one of the central goals of the current AFRI project. A paper describing the results of the qualitative comparison is in the works, and will be submitted to the Journal of Environmental Quality later this spring. We continue to monitor runoff occurrence in all four project watersheds. Data from these efforts are being used to confirm runoff predictions by the Fertilizer Forecaster and assess overall model skill. In addition, wet boot mapping in the Mattern and FD-36 watersheds will be used to corroborate field-level forecast maps of runoff contributing areas made by the Fertilizer Forecaster. PhD Student Lauren Vitko has drafted her thesis and 4 peer-reviewed papers outlining her restrictive layer modeling efforts under the grant team's mentorship. These papers outline the geophysical, pedological, and hydrologic techniques used to identify and map restrictive layers at a high resolution across several study watershed locations. Ms. Vitko will be defending her thesis in May 2016.



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Phosphorus Cycling in Soils: Assessing the Impact of Agricultural Practices on Phosphorous Availability and Loss Using Oxygen Isotopes of Phosphate

Adina Paytan, EPS, UCSC, CA; Asmeret Berhe, ES, UCM, CA; Kate Scow, LAW, UCD, CA

Summary: Determining soil P availability and mobility and how these characteristics vary with soil type and agriculture practices will help reduce P loss from agriculture systems and contribute fundamental understanding to inform science based management plans. However, tracking P cycling, mobility in soils, and determining soils' P availability to plants is challenging because adsorption/desorption, immobilization (occlusion by or precipitation as minerals), mineralization (conversion of organic P compounds to Pi), and uptake (by organisms) all occur simultaneously in the soil. A clear understanding of all aspects of soil P biogeochemistry is required to determine P availability and mobility in soils, but analytical techniques have not been available to fully characterize P cycling in soils. This project will test a newly developed isotope system to shed light on soil P cycling under different management practices.

We utilize the oxygen isotopic composition of phosphate ($\delta^{18}\text{O}_p$) which is associated with various pools of P in soil (soil solution, loosely adsorbed, Fe and Al associated, and Ca associated) to elucidate some of the P transformations that take place within different soil types and under different agriculture management practices (no tillage, standard tillage, organic or mineral fertilizers etc. in a factorial design). Specifically, we will investigate how adsorption/desorption, mineralization, uptake, and immobilization processes differ between different soils and under different management and link these characteristics to P availability and mobility. Work takes place at the Russell Ranch Experimental LTRAS, a long-term comparison of 10 conventional, organic and alternative cropping systems, both irrigated and non-irrigated. Four distinct treatments are compared and the changes in $\delta^{18}\text{O}_p$ among treatments and within each treatment plot with depth and over time are compared. We found that the SRP concentrations decrease with depth for all treatments but that plots receiving organic treatments have higher SRP concentrations than those treated with mineral fertilizer. The very labile phosphate (extracted by water and bicarbonate) concentrations in these soils is very low and higher concentrations are seen in the less labile fraction (NaOH and HCl extractions). Soils receiving organic fertilizer have higher SRP and TP concentrations for all fractions in the upper 60cm of the soil core, while at depth (200m) all fractions and treatments converge to lower values. Isotope data suggest that the latter more refractory fractions however are also bioavailable to crops but on longer time scales.

Impact: The combined approach of determining P association with different soil fractions and $\delta^{18}\text{O}_p$ shed more light on P availability and cycling in soils. Determining soil P availability and mobility and how these characteristics vary with soil type and agriculture practices will help reduce P loss from agriculture systems and contribute towards science based management plans. Sustainable P management is critical for reducing environmental P pollution (i.e. reducing surface and groundwater pollution and risks of eutrophication). In addition, with impending shortages in fertilizer P availability in the world, data and understanding derived from this work will play critical role in our understanding of how different soil, as well as human variables affect not just total stocks but also availability of P for critical crops and vegetables.

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Watershed Scale Project in Oostanaula Creek

F.R. Walker¹, C.D. Clark², M. Essington¹, S. Hawkins¹, D.M. Lambert²,
A. Layton³, J. Schwartz⁴ and L-B Reynolds⁵

¹Biosystems Engineering and Soil Science, Agricultural and Resource Economics², Center for Environmental Biotechnology³, Civil and Environmental Engineering⁴, and University of Tennessee Extension⁵

The University of Tennessee Knoxville

Summary: The Oostanaula Creek watershed in eastern Tennessee is typical of the ridge and valley region that occupies much of the eastern United States along the Appalachian Mountain chain from central Mississippi to southern New York. Ridge and valley regions are characterized by rolling hills and many meandering tributaries. Agriculture operations are typically located in the low lying areas. The issues facing the Watershed are common throughout the ridge and valley region; e.g., urbanization and water quality degradation. This project demonstrated how we can use the best available science to identify sources of non-point pollution (bacteria and sediment) in the watershed, prioritize and implement practices to reduce non-point pollution and educate stakeholders on the use of best management practices that maintain agricultural productivity without negatively impacting environmental quality. We identified some of the dominant sources of fine sediment to Oostanaula Creek watershed, conducted economic cost-benefit analysis of sediment source-dependent BMPs specific to the Oostanaula Creek watershed and assess the behavior response of farmer willingness to implement sediment BMPs. Our comprehensive watershed-wide education program informed farmers, youth and adult residents about the importance of maintaining and improving water quality in the Watershed and conduct educational events throughout the Watershed to demonstrate that BMPs can simultaneously improve water quality and increase agricultural productivity.edward

Problem and Project Goal

The overall objective of our research efforts in the Watershed have been to use the best available science to identify sources of water quality degrading pollutants in the Watershed and to encourage agricultural producers and other stakeholders to adopt cost-effective BMPs to reduce the pollutant loading.

Objective A. Develop a watershed-scale sediment budget that identifies dominant sources of fine sediment to Oostanaula

Objective B. Conduct an economic cost-benefit analysis of sediment source-dependent BMPs specific to the Oostanaula Creek watershed

Objective C. Assess the behavior response of farmer's willingness to implement sediment BMPs

Objectives D & E. Conduct comprehensive watershed-wide education program to inform farmers, youth and adult residents and demonstrate that BMPs can simultaneously improve water quality and increase agricultural productivity

Impacts:

1. We successfully characterized microbial communities for eroding soil and suspended sediment, studied the interrelationship of the microbial communities among different soil eroding materials and determined bacterial communities can serve as an eroding material source tracker with

discriminatory power between contributing suspended sediment sources and in-stream suspended sediment. Our findings indicate that the dominant phyla in providing discriminatory power are *Acidobacteria*, *Actinobacteria*, *Bacteroidetes*, *Chloroflexi*, *Crenarchaeota*, *Euryarchaeota*, *Firmicutes*, *Gemmatimonadetes*, *Nitrospirae* and *Proteobacteria*. These core microbiomes play key roles in the ecosystem and could also serve as tracers in microbial source tracking.

2. For sediment elemental fingerprinting Si, Co, P, Mn, Ba, Cu and Zn were the optimum combination of elements for visualizing the clustering effect of sediment from different categories (upland erosion versus stream bank).
3. Other research focused on better understanding stream bank erosion processes and channel degradation in this southern Appalachian region examining the potential influence of urbanization on increased erosion, how vegetation and bedrock influence bank stability, estimating sediment yields energy production fields where have similar characteristics of hay pasture, and estimating sediment yields specifically generated from cattle trails along pasture hillslopes.
4. The likelihood that producers would adopt rotational grazing was integrated into the Soil and Water Assessment Tool (SWAT) hydrologic model. It was estimated that the maximum upland sediment loss reduction with rotational grazing totals 1,450 tons/year at a cost of \$170/ton across the Oostanaula Creek Watershed.
5. During the project we implemented agricultural and urban BMPs: several 100 acres of pastures were renovated, several miles of cattle exclusion fencing, heavy use cattle lanes, and cattle waterers were installed during this project
6. Significant reaches of Oostanaula creek were “de-posted” (a prelude to de-listing from 303 d list) in mid-2015



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Variable Thinning Using Historical Stand Structure Data to Create Fire-Resilient Forests and Enhance Ecosystem Services in a Changing Climate

Eric Knapp, USFS Pacific Southwest Research Station, CA
Roger Bales, University of California Merced, CA
Matt Busse, USFS Pacific Southwest Research Station, CA
Malcolm North, USFS Pacific Southwest Research Station, CA
Scott Stephens, University of California, Berkeley, CA

Summary: Historical data show that forests in areas that experienced frequent fire were highly heterogeneous with trees arranged in groups interspersed with small gaps. Variability produced high quality habitat for many wildlife species and broke up fuel continuity, likely contributing to the rarity of crown fire. Openings allowed light-requiring shrubs, which provided important browse and cover, and tree species such as pines, to establish. Small openings surrounded by trees also were areas where snow accumulated, which not only provided water, but likely influenced forest regeneration dynamics. Much of this variability has been lost due tree encroachment resulting from fire exclusion, as well as past logging of the largest, most fire-resilient trees. Standard fuel reduction thinning prescriptions that typically call for spacing crowns of individual trees can further reduce structural heterogeneity. The purpose of this study is to evaluate how retaining and creating structural heterogeneity within fuels reduction and forest restoration treatments influences biotic and physical variables including tree regeneration and growth, understory diversity, habitat suitability for small mammals and birds, snow accumulation, date of snow melt, and soil moisture. Our hypothesis is that treatments having the greatest within-stand variability at a spatial scale similar to what existed in historical forest stands will enhance diversity and abundance of understory vegetation, improve natural pine regeneration, increase snow accumulation and melt duration, and provide a better balance with fuel management objectives such as reducing the vulnerability to crown fire. By evaluating the linkages of biotic variables with snow pack, soil moisture, and other within-stand environmental variables, we will better understand mechanisms, which allow predictions about sustainability in a future changing climate to be made. Two post-treatment evaluations of vegetation variables have now been completed, the final one wrapping up in September 2016. Weather and within-stand microclimate variables have been measured continuously since 2013 and snow surveys were conducted each winter since 2012/2013.

Impact: Snow survey data indicated that more snow accumulated in the high variability thin units. This is believed to be because of the larger forest gap sizes within these units. Data from light/temperature loggers also indicated that snow persisted longer in the high variability units than the low variability thin or unthinned control units. Unfortunately, the data we collected in 2012/13 remain the best test of treatments. California is in the midst of a major drought and subsequent years have been much drier and warmer than normal. The hoped for change back to a more normal snow pack during the winter of 2015/16 did not materialize. While we wish that snow yield benefits of variable thinning had been more thoroughly tested across multiple years, a publication from this aspect of the project is in progress.

While the 2016 vegetation data have yet to be analyzed, early results from the 2014 surveys indicate that the variable thinning treatment produced a forest similar in density, spatial structure, and tree species composition to what existed prior to extensive logging and fire exclusion. Prescribed fire alone did not substantially thin the forest or alter tree species composition, killing less than 10% of trees.

The combination of thinning and prescribed fire appeared to produce the greatest increase in understory shrubs, which once provided important browse and structure for wildlife species. Average rates of individual tree growth increased substantially with thinning, but no difference was noted between the even thin and variable thin treatments.

The full impact of a study is usually best gauged after the data have been collected and published but we are already seeing substantial interest in our experimental demonstration of variable thinning. The concepts behind variable density thinning have been shared extensively with different stakeholder groups through presentations and workshops. This study, and other related publications have already led to changes in how the USFS is approaching forest thinning in many areas. Such shifts are slow and incremental, but the ideas have inspired projects with broader support among stakeholder groups. Unfortunately, we have no means of determining the extent to which our efforts have contributed, beyond interactions that involve us directly.

With drought dominating the news, our study has been featured on television, in local newspapers, and on the radio. In the summer of 2015, the study area hosted several tours for large groups of stakeholders, including representatives from the timber industry, environmental groups, the US Forest Service, as well as politicians (from county supervisors to congressman Tom McClintock, whose district includes the study area), all interested in scaling up forest treatments to prevent future uncharacteristically severe wildfires like the 2013 Rim Fire, which occurred just a few miles south of the study. Many of these stakeholders are interested in treatments that best deal with the excess fuels issue without detrimental impacts to wildlife habitat. There is also a broad interest in seeking win-win solutions, such as increasing water yield and benefiting the local economy. Two additional tours are scheduled for early October, 2016.

Brought on by the extreme drought, the forests in the vicinity of the study area are currently in the midst of a major bark beetle epidemic, causing widespread tree mortality. While catastrophic tree mortality yet to reach the study area, the rate of mortality is already elevated, and we hope that our data will provide useful information about the extent to which the treatments being tested can increase resilience to drought and bark beetles.



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Physicochemical Controls on Transport of Veterinary Pharmaceuticals and Hormones to Surface Waters

Cheng-Hua Liu, Ya-Hui Chuang, Wei Zhang, Hui Li, Brian J. Teppen, and Stephn A. Boyd,
Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI
Javier M. Gonzalez, National Soil Erosion Research Lab, USDA-ARS, West Lafayette, IN
Cliff T. Johnston, Department of Agronomy, Purdue University, West Lafayette, IN

Summary: Veterinary pharmaceuticals and hormones in animal manures are chemicals of emerging concerns (CECs), resulting in surface water contamination, bacteria antibiotic resistance, and endocrine disruption in humans and animals. CEC-contaminated manures are typically applied to agricultural fields. As CECs tend to sorb strongly to major soil geosorbents, i.e., clay minerals, amorphous organic matter (AOM), and black carbon/biochar (BC), top-soils and specifically certain geosorbent particles become highly enriched in CECs. We envision that CEC-enriched geosorbent particles mobilized from top-soils and transported in surface runoff or to shallow tile-drainage water can contribute a substantial CEC load to surface waters. We will mechanistically examine CEC sorption and transport in surface runoff and subsurface flows. Objectives are: 1) Determine sorption capacities of clay minerals, AOM, and BC for representative CECs and assess possible sorption attenuation of CECs by manure- and natural biomass- derived organic acids; 2) Develop a mechanistic, predictive sorption model based on additive sorption by these geosorbents and validate this technique with whole soils and soils amended with biochars, 3) Investigate and model the facilitated transport of CECs by geosorbent colloids in surface and shallow subsurface flows. We are investigating a novel management tool, i.e., biochar soil amendment for enhanced sequestration of CECs in soils, thereby reducing CEC bioavailability. Knowledge gained will help improve process-based modeling of CEC transport in surface runoff and shallow drainage waters. Improved assessment of CEC fate and transport in soil ecosystems will contribute to management strategies to mitigate the spread of CECs in the environment, thus protecting human and ecosystem health.

Impact: The primary target audience of this project are scientific community and extension professionals in the field of environmental science and engineering, soil and water sciences, animal manure management, etc. This research could also benefit farming communities because improved assessment of CEC fate and transport in agroecosystems will contribute to management strategies to mitigate the environmental spread of CECs. Consequently, this project will also be of interest to policymakers and the general public who are keen to protecting water quality and the public and environmental health.

We studied the kinetic and quasi-equilibrium sorption of antibiotics on biochars, using lincomycin and tetracycline as two model antibiotics of contrasting sorption behaviors and environmental stability. We investigated the release of dissolved organic matter from biochars and its effect on sorption of antibiotics. We confirmed facilitated transport of lincomycin, oxytetracycline, and sulfamethoxazole by biochar particles. Rainfall simulation experiments on pharmaceutical transport in surface and subsurface flow is ongoing. Our work contributed to 10 conference presentations and 16 invited presentations. One article was published in *Journal of Environmental Quality*, and five manuscripts are currently under preparation.

Oral Session II

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goCrop: Integration of Mobile Technology to Enhance Nutrient Management Program Implementation

Darby, H. M.; Daley, C.; Heemstra, J.; Karle, B.

Summary: Through initial funding a web-based and mobile application have been developed that help Vermont farmers develop, record and store their NMP information and simplify the process of recordkeeping and compliance with state and federal regulations. This innovative NMP program, titled GoCrop, has been undergoing testing with farmers and nutrient planners, and is scheduled to be publicly available to Vermont farmers in fall of 2012. The purpose of this proposed project is to further refine this tool and develop new innovations within GoCrop that will further broaden and expand the livestock farmer user base for this tool. Because there are no other software applications quite like GoCrop, it is a true innovation, and its success and adoption by farmers is highly likely. The primary deliverable from this project is the enhanced and expanded version of GoCrop. This project will deliver new modifications to the applications including functions for mapping, grazing and pest management. In addition, the tool will be expanded for use in California, the Northeastern States, and on certified organic dairy farms across the nation. A series of webinars will be designed to provide detailed instructions to participants. YouTube videos will be created to help users adopt this tool. All outreach information will be posted on the GoCrop website and through eXtension. Through mail and web surveys conducted among farmers and other clients, we will evaluate the usability and impact the applications have on NMP implementation. Users will also have a chance to post reviews and suggestions for GoCrop online.

Impact: What was accomplished under these goals? During this project period we have worked with developers to outline changes and modifications that need to be made to goCrop so that information can be added to meet California nutrient management planning standards. First our co-PIs from CA attended the goCrop training course held in February and March of 2013. During this course they documented specific changes that would be required to meet CA state standards for NMPs. During the remainder of 2013, developers worked to finalize version 1.0 goCrop and launched to the public in September of 2013. A payment structure was developed as well. In addition, developers worked with project PIs to outline storyboards for grazing management tool and whole farm nutrient balance. Development should begin in 2014.

An Integrated Approach to Foster Science-Based Management of Agricultural Drainage Channels in the Western Lake Erie Basin

Witter, J. D.; Koontz, T.; Mouser, P.; Islam, K.; Vollmer-Sanders, C.; Jolliff, S.; Ward, A.

Summary: The Western Lake Erie Basin (WLEB) is one of the most highly productive and intensively farmed areas of the world. Agriculture in this region is highly dependent on improved drainage practices, such as channelization (i.e. ditching), that facilitate reliable and economic production of crops. However, channelization is also widely recognized as a primary source of water quality impairment. Excess nutrients and sediment are exported from and through channels to Lake Erie fueling harmful algal blooms that release neurotoxins potentially impacting human health and creating seasonal hypoxic zones that impact the entire lake ecosystem and the water-based industries it supports. This project seeks to quantify the water quality benefits of these innovative, alternative channel designs and understand the factors that lead to adoption. It also seeks to develop a methodology that targets implementation to areas that provide the most benefit at least cost. Most importantly, this project will disseminate knowledge to stakeholders and policy makers that will then be able to make informed decisions about drainage. To quantify water quality benefits of these practices we will sample and analyze sediments and nutrients from these practices for their soil physical properties and nutrient content. These measurements will be made throughout the basin and over time to assess variability in nutrient retention and cycling. We will utilize a suite of molecular genetic methods to assess microbial diversity and functional potential. We will also utilize interviews, surveys, case studies, and a field experiment to better understand the factors that influence adoption of these innovative practices. To target implementation we will utilize GIS tools and remote sensing databases to identify locations that are best suited for alternative channel designs. Finally, we will disseminate our findings through our extension programs, coursework, conferences and meetings, and a partnership with the Ridgmont Local Schools Future Farmers of America.

Impact: What was accomplished under these goals? The following accomplishments are listed by objective: Objective 1 - Sites which fit the study experimental design were identified using GIS data. Sites were then randomly selected from the candidate pool until 3 sites per ecoregion (5 total ecoregions) could be established. Soil core sampling and field surveys were conducted in May/June and September/October. Lab analysis of soil physical and chemical properties and soil microbial biomass are ongoing. Objective 2 - Based on results from the analysis of soil microbial biomass several sites with high biological activity have been identified and will be targeted during the next round of sampling. Preliminary tests have been undertaken to test the DNA extraction methods on the sediments and soils in the floodplain benches. Objective 3 - The survey instrument for telephone interviews of local level conservation professionals has been developed and cleared the university Institutional Review Board. Potential candidates for the interview process have been identified and the interview process is underway. Objective 4 - No activities are scheduled until Year 2 of the study; however, a spreadsheet tool to quantify construction costs of BMP implementation has been developed to facilitate that work. Objective 5 - A number of outreach engagement activities have been conducted including training workshops for conservation professionals and landowners, STEM education events with high school students, oral presentations and posters at academic conferences, and lectures in university classrooms. The outreach education activities to disseminate research results and the development of practical tools to facilitate informed management have led to increased interest in implementing the two-stage ditch and self-forming channel BMPs. Landowners or conservation professionals in Fulton, Putnam, Seneca, and Hardin counties have contacted us to discuss specific projects where alternative channel designs might be appropriate management strategies.



2012-67019-19294

Enabling The Flow Of Ecosystem Services From Agriculture to Improve Puerto Rico's Water Quality and Mitigate Global Climate Change

Jonathan R. Winsten, Ph.D., Winrock International; Luis Perez-Alegria, Ph.D., University of Puerto Rico; Neville Millar, Ph.D., Kellogg Biological Station; Fabian Carmona, University of Puerto Rico

Summary: Agriculture is an important contributor of nutrients and sediments to ground and surface water, as well as nitrous oxide (N₂O) to the atmosphere. However, maintaining viable farms is also crucial to our nation's food security and rural economic health. Therefore, it is essential that we develop ways to reward farmers for innovative and cost-effective actions to improve water quality and mitigate global climate change. The primary goal of this project is to develop additional farm revenue streams for the production of ecosystem services from agriculture in Puerto Rico that reduce nutrient losses to surface and ground water and to reduce N₂O emissions to the atmosphere. Plantain is an important food crop throughout the tropical regions of the world. However, a dearth of information exists on the environmental impact of production or best management practices. This project seeks to contribute valuable information on ways to reduce nutrient and GHG loss from plantain production.

Impact: This project experienced significant delays in commencement of field research due to an administrative issue at the University of Puerto Rico, but is now completing the second year of field data collection. The project is conducting intensive research trials on the grounds of a large commercial farm in southcentral Puerto Rico. Three nutrient management treatments are being

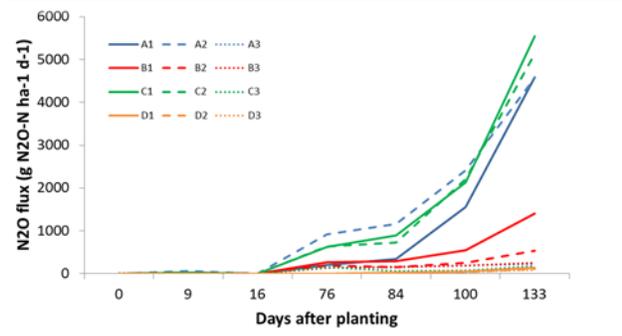


Figure 1. Initial N₂O Flux Results

studied in comparison to a business-as-usual control (green lines in Figure 1). Initial results indicate that typical nitrogen application rates in Puerto Rico are much higher than the published UPR recommendations (red lines in Figure 1) and that significant reductions in N₂O emissions are likely from reducing application rates to the UPR recommendation. Final yield results are still being analyzed, which are needed to understand the full economic costs of following the UPR recommendation. Data from the field research are being used to calibrate and validate the Nutrient Tracking Tool (NTT) model to estimate the nutrient loss and GHG emissions from plantain production in Puerto Rico. NTT will then be usable to quantify the relevant ecosystem services and allow farmers to participate in environmental markets or certification programs to increase farm revenue streams.



2012-67019-19484

Consequences of Stand Age and Structure on Forest Water Yield

Chelcy Ford Miniati (Forest Service; USDA), Peter V. Caldwell (Forest Service; USDA), Paul V. Bolstad (University of Minnesota), Steven T. Brantley (Joseph W. Jones Ecological Research Center), Katherine J. Elliott (Forest Service; USDA), Kim A. Novick (University of Indiana), and A. Chris Oishi (Forest Service; USDA)

Summary: Climate change and forest disturbances are threatening the ability of forested mountain watersheds to provide the clean, reliable, and abundant fresh water necessary to support aquatic ecosystems and a growing human population. Here, we used 76 years of water yield, climate, and field plot vegetation measurements in six unmanaged, reference watersheds in the southern Appalachian Mountains of North Carolina, USA to determine whether water yield has changed over time, and to examine and attribute the causal mechanisms of change. We found that water yield declined by up to 22 percent in some watersheds since the 1970s. Changes in water yield were mostly related to changes in climate, but disturbance-related shifts in forest structure and species composition may have decreased water yield by up to 18% in a given year after accounting for climate. Our results suggest that changes in climate and forest structure and species composition in unmanaged forests brought about by disturbance and natural community dynamics over time can result in large changes in water supply.

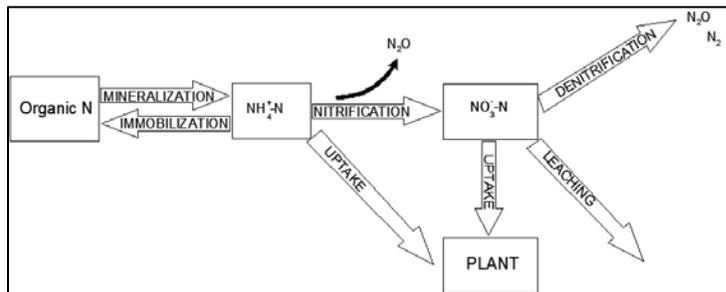
Impact: The study findings have implications for managing forested watersheds to ensure adequate water supply under future climate change. Future studies on managing watersheds more towards oak-hickory canopy dominance—and away from tulip poplar, red maple and rhododendron shrub dominance in the overstory and shrub layers—should increase both water yield and high value timber products.

2011-67019-30178

Functional and Molecular Diversity in Nitrogen Cycle Enzymes under Contrasting Agricultural Management Systems

 Jeanette M. Norton¹, Yang Ouyang¹, John Stark¹, Jennifer Reeve¹, Mussie Y. Habteselassie²
¹Utah State University and ²University of Georgia

Summary: On a global basis reactive nitrogen (N) inputs related to human activities now exceed natural input levels, more than 50% of these inputs are linked to agriculture, primarily through the use of fertilizers. Availability of N from fertilizers and organic sources is the result of microbial enzymatic processes especially nitrogen mineralization, immobilization and nitrification. In many agricultural systems, large amounts of fertilizer N are lost from the root zone as nitrate-N through leaching and denitrification resulting in low N use



efficiency. In this project, novel methods for the examination of functional diversity of the microorganisms responsible for nitrogen turnover in soils were developed and applied. We characterized the root-zone microbial communities responsible for selected N transformations in agroecosystems under contrasting management. Knowledge of the microorganisms of the internal N cycle will strengthen our understanding of microbial controls on N availability to plants and the propensity for N loss. Avoiding the combination of high external N inputs with low N use efficiency remains a major concern for the sustainability of agroecosystems.

Impact: We assessed the impacts of contrasting N management on soil microbial communities, enzyme activities, and functional genes for nitrification and nitrogen mineralization in Utah and Georgia agricultural systems. Process rates and activities were measured in laboratory potential assays and N-15 isotope pool dilution experiments. The abundance and diversity of genes involved in nitrification and nitrogen mineralization were examined using quantitative real-time PCR, pyrosequencing, clone libraries, and metagenomics. Key enzymes and their relevant marker genes included ammonia monooxygenase (*amoA*), nitrite oxidoreductase (*nxrB*), protease (*npr* and *sub*), chitinase (*chiA*), and urease (*ureC*).

Ammonia oxidizing bacteria were more responsive than archaea to ammonium fertilizers while the archaea were competitive under low ammonium levels. The relative contribution of ammonia oxidizing archaea to nitrification increased with increasing temperature and their activity had a higher temperature optimum than bacteria. Controlling the activity of AOB immediately after the application of mineral N fertilizers would be an effective strategy to reduce and delay nitrification and therefore decrease the potential for N loss and improve N use efficiency.

Fig. 2. Response of nitrification by ammonia oxidizing bacteria versus archaea to ammonium

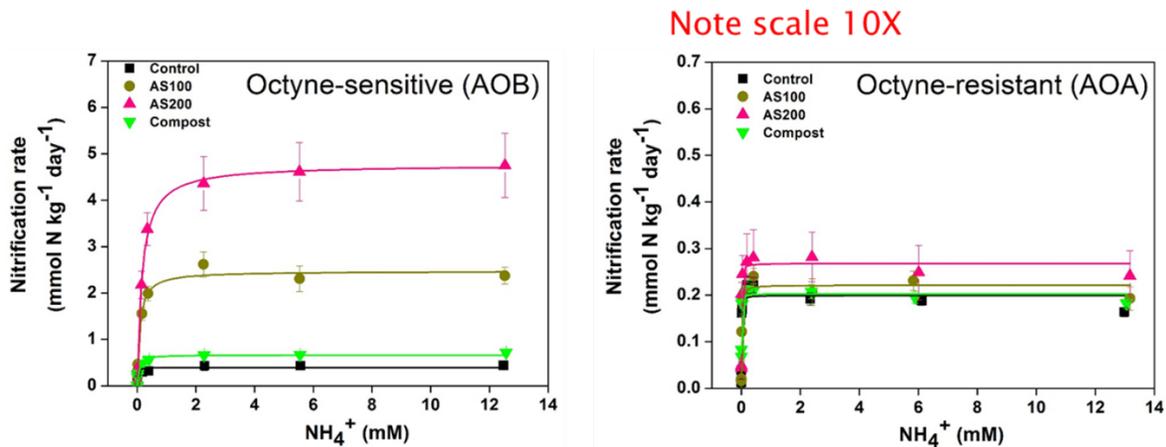
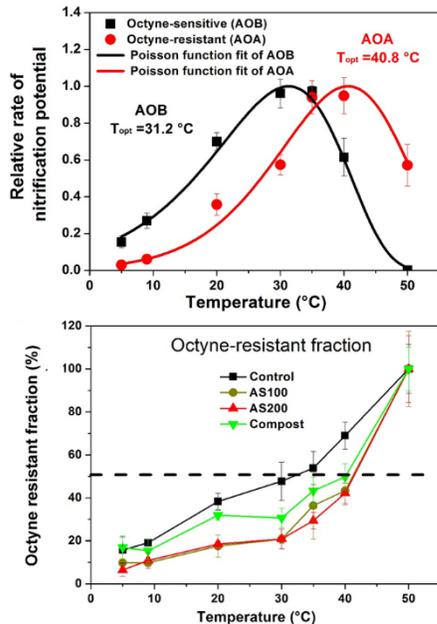


Fig. 3. Temperature response of



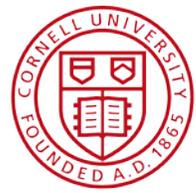
The abundance of ammonia oxidizers in the organic farming system increased with organic N fertilizers and their activity was higher in manure than in compost treated soil. Nitrification potential, nitrite oxidation potential, and denitrification potential in manure treatment were significantly higher than those in control and compost treatment, indicating the application of manure had a higher N loss potential than compost application in this organic farming system. Nitrogen fertilizers strongly stimulated the rates of potential nitrite oxidation. *Nitrospira* was the only known nitrite oxidizer genus recovered from Utah soils. The application of organic nitrogen fertilizers, but not inorganic, increased the diversity of the prokaryotic community and the activities of soil enzymes. In the organic farming system, abundances of functional genes for mineralization were increased by organic N fertilizer and these abundances were significantly correlated with corresponding enzyme activity. Understanding the link between microbial communities and the biogeochemical functions of nitrification and mineralization may allow ecosystem models to incorporate

microorganisms as dynamic components driving nitrogen flux.

Ouyang, Y., Norton, J.M., Stark, J.M., Reeve, J.R., Habteselassie, M.Y., 2016. Ammonia-oxidizing bacteria are more responsive than archaea to nitrogen source in an agricultural soil. *Soil Biology and Biochemistry* 96, 4-15.

Ouyang, Y., 2016. Agricultural nitrogen management affects microbial communities, enzyme activities, and functional genes for nitrification and nitrogen mineralization. PhD Dissertation. Utah State University. 299 pp

Woodruff, L.K. 2016. Nitrogen dynamics under contrasting management systems. PhD Dissertation University of Georgia. 148 pp.



2013-51130-21490

Advancing Climate- Adaptive Decision Tools to Reduce Nutrient Pollution from Agricultural Fields

Dr. Harold van Es, Soil and Crop Sciences Section, Cornell University, New York

Summary: Nitrogen (N) typically accounts for the largest monetary input for corn production. However, excessive N may be readily lost to the environment through leaching and volatilization. N losses may negatively impact yield while also contributing nutrient-laden runoff to the nation's water resources, leading to their ecological degradation. Better tools are needed to equip producers to effectively apply fertilizer and manure N to enhance crop productivity and farm profitability while decreasing farm operation costs and minimizing nutrient loss to the environment.

The goal of this project is to research, develop, and facilitate the adoption of practical decision tools and solutions to improve water quality and buffer water quantity in the face of extreme weather events. The specific aims of the project are to further develop the Adapt-N and the Comprehensive Assessment of Soil Health (CASH) decision tools to foster their broader implementation, application, and use.

Impact: Primary beneficiaries of Adapt-N are corn producers using a variety of management styles and scales (Adapt-N is scale-neutral), but particularly those who already have sidedressing equipment. However, Adapt-N is encouraging new growers to shift N application toward sidedressing. The project is also benefiting agricultural service providers and researchers, who can use the tool to teach about N dynamics and to provide better N management advice. Society is a secondary beneficiary through improved water quality, reduced greenhouse gas losses, and mitigation of climate change associated with better N management on the most common and environmentally impactful crop in the U.S. We have published a number of newsletter articles both demonstrating the effectiveness of Adapt-N at estimating the economic optimum N rate (EONR) and minimizing environmental losses in the Soil and Crop Sciences newsletter, *What's Cropping Up?* (<https://scs.cals.cornell.edu/extension-outreach/whats-cropping-up/archives>).

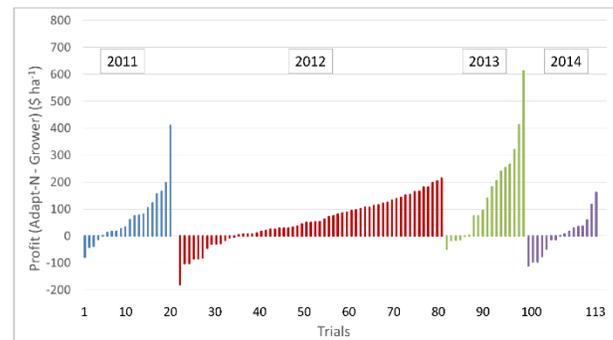


Figure 2. Bars show difference between Adapt-N and Grower profits (\$/ac) in 113 strip trials in NY and IA.

We have developed two management tools that can potentially make considerable positive impacts for the nation's water resources: the [Adapt-N tool for precision nitrogen management in corn production](#) and the [Cornell Soil Health Assessment and Management Framework](#). We believe that broader adoption of these decision tools provides exceptional “win-win” opportunities for enhancing farm productivity, while also reducing or minimizing environmental impacts through water quality/quantity reduction, greenhouse gas emission, and soil degradation and loss. This project has been advancing the research and development of these tools through the use of a network of on-farm research collaborators and an increasing base of involved stakeholders using these tools across the Northeast and Midwest. Both tools have been made available online as web applications that can be used on any device with information being stored in the ‘cloud’ online.

We have worked closely with growers, consultants and extension agents to implement field trials with multi-N rates at sidedress time. Overall Adapt-N treatments have a mean profit increase of 28.68 \$/ac while minimizing gaseous loss by 41% and leaching by 36% versus the Grower rate.

The project team concludes that use of the Adapt-N tool for informing sidedress application rates in corn should be recommended and implemented in corn systems. Benefits from Soil Health Assessments come from identifying constraints and targeting management. Implementing both tools with cost-share incentives and acknowledging the inherent risk- and profit-related incentives from Adapt-N and improved Soil Health will aid in improving water quality, decreasing greenhouse gas emissions, and helping producers adapt to variable early season weather and maintain profitability on broad acreages. All recent publications are available on our websites - (adapt-n.cals.cornell.edu; soilhealth.cals.cornell.edu).

2013-51130-21484

Implementation of In-Stream, Streambank, and Riparian Practices in Conjunction with Upland Practices for Conservation of Water Resources

Garey Fox, Daniel Storm, and Jason Vogel - Biosystems Engineering, Oklahoma State University
 Tracy Boyer, Larry Sanders, and Art Stoecker - Agricultural Economics, Oklahoma State University
 Jean Steiner, Patrick Starks, and Daniel Moriasi - USDA-ARS Grazinglands Research Laboratory

Summary: Typically conservation practices aimed at minimizing sediment loading to streams and reservoirs have focused on upland and riparian erosion control and sediment transport reduction. However, in many watersheds, significant sediment loads originate from streambanks and channels currently in disequilibrium. Channel and riparian conservation practices can be implemented to reduce this erosion in conjunction with upland practices, but little knowledge exists on prioritizing locations and evaluating performance of integrated upland, riparian, and in-stream practices¹. This research hypothesizes that watershed-scale biophysical research, socioeconomic research, and outreach activities can effectively identify and encourage implementation of the most cost-effective and ecologically-beneficial combination of upland, riparian, and in-stream practices to reduce sediment loads and improve water quality, thereby conserving resources to meet potentially altered water availability and demand. Research, education, and extension activities will be focused in the Fort Cobb watershed (Figure 1), located in southwest Oklahoma, but generalizable to other watersheds, especially those throughout the Great Plains. Research includes process-based modeling of upland and channel erosion with and without conservation practices under various land management and climate scenarios. Preferences of adjacent landowners, policymakers, and citizens were surveyed in order to prioritize potential stabilization schemes and determine benefits from upland and/or in-stream erosion control.

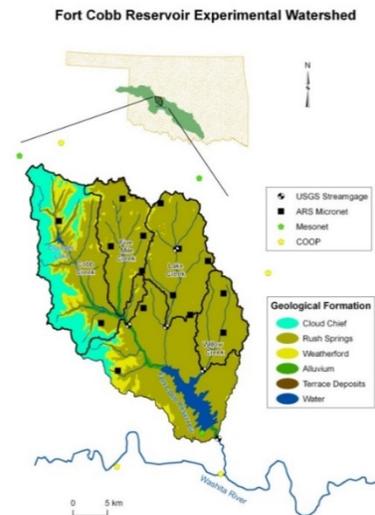


Figure 1. Fort Cobb experimental watershed showing geologic formation and data collection sites for stream flow and climate stations from the USDA-ARS Micronet, Oklahoma Mesonet, and National Weather Service Cooperative Observer Program (COOP) networks.

Impact: This research builds upon a strong foundation of stakeholder input and assistance, and allows data collection on past adoption and retrospective views of stakeholder participation in conservation practices. Numerous farmers in the watershed have allowed us access to their property to quantify streambank characteristics and discussed the use of conservation practices for limiting impacts due to floods and erosion. We continue to monitor streambank erosion and failure at nine sites in the watershed. This research is one of the first uses of a mini jet erosion test (JET) for characterizing erodibility at the watershed scale. Knowledge gained includes the variability in erodibility characteristics at the watershed scale for a highly erosive watershed, which will provide guidance on how to model stream systems. The erodibility parameters were used in a process-based model for streambank erosion and stability called the Bank Stability and Toe Erosion Model (BSTEM) at eight sites.

Also, a larger-scale process-based model of hydraulics, sediment transport, and bank erosion/failure called CONCEPTS is being used to simulate larger reach-scale dynamics. In addition, the effect of stabilizing multiple sites is being evaluated. Both BSTEM and CONCEPTS models are using incoming flow and sediment into the stream system from updated watershed-scale simulations using SWAT (Soil and Water Assessment Tool). SWAT models will be completed soon that consider both incoming flow and sediment. These data will be integrated into the SWAT model to simulate changing land use/land management rather than the traditional “static” land cover. The land cover analysis of the black-and-white aerial photographs showed a decline in upland and riparian tree cover from the 1940s through the 1960s, and land in winter crops, summer crops, and in grass varied from decade to decade. As expected, conservation practices implemented on the landscape, as observed from the imagery, were not prevalent until the 1950s. Large areas of bare soil and ephemeral gullies were observed in the 1940s imagery. The full impact of this research will not be observed until the modeling portion is implemented later this year or early next year.

Two studies on conservation adoption were completed. In summary, the recreation study showed that increasing temperatures will shift recreation from current summer use to spring and fall. A second study assessed the preferences of farmers and landowners with respect to adoption of soil and water conservation practices, which is available in an M.S. Thesis⁸ (two research articles under review). More educated, female-headed and higher revenue farms were more likely to adopt conservation methods promoted by federal and state programs. As expected, farmers who rented land were more likely to adopt conservation methods if they improved profit as opposed to landowners who valued both profit and maintaining the on and off farm soil and ecosystem benefits.

An additional thesis has been completed on economics of reducing field surface erosion from cropland in the Five-mile Creek subwatershed in the Fort Cobb basin⁹. In this thesis, the student developed a SWAT model to simulate soil erosion with and without the presence of conservation tillage, no-till, and contour farming. Linear programming was then used to find the tillage method for each HRU such that total erosion reduction targets for the watershed could be met at least cost. The results verified that combinations of no-till with contour farming had the lowest cost per ton of erosion prevented. However, no-till with contour farming alone was not sufficient to reduce total erosion loads to target levels. It was necessary to use the costliest method of converting some of the land with higher slopes to pasture to meet target erosion levels. A second MS thesis is being completed with the similar objectives for the Willow Creek watershed. In this study, the student also examined economics of adoption of no-till methods among the more than 150 individual farms with specific soil types, land slopes, and land uses in the Willow Creek watershed. The cost of converting conventional to no-till farming was affected by farm size and the amount of highly erodible soils within each farm. A Ph.D. student will be using the SWAT model developed by the USDA ARS staff at the Grazinglands Research station to determine the least-cost set of practices for the entire Fort Cobb watershed. This will allow the watershed decision-makers to base recreation infrastructure investment decisions on science-based values, thereby improving the efficiency of limited resources. State and Federal agencies who provide programs and technical assistance for farmland soil and water conservation practices can now more effectively target assistance and design for improved program participation. Extension activities also included a one-day workshop with more than 50 attendees for academics, government agencies, and consulting firms on stream restoration design by Dr. Doug Shields of Shields Engineering. A field methods course was also taught this summer to eight graduate students in multiple disciplines on rapid geomorphic assessments of stream systems. Materials developed for this course will be used for future Extension programming related to streambank erosion and failure. Educational activities included K-12 demonstrations with the Oklahoma State University stream trailer to an Environmental Science class at El Reno High School (in the watershed), emphasizing fluvial and sediment transport processes and the importance of our streams from a watershed perspective.



2013-67019-21365

Water Quality Implications of Unique Transformation Processes Of Synthetic Steroids Used As Agricultural Pharmaceuticals

- 1) Kolodziej, Edward P. Interdisciplinary Arts and Sciences (UW Tacoma); Civil and Environmental Engineering (UW Seattle), University of Washington, Washington
- 2) Cwiertny, David M., Civil and Environmental Engineering, University of Iowa, Iowa
- 3) Jeffrey, Christopher S., Chemistry, University of Nevada, Reno, Nevada
- 4) Tate, Kenneth W., Plant Sciences, University of California, Davis, California
- 5) Ward, Adam S., School of Public and Environmental Affairs, University of Indiana, Indiana

Summary: This study focuses on evaluating the environmental fate of steroidal pharmaceuticals used in animal agriculture, including trenbolone acetate (TBA), which is an anabolic steroid dosed to the majority of U.S. beef cattle that also is a potent endocrine disruptor. In our previous USDA research, we unexpectedly discovered that transformation mechanisms appear to be reversible for trenbolone metabolites and strongly dependent on temperature and pH. This observation of a unique reversible transformation process is significant, as it strongly suggests unexpected environmental persistence and transport potential for trenbolone and that we may be underestimating the occurrence of bioactive steroids present in agroecosystems. In this project, our objectives are to use laboratory and field studies to understand the potential implications of trenbolone reversion processes on agroecosystem health and runoff management practices. We will seek to understand the fate of these compounds in the aquatic environment, understand their persistence, and evaluate the implications of these process on their transport. We also will develop analytical methods for novel trenbolone products, investigate reversible transformation processes in water and soil, detect uncharacterized trenbolone-derived products in field settings, and use numerical simulations to predict the impact of reversion processes on agroecosystems. We also will extend these results concerning trenbolone to other agricultural pharmaceuticals such as altrenogest, a zootonic progestin widely used for estrous synchronization in horses and swine. This work will address a substantial area of environmental fate research on steroidal agricultural pharmaceuticals which is yet unaddressed in the scientific literature and is critical to accurately understanding the environmental implications of steroid pharmaceutical use in animal agriculture. For example, study outcomes will identify high risk and low risk scenarios for the use of synthetic steroids in animal agriculture, and data generated can be used to optimize the attenuation of these compounds in agro-ecosystems.

Impact: Our stakeholders include local, state, and federal regulatory agencies, personnel involved with controlling storm water management from animal agriculture, state and local cooperative extension personnel, and operators of animal agriculture facilities. In particular, we are addressing shortcomings in the existing environmental fate assessments for a class of very potent steroids widely used as agricultural pharmaceuticals. We have now assessed the environmental fate of trenbolone and altrenogest, numerically modeled their transport in stream/creek scenarios, developed analytical methods for their detection, assessed their sorption and transport in static soil-water systems and soil columns, and evaluated the implications of compound bioactivity on agroecosystems. Notably, we discovered that phototransformation products of altrenogest are likely highly potent endocrine

disruptors themselves, and they may also have unexpectedly persistent behavior in sunlit waters. New knowledge gained was primarily basic science, and focused upon improved characterization of the environmental fate of these compounds in receiving waters by more completely understanding the fate of important transformation products.

Poster Session I

&

Networking Reception

2014-51130-22491

Water Quality and Productivity Enhancement in an Irrigated River Basin through Participatory Conservation Planning and Analysis

Timothy K. Gates¹, John W. Labadie¹, Ryan T. Bailey¹, Saman Tavakoli¹, Christopher D. Shultz¹, Dana L. Hoag², Anthony Orlando², James C. Valliant³, Blake Osborn³

¹*Department of Civil and Environmental Engineering, Colorado State University*

²*Department of Agricultural and Resource Economics, Colorado State University*

³*Colorado State University Extension*

Summary: Two great challenges to the nation's highly productive irrigated lands are salt and pollutant build-up in surface and groundwater, with consequent damage to crop yields and the environment, and growing urban competition for water supplies. Improved conservation practices, including schemes such as rotational lease-fallowing for preventing permanent dry-up of irrigated lands, can sustain productivity and benefit the environment by lowering return flows and pollutant loads to streams and aquifers while allowing continued access to irrigation water. A major obstacle to using these methods in western irrigated river valleys is the requirement that altered stream flow patterns cannot violate water rights or interstate river compacts. Finding river-reservoir system management schemes and economical ways to enhance water quality, boost productivity, and conserve water while complying with water law, requires collaborating with water users and agencies to implement data-founded computational tools.

This project's goal is to identify and rank conservation practices, with extensive advisory stakeholder and student participation in model building and application processes, for sustaining the valuable agriculture sector in Colorado's Lower Arkansas River Valley (LARV) by reducing salinity and selenium, increasing the productivity and economic viability of the land and its rural communities, and maintaining access to irrigation water. Calibrated regional and basin scale models are used to find effective conservation scenarios in a characteristic irrigated basin that satisfy socioeconomic and institutional constraints. Access through a web-based platform, documents and conference presentations, and course material will promote a vehicle for regional interaction and dissemination of findings nationally.

Impact: Groundwater (MODFLOW-UZF, UZF-RT3D) and surface water (SFR, OTIS-QUAL2E) flow and solute transport models have been successfully linked and initially calibrated and tested using extensive field data from a region in the LARV. The linked models have been used to simulate groundwater concentrations, loading rates to streams, and concentrations in streams for selenium and nitrogen under baseline conditions over the period 1999 – 2009. They have been applied to explore the potential for alternative best management practices (BMPs) to lower concentrations in the region toward compliance with regulatory standards and performance goals. The following BMPs have been examined so far: reduced fertilizer application by 30% (RF30); reduced irrigation application by 30% (RI30); canal sealing to reduce seepage by 80% (CS80); rotational lease-fallowing of irrigated land by 25% (LF25); combination of RF30 and CS80; and combination of RF30, CS80, and RI30. Preliminary results indicate the potential to reduce average concentrations along the Arkansas River within the region by as much as about 9% for nitrate and 11% for selenium. Additional BMPs, both single and combined, are being considered. Application of the models to examine BMPs for another LARV region located further downstream has been initiated.

The groundwater models also were revised to include the transport and equilibrium chemical reactions of all major dissolved inorganic ions that make up salinity. Preliminary simulations have been completed, including a comparison to observed sulfate concentrations in the study region for baseline

conditions. Calibration and testing activities are underway, leading to model applications to evaluate the impact of several alternative BMPs on groundwater salinity and soil salinity, with consequent impacts on crop yield. Preliminary assessment of a few BMPs indicates potential for substantial decrease in salt loading to the Arkansas River.

The LARV basin-scale model (ArkGeoDSS) is being revised to examine ways to implement BMPs without harming Colorado water rights or violating the Arkansas River Compact. Results from regional-scale modeling are being incorporated, using artificial neural networks, to estimate how irrigation return flow and in-stream flow will be impacted by BMPs and to explore different operational schemes for mitigating impacts. The model employs a hydro-administrative component and considers up-to-date spatial features, stream gauge measurements, rainfall measurements, groundwater return flow model, water rights and storage accounts in the LARV. A meeting was held with personnel from the Colorado Division of Water Resources to discuss options for setting up reservoir storage accounts and altering river operations to meet Compact requirements.

The Arkansas River Management Action Committee (ARMAC), made up of about 10 farmers and 17 other water stakeholders in the LARV, met three times to assess study results and provide guidance in the search for BMPs that are practicable as well as effective. A website (www.coloradoarmac.org) was set up for exchange of information about the project, including access to GIS-based data and model results through the eRAMs platform. A survey was sent to 400 LARV farmers to establish a baseline about farmers' awareness and actions toward BMPs related to salinity, selenium and nitrogen. A similar survey is planned at the end of the project to determine if attitudes and/or practices have changed. About 30% responded, nearly 50% when you exclude surveys sent to farmers that no longer irrigate. Early results suggest that producers are more aware about salinity and nitrogen problems than about selenium problems. They are split as to whether they would be willing to incur costs to adopt BMPs, but would implement them to avoid regulations. They are united in feeling that if they do not change their practices then both water quality and quantity will be at risk in the future.

A report entitled "The Economics of Irrigation in Colorado's Lower Arkansas River Basin", has been drafted for publication through the Colorado Water Institute. The report documents the basic economic factors a farmer must consider at the field level as well as institutional hurdles that have to be addressed when switching to a more efficient irrigation practice. The report is based on extensive interviews of farmers and other stakeholders in the LARV, and includes information about water management beyond the farm gate. Budgets also have been developed to describe costs of lining canals, which occurs off the farm. This basic economic information will be combined with data and modeling results to determine economic and environmental tradeoffs for different BMP strategies in the LARV, then communicated to the ARMAC at the end of the project.

Project activities and findings have been spread to the broader LARV community through radio interviews, newspaper articles, conferences, and the ARMAC website. A report also has been made to the Lower Arkansas Valley Water Conservancy District, a key agency for preservation of agricultural water resources in the LARV.

Innovative Policies to Optimize the Allocation of Water Quality and Conservation Investments and Maximize Multiple Benefits

Grogan, K. A.; Bi, XI.; Borisova, TA.; Hodges, AL, WA

Summary: This project focuses on the Lower Suwannee and Santa Fe River Basin (LSSFRB) in northern Florida. We propose to estimate the economic value of water in agricultural and in-stream (recreational) uses by examining the feasibility of a market-based payment program for ecosystem service provision. The basin's large recreational user base provides an opportunity to transfer benefits from users to those who undertake water quality/quantity investments. Changes in on-farm water use and water management can lead to water use reductions, increased aquifer recharge rates, and surface and ground water quality improvements. To achieve this overarching goal, we will use the SWAT hydrological and water quality model to determine how changes in production practices and crops will affect water quality and flow, and examine the kinds and levels of changes that will be necessary to achieve the state's water quality targets. Using survey data, we will examine the potential water use reductions and water quality improvements that would be undertaken by agricultural producers given various levels of market-based payments for ecosystem service provision. We will also determine the economic value of in-stream water use and water quality improvements by in-stream water users (beneficiaries) through the use of a survey to implement the travel cost and continuation valuation methods of non-market valuation. This will allow us to determine if collection of payments from users could partially or wholly offset necessary investments made by agricultural producers to achieve water quality and flow standards.

Impact: To assess the value of water quantity and quality for recreation, we plan to examine the relationship between the costs of travel to the spring sites, the frequency of spring site visits, and visitors' perception of the site amenities (including water quality and flow). Two rounds of surveys will be conducted. The first round of the survey will be conducted in person, through interviewing a sample of visitors at several spring sites in the Suwannee/Santa Fe River Basin. The second survey will be conducted electronically, and the survey link will be sent to a sample of households in the region. This latter survey will enable us to capture non-use value as well. A draft questionnaire for the in-person surveys was developed and pretested in Blue Springs Park in August 2015, with the help of the park's owner and project Advisory Committee member Ms. Kim Davis. These pre-tests showed that visitors require incentives to complete the survey (the response rate for the pre-test with no incentives was low), and that some survey questions were difficult for the respondents to understand and have to be revised. Based on pre-test results, we decided that to increase the survey response rate we will need to provide \$5 incentive payments for those completing the survey. We also revised the survey questionnaire and circulated it among the Food and Resource Economics Department's faculty members. The survey instrument was also discussed with project advisory committee member Ms. Stacy Greco from the Alachua County Department of Environmental Protection. After additional revisions, the survey questionnaire will be circulated among the whole Advisory Committee for further comments. Hydrologic modeling As a part of this project, we proposed to create model simulations of the major crops/land uses in the region. The purpose of these simulations is to provide estimates of the changes in groundwater recharge and nitrogen leaching when best management practices are implemented and when changes in crops/land uses are made. To-date, we have focused on collecting the data necessary to conduct the simulations. The data that have been collected include historical weather data (from the Lake City Station for 1979-Present), soil property data from soil maps available from the National Resources Conservation Service, and crop- and management-specific parameters

for the major crops grown in the region. The latter includes typical planting and harvesting dates, recommended fertilization rates and recommended fertilizer application timing. Preliminary model simulations using the Soil and Water Assessment Tool have also been conducted. Changes in agricultural land use Once effective land use changes are identified by the hydrological modeling, we will survey agricultural land owners about the kinds of incentives that would induce adoption of the identified land use changes and agricultural practices. We have conducted an extensive literature review pertaining to the use of choice experiments in agricultural and land use contexts and have begun drafting a general survey to be refined when our target practices and land uses are known. We will ask for advisory committee input in late spring, and plan on administering the survey this summer.

Outreach and extension As a part of this project, we proposed to develop and deliver a Water School Extension program to educate stakeholders about research results. The Water School will be aimed at introducing elected officials, local/community leaders, planners, consultants, decision-makers, and concerned citizens to the complex world of water management issues. Additionally, the Water School will be aimed at promoting awareness of water issues and informed decision-making regarding local, regional, and statewide water management and policy. The first step in any outreach program is to "train the trainer." As a part of this project, project team members and collaborators have offered two Cooperative Extension In-Service Trainings to the county extension faculty in the Suwannee River Basin. The first training focused on providing extension faculty with skills in design and delivery of Water Schools in their counties. The training was conducted in Live Oak, FL, and six county extension faculty members attended. As a result of the in-service training (evaluated by retrospective pre-then-post program surveys), the attendees gained skills in defining Water School program objectives, developing agendas, recruiting target audiences, working with advisory committees, establishing funding, and evaluating Water Schools. Based on the results of the In-Service Training, in 2016 the project team will start the planning process for implementing Water School Extension programs targeting decision makers in one or two counties in the Suwannee River Basin.

Integrated Plan for Drought Preparedness and Mitigation, and Water Conservation at the Watershed Scale

Sandeep Kumar and Kunal Sood

Department of Agronomy, Horticulture and Plant Science, South Dakota State University (SDSU)

Summary: Drought is one of the natural hazard that impacts socio-economic and agricultural sectors. Each year drought has its own unique characteristics with respect to climatic aspects and timing. Monitoring drought has always been unique in its nature as it directly depends on the sensitivity to the climatic conditions each year. Identification of droughts is very difficult because of complex spatial and temporal extent. The present study attempts to assess the efficiency of remote sensing and GIS techniques for monitoring the spatio-temporal extent of agricultural drought. In the present work, Landsat7 data has been used to deduce surface and meteorological parameters (vegetation index, temperature) of Skunk Creek watershed of South Dakota for the cropping season for 2010 through 2015 together with actual ground data (rainfall, temperature) for detailed drought analysis. Using various surface and meteorological parameters, numerous drought indices have been computed, and maps of various drought indices have been generated through GIS based analysis. Drought indices in the study are used to assess the severity, duration and spatial extent of the drought affected area. The Standardized Precipitation Index (SPI) is used to quantify the precipitation deficit. Vegetative drought index has been calculated using NDVI values obtained from Landsat7 satellite imagery. The Temperature Condition Index (TCI) has been derived by calculating the land surface temperature for the period over 2010-2015 for May, June, July and August. Spatial and temporal variations in meteorological, hydrological, and vegetative droughts in the study area have been analyzed and correlated for cropping seasons during the years 2010-2015. The month wise VCI and TCI indices depict some differences which determine the severity of drought as evident in the Vegetative Health Index (VHI).

The various indices calculated during the study can be used to correlate the impact of major climatic parameters required for crop growth. It is evident the water plays a vital role at the different stages of crop growth from emergence to tasseling. Prediction of drought spatially during crop growth stages can help the producers to use the alternative sources of water at the critical stages of crop growth.

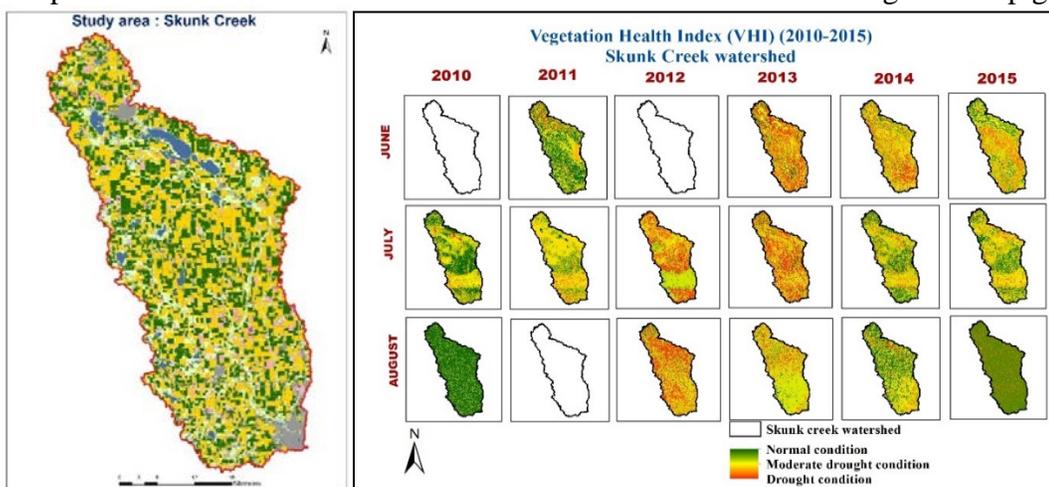


Fig. 1: Land use map of Skunk Creek Watershed (left) showing cropland mainly covered by corn and soybean and calculated Vegetation Health Index (VHI) (right) using Landsat 7 satellite images.

Impact: After the completion of the project, the indices can be used in identifying the spatial distribution of drought across the watershed areas those are under water stress during the crop growth period. A comparison will be drawn within various indices that can be used for real time monitoring. This will help in timely identification of the drought occurrence. Practices for efficient water use for crops can be formulated which can help the stake holders during the drought period.

2015-68007-23191

Enhanced Resilience of Local Agricultural Water Supplies through the Reuse of Municipal and Agricultural Wastewater: A Dynamic Economic Analysis of Technological and Policy Options

Dr. K.A. Schwabe¹, Co-PI; Dr. D. Jassby², Co-PI; Dr. Iddo Kan^{3,4}, Collaborator (Co-PI, BARD); Dr. Benny Chefetz^{3,4}, Collaborator (Co-PI BARD)

¹School of Public Policy, University of California Riverside, California

²Dept. of Chemistry and Environmental Engineering, University of California Riverside, California ³Dept. of Agricultural Economics, The Hebrew University of Jerusalem, Israel

⁴Management Department of Soil and Water Sciences, The Hebrew University of Jerusalem, Israel

Summary: The central issue this research addresses is how wastewater treatment plant processes can be designed to develop a competitive, fit-for-purpose water supply source that can enhance the water supply portfolios of urban water agencies and increase water supply reliability.

The goals / objectives of the project are to:

- illustrate how a fit-for-purpose wastewater treatment plant design that incorporates blending can meet crop requirements at lower cost than conventional treatment strategies,
- develop a simple and flexible regional water reuse decision support model that can be used to analyze the cost-effectiveness of alternative treatment trains to generate irrigation water from reclaimed wastewater, and
- apply the decision support model to two cases studies—one in Israel and one in Southern California—to illustrate its usefulness in analyzing the costs of water supply decisions in municipal environments and identifying cost-effective solutions.

Impact:

- As this is the end of the first year of a two-year seed grant, our research is still developing. To date, though, our key contribution—through a recently accepted publication (Tran et al. 2016),¹—is the identification of cost-effective blending combinations across treatment processes that maintain crop yield and long-term soil health. This research also reflects different degrees of cost savings on synthetic fertilizers due to the appreciable amount of nutrients present in the wastewater streams associated with different blending combinations.
- Currently the RWRM is being incorporated into a larger regional water supply model—Multi-Year Water Allocation System Model (MYWAS)—from our collaborators in Israel (via the USDA-BARD program) to evaluate the cost-effectiveness of alternative water supply policies in Israel, after which it will be applied to regional water supply decisions in Southern California.

¹ Tran, Q., Schwabe, K., and Jassby, D. 2016. “Wastewater Reuse for Agriculture: Development of a Regional Water Reuse Decision-Support Model (RWRM) for Cost-Effective Irrigation Sources,” *Environmental Science and Technology*. Accepted August 7, 2016. 34 ms pages.

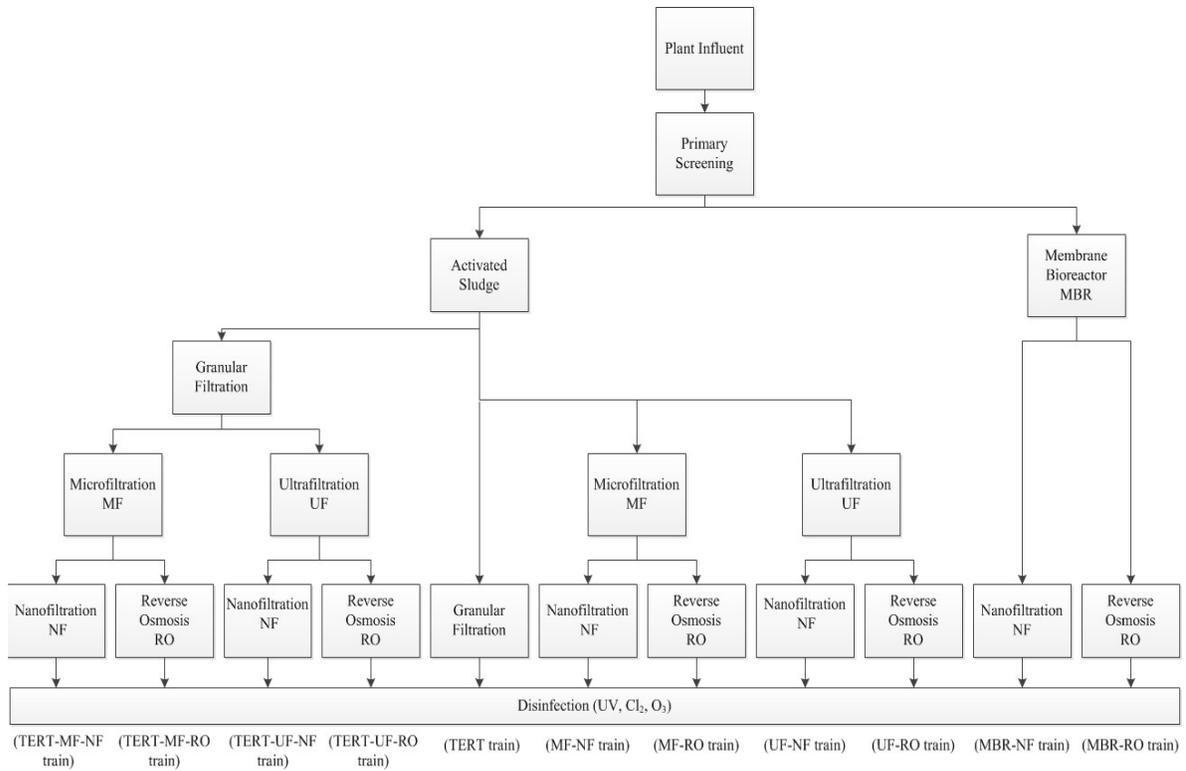


Figure 1. Different treatment train processes

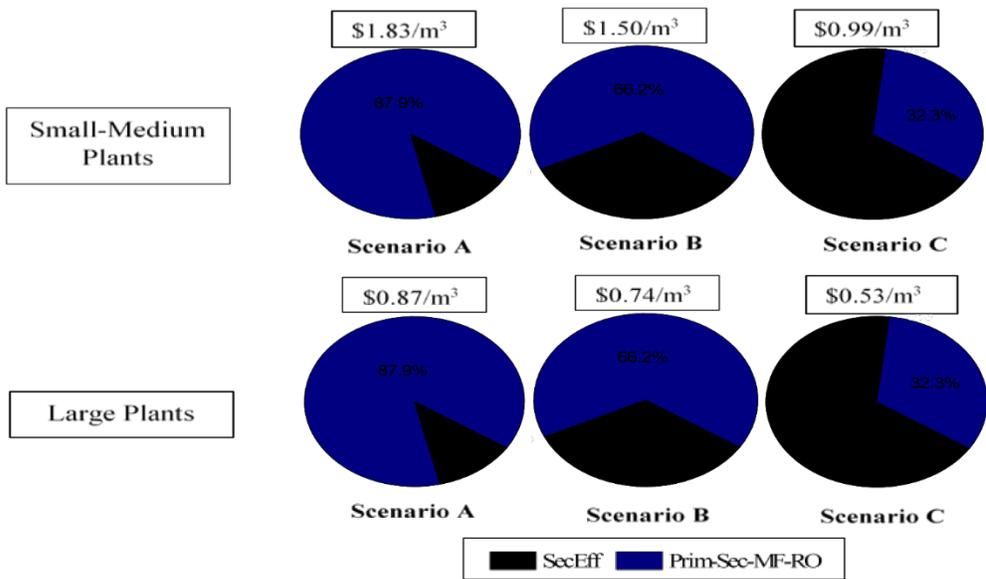


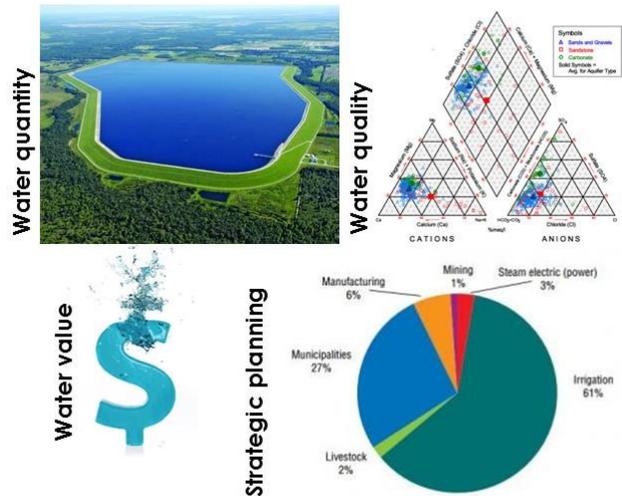
Figure 2. Optimized blending ratios for citrus irrigation from the MF-RO treatment train for small-medium and large treatment facilities; due to TDS restrictions, all model solutions require some degree of desalination (RO). Three scenarios were investigated: (A) with crop nutrient and bicarbonate constraints (baseline); (B) without crop nutrient constraints; and (C) without crop nutrient and bicarbonate constraints.

2015-68007-23189

A Water Quality Valuation Approach to Strategic Planning

 Nathan Howell¹, Erick Butler¹, Bridget Guerrero²
¹School of engineering, computer science, and mathematics, West Texas A&M University, ²Department of agricultural sciences, West Texas A&M University

Summary: Water for all uses in the Southern High Plains is becoming increasingly limited no more so than in the Texas Panhandle specifically, where more than 90% of all water use is for agriculture. Thus, it is imperative that the necessary scientific information be made available to decision makers to help them to make sure that regional agricultural water security is sufficient for diverse and conflicting needs. This project examines this problem through the combined analysis of water quality and water quantity with a particular focus on water quality in a small basin-sized study area, the Tierra Blanca reach of the Red



River basin. Publically available water quality, hydrologic, meteorologic, and economic data will be gathered to ascertain the physical-chemical nature of all water sources. Then additional environmental sampling of water quality parameters will be conducted to fill knowledge gaps and area wastewater will be further investigated for treatment options that improve water use potential. Finally, the water quality information will be converted into possible water uses, and those water uses will be given an economic value. The result will be a link between water quality and the economic value that the water affords. The goals that these projects activities will enable are:

1. Fill the knowledge gap that exists between water source, water use, and water quality in a small study area in the semi-arid Southern High Plains.
2. Develop a framework to translate known and easily measured water quality constituents into possible water applications of relevance.
3. Estimate the economic value of different water quality levels as they pertain to particular uses in agricultural production.

Impact: The project is in its first year, and it will benefit several kinds of stakeholders in the study watershed.

These stakeholders include producers, municipalities, and water-planning decision-makers. For the specific region of the Southern High Plains those stakeholders will often be cattle feedlot owners and operators, farmers, groundwater district managers, state regulators, and city/county officials.

These stakeholders are individual actors that make decisions on water use that most benefit their activities. However, there are particular knowledge gaps that they have including

what all of the water sources in their region are (including wastewaters), understanding how waters of varying qualities have different options for use, and how efficient choices about water use can maximize the economic benefit of the water. The larger impact of this approach is that we will develop a method to assess a hydroscape (e.g., a watershed, river basin, groundwater district) in terms of what waters are available and what potential uses of that water exist for its inhabitants. Water is often the limiting resource for economic activity in our region, and so choices in its use are paramount for economic resilience. If this approach is successful, we will engage in a project to demonstrate its use at a larger scale.

2015-68007-23212

Increasing the Resilience of Agricultural Production in the Tennessee and Cumberland River Basins through More Efficient Water Resource Use

Forbes Walker

Summary: This project is designed to increase the resilience of agricultural production in the Tennessee and Cumberland River Basins (TCB) by promoting the adaptation of land management practices to climate-related changes in water availability and growing conditions. Our action plan will address the following questions: (1) How do changes in climate, land use and industrial/ consumer demand affect the quantity, quality, and availability of water for agriculture in the TCB? (2) How can agriculture in the TCB adapt to these changes? (3) What are the economic impacts of these changes? and (4) What policy, institutional, or technological changes will help ensure that sufficient amounts of high quality water are available to meet the demand in the TCB? We will answer these questions by coupling hydrodynamic and biogeophysical models with economic models in a framework to analyze a range of anticipated climate and land use scenarios for the southeastern US. We will also conduct field trials at University of Tennessee Research & Education Centers to test the effects of adaptive management practice (AMP) adoption on watershed-scale hydrology, thus providing data for the coupled models. The model results will then be upscaled from a local to a regional scale. Finally, we will estimate how changes in water availability affect the farmers' willingness to adopt AMPs, as well as farm profitability and rural economies. We will integrate all these activities around faculty- and student-led outreach and education.

Impact: Over 10,000 direct contacts were made with agricultural producers, during the course of more than 120 meetings. Approximately 64 media articles were written. The Education Team at the University of Tennessee at Martin is providing public awareness of these issues (#4) through interaction with their students in the current courses and in the new courses that they are developing. Dr. Nail has been working on the development of a new course for Engineering students (Computational Hydraulic Modeling). This course is to be taught in Fall 2016. At Middle Tennessee State University, Dr. Cui is currently working with two undergraduate students on research projects related to sustainable water use of agricultural production in Middle Tennessee (detecting both botanical nitrate concentration and drought stress of two bioenergy feedstock species, including switchgrass and indiangrass using spectroscopy analysis and sustainable vegetable production using different nitrogen sources and biochar amendment). In both projects, we incorporated mathematical modeling such as probabilistic neural network and linear regression into traditional agronomic studies. We presented the preliminary results in regional and national conferences and we expected at least two journal articles could be successfully derived from these studies after another year.

2014-67019-21615

Impacts of Prescribed Fire on Polycyclic Aromatic Hydrocarbon Production and Contaminant Phototransformation Reactions in Coastal Plain

Alex Chow¹, Carl Trettin², Randy Dahlgren³, Geoff Wang¹, Po-Keung Wong⁴

¹Department of Forestry and Environmental Conservation, Clemson University, SC

²Center for Forested Wetland, Southern Research Station, USDA Forest Service, SC

³Department of Land, Air, and Water Resources, University of California, Davis, CA

⁴School of Life Science, The Chinese University of Hong Kong, Hong Kong.

Summary: Climate change could lead to more frequent and severe droughts. Hot temperatures and dry conditions increase the likelihood of wildfires and pine beetle infestations. Prescribed burning is an essential forest management practice to reduce the susceptibility of forests to southern pine beetle attack and wildfire in the Southeastern U.S. However, production of carcinogenic polycyclic aromatic hydrocarbons (PAHs) from biomass burning is a significant health concern for both forest workers and local communities. Also, dissolved organic matter (DOM) leaching from pyrogenic organic matter, or dissolved black carbon (BC), could have different photochemical and affinity properties compared to the DOM leaching from unburned detritus materials, and could alter transport and fate of contaminants of emerging concern (CECs) and eventually affect source water quality.

The goal of the proposed study is to increase understanding of the fundamental biogeochemical processes and forest management practices that control the production and movement of PAHs and black carbon (BC) in managed forested watersheds. The proposed program addresses two important research questions related to forest management and the fates of contaminants of emerging concerns (CECs): 1. Can we control PAH and dissolved BC production and export through effective prescribed burn practices? 2. How does dissolved BC affect downstream biogeochemical processes and fate of CECs?

Impact: The forest floor detritus layer is the major source of terrestrial DOM to aquatic ecosystems, affecting many ecological and biogeochemical processes in soil and water. Our study addresses the effects of severity and frequency of prescribed burns on the production and exports of PAHs and DOM in forested watersheds. The knowledge gained from combined laboratory and field studies will increase our understanding of (i) fundamental physical and biogeochemical processes controlling the formation and movement of PAHs and BC in forest ecosystems, and (ii) the roles of DOM in CECs transformation and transport in actively managed forests.

Forests are critically important to the supply of clean drinking water in the United States. National forests and grasslands, which represent 30% of the forest area in the U.S., provide drinking water for over 60 million people. The number of people served by all forests and grasslands in the U.S. are far greater than this number. The chemical characteristics of DOM leaching from forested watersheds determine the fates of many CECs in source waters. In addition, PAH produced from prescribed burns and wildfires represents one of the CECs that can pollute our source waters. Identifying the environmental factors controlling their production and transportation will help identify the best management practices that can achieve sustainable forestry and provide safe water to the nation.



2014-67019-21613

Rangeland Production in a Variable Climate: Linking Functional Compensation and Soil Nutrient Retention

Katharine Suding¹, Whendee Silver², Lauren Hallett¹, Andrew Moyes², Caitlin White¹

¹Institute of Arctic and Alpine Research, CU Boulder, Colorado

Department of Environmental Science, Policy & Management, UC Berkeley, California

Summary: Increased precipitation variability is predicted to be a consequence of anthropogenic climate change across rangelands. Maintaining stable forage production despite an increasingly variable climate will be a critical management priority in range agroecosystems. Indeed, the USDA has concluded that: “A climate-ready U.S. agriculture will depend on ... management practices that enhance agricultural production system resilience to climatic variability and extremes (USDA 2013).” Key mechanisms that can increase the resilience of a system to climate variability are compensatory dynamics, which occur when different functional responses to precipitation generate trade-offs between species over time (i.e., some species do better in wet years, other species better tolerate drought years). These trade-offs may help to maintain plant species diversity over time (provided that species can “store” in the seed bank during unfavorable years). In addition, trade-off among functional groups should buffer key ecosystem functions, such as forage production, nutrient retention and soil C sequestration, to climate variability.

Our goal is to test the degree to which compensatory dynamics confer climate resilience in range agroecosystems. We test three overarching questions:

- 1) Does rainfall variability maintain species diversity by favoring different functional groups over time?
- 2) To what extent does increasing rainfall variability impact the flux and fate of soil carbon and nutrients, water use, and forage production?
- 3) Does functional diversity stabilize forage production and increase retention of carbon and nutrients in a variable climate?

We test these questions in California rangelands, which both support a large cattle industry and experience high rainfall variability.

Impact: 1) Rainfall variability maintains species diversity. A primary test of whether variable environmental conditions enhance diversity is if different species can “increase when rare” under different conditions. We hypothesized that rainfall variability would maintain grass and forb species by favoring forbs under early-drought conditions and grasses under wet conditions. Within each rainfall treatment we altered total seed density (low, moderate, high) and the seeding ratio of a dominant annual grass, *Avena barbata*, and an annual forb, *Erodium botrys* (10:0, 9:1, 5:5, 9:1, 10:0) to test if they increased when rare (i.e., produced more seeds than were added) under different climate conditions. We found that *Avena* could always increase when rare, but that *Erodium* could only increase when rare under dry fall conditions (Figure 2). Consequently, the coexistence of *Avena* and *Erodium* is promoted by rainfall patterns that early-season drought as well as optimal (non-drought) years. **2) Current and legacy effects of drought alter greenhouse gas emissions.** To evaluate treatment effects on seasonal exchange of greenhouse gases across the soil-atmosphere interface, we measured flux densities of CO₂, CH₄, and N₂O approximately once a month from November 2014 to

June 2016, and daily during the wet-up period in October 2015. We used vented static surface chambers to collect gas samples within the four rainfall treatments, and we measured samples for mole fractions of CO₂, CH₄, and N₂O with a gas chromatograph. Flux density responses to drought differed among the three trace gasses. Soil CO₂ release was only sensitive to current rainfall conditions, with cumulative soil CO₂ efflux reduced with increasing drought (Figure 4a). In contrast, N₂O was produced in greatest quantities following the initial early-season wet-up, and was sensitive to a legacy of drought such that plots that had experienced drought in the preceding season released substantially more N₂O upon early-season rewetting than plots that received full ambient precipitation. Cumulative N₂O production was therefore greatest in late-season drought plots and lowest overall in consistent-dry plots (Figure 4b). Methane was not significantly affected by rainfall treatment (Figure 4c). Taken together, our results demonstrate that legacy effects as well as concurrent rainfall conditions may combine to alter greenhouse gas emissions in an increasingly variable climate. **Ongoing research:** Preliminary analyses of aboveground annual net primary productivity (ANPP) within the grass-only, forb-only and mixed plots suggest that functional response diversity may help buffer ANPP across experimental rainfall treatments, but that this buffering effect is constrained by the limited production capacity of drought-tolerant forbs. We are exploring optimal combinations of response- and effect-trait diversity to maintain the stability of ANPP by collecting species level and species-by-treatment level functional trait data and linking these data to shifts in vegetation patterns and resultant ANPP. Similarly, we have collected and are processing belowground net primary productivity (BNPP) to link these patterns with belowground biomass associated with soil C sequestration. We are continuously monitoring soil moisture in the grass-only, forb-only and mixed plots to differentiate how species responses and effects on water availability combine with species effects on production to alter ANPP and BNPP. **Outreach and implications:** Our primary stakeholders are ranchers concerned about the effect of climate change on their livelihoods. Range managers cannot control the weather, but they can actively manage for functional diversity via the common practice of setting standards for residual dry matter (RDM) left at the end of a season, as RDM affects functional diversity by influencing germination and soil organic matter. Our research will provide insights into the plant functional groups that range managers should target with their grazing practices. In addition, rangelands are increasingly viewed as both sources of greenhouse gas emissions but also as potential carbon sinks; our research provides insights into projected emissions patterns given an increasingly variable climate. We have based our research at the Sierra Foothills Research and Extension Center (SFREC), in part because the site actively fosters relationships between researchers and managers. The theme of our project has been highlighted on SFREC's blog (<http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=17047>) as well as the Environmental Biophysics blog supported by Decagon Devices (<http://www.environmentalbiophysics.org/predicting-the-stability-of-rangeland-productivity-to-climate-change/>); we will share future results with ranchers both via SFREC's outreach mechanisms and through our involvement with the Central Coast Rangeland Coalition.

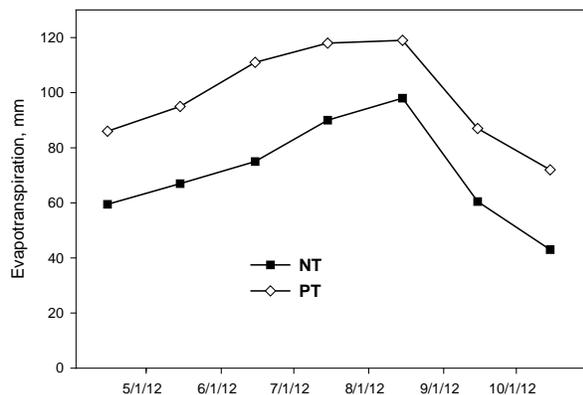
2014-51130-22492

Assessing Threshold Benefits of Conservation Tillage During Drought Years: Implications For Nutrient Use Efficiency And Water Quality

Pierre-Andre Jacinthe, Lin Li, Lixin Wang, and Pam Martin, Department of Earth Sciences, Indiana University-Purdue University Indianapolis; Juan Sesmero and Dev Niyogi, Department of Agricultural Economics and Indiana State Climate Office, respectively, Purdue University

Summary: Nutrient export from US Midwest croplands has created serious water quality challenges both in the region and beyond. In addition, several climate models have predicted that the region will experience frequent summer droughts interspaced by excessive rainfall. These hydro-climatic alterations could exacerbate nutrient export and water quality challenges. During drought periods, nutrient uptake by growing crops is expected to be limited, thus leading to a large pool of nutrients that are susceptible to export during post-harvest rainstorms.

In this project, we argue that no-till (NT) farming could improve soil moisture storage and, during drought years, result in greater nutrient use-efficiency (NUE) compared to conventional plow till (PT). As a result, the impact of agriculture on water quality would be minimized. Several objectives are pursued in this project, including drought simulation experiments, leaching and NUE measurements in research plots under NT and PT, economic analysis of NT farming to identify barriers to NT adoption, and education/outreach efforts. In this year's highlight, we report on ongoing research for large-scale assessment of soil moisture regime under NT and PT.



As shown in the enclosed figure, soil moisture loss was 1.4 times lower under NT compared to PT, likely due to crop residue on land surface and lower soil temperature. Work will continue in order to upscale ET maps to higher spatial resolution (e.g. 30 m), and also to derive root zone soil moisture during the growing season. Our ultimate goal is to be able to link tillage practice and drought index, with the expectation of greater drought sensitivity with PT than NT.

Impacts: Research was conducted in the Eagle Creek watershed (IN) to derive growing-season evapotranspiration (ET) for the period 2000-2014 using MODIS data products and the SEBAL model (surface energy balance algorithms for land). For most years, no significant difference was observed between PT and NT fields with respect to ET. However, a tillage effect was noted in 2007, 2008, 2009 and 2012. These years, especially 2007 and 2012, were the driest years (growing season rainfall 44 and 40% below normal, respectively) during that decade, underscoring the soil water storage benefits of NT during drought years.

2014-51130-22494

The Value of Water Quantity versus Quality: Assessing the Tradeoffs between Agricultural Yields and Downstream Uses of Water

Resources

David Keiser¹, Jacqueline Comito², John Downing³, Philip Gassman⁴, Matthew Helmers⁵, Thomas Isenhardt⁶, Catherine Kling¹ ¹Economics and Center for Agricultural and Rural Development, Iowa State, IA ²Water Rocks! and Iowa Learning Farms Project, Iowa State, IA ³Ecology, Evolution & Organismal Biology and Agriculture & Biosystems Eng., Iowa State, IA ⁴Center for Agricultural and Rural Development, Iowa State, IA ⁵Dept. of Agricultural and Biosystems Engineering, Iowa State, IA ⁶Department. of Natural Resource Ecology and Management, Iowa State, IA

Summary: Land use decisions and land management practices play a critical role in highly productive cropland. For example, decisions regarding agricultural drainage systems, tillage types, fertilizer use, and crop choices boost yields by responding to changes in economic, climatic, and other environmental conditions. However, due to the interconnectedness of hydrologic systems, these farm-level choices have important consequences for competing uses of water resources. In particular, important downstream uses such as drinking water, recreation, and aquatic life uses may be affected by changes in water quality due to these land management practices. In this project, we explore this important tradeoff between water quantity for agriculture and water quality for downstream uses. Our setting is the Upper Mississippi River basin and Ohio Tennessee River basin. These Midwestern watersheds encompass much of the economically valuable Corn Belt region of the U.S. However, due to nutrient and sediment loading from agriculture, many high value downstream uses currently experience significant strains. This project develops a spatially-explicit integrated hydrologic-economic model that estimates the economic value of water across uses. Through novel field, classroom, and online extension and education programs, we engage students, stakeholders, and the general public on the importance of the economic value of water. Obtaining estimates of the value of water across uses is important to inform efficient and effective water policies and conservation practices.

Impact: This project develops an integrated hydrologic-economic model that links farm-level decisions to downstream uses of water resources. We are making progress in developing several important components of this model. We are currently improving how large-scale hydrologic models capture the effects of sub-surface drainage on crop yields and downstream delivery of nutrients. We are also incorporating new data sets on subsurface drainage into econometric studies of the effects of climate change on US agriculture. With these new advances, we are improving our understanding of how climate change will affect both the value of US agriculture and the value of water resources for downstream users. These new economic estimates will inform policy at a national and global level through improved economic damage estimates from climate change. In addition, localized estimates of the economic value of water to agriculture and economic value of water quality to downstream users are used to engage farmers, students, and other stakeholders to increase the understanding of the economic value of water. To accomplish this objective, we are integrating research elements of the project with demonstration field sites, classroom learning modules, and online resources and educational games. These extension and outreach activities target Iowa farmers, students, and the general public through Iowa Learning Farms, Water Rocks!, and the Bear Creek National Restoration Demonstration Watershed.

Project Goals

- Develop an integrated hydrologic-economic model to measure spatially-explicit values of water across uses
- Engage students, farmers, stakeholders, and the general public on the economic value of water and its role in efficient and effective water policies

2014-51130-22493

Using Hydro-Economic Modeling to Optimally Allocate Water in the Humid Southeastern U.S.

Clark, C. D.; Walker, FO.; Papanicolaou, TH.; Lambert, LI, HE.; Hawkins, SH.; Duncan, LO.; Boyer, CH.

Summary: The long-term goal of this project is to assist agricultural producers, policymakers, and local communities throughout the Southeastern United States adapt to a new reality of water scarcity by more efficiently allocating water and adopting water-conserving practices and technologies. Efforts to achieve this goal are organized into five integrated project tasks: develop water use budgets for five representative agricultural enterprises (i.e., irrigated crop, beef cattle, dairy, goat, and broiler production) by monitoring water use at three University of Tennessee Research & Education Centers (RECs); develop and disseminate a comprehensive state-wide education program to inform county Extension agents, agricultural producers and landowners about water use in agriculture and potential water-saving techniques for different agricultural enterprises using the water budgets and monitoring efforts at the RECs; generate temporally- and spatially-explicit estimates of water availability and scarcity across the study region, which consists of the Mississippi River - Hatchie, Tennessee River and Cumberland River Basins, using the Variable Infiltration Capacity (VIC) water balance model under current and projected economic and environmental conditions; develop and apply an economic model of the agricultural sector to generate spatially- and temporally-specific estimates of the economic values of water in different agricultural uses; apply data from a regional input-output model to impute the economic value of water for non-agricultural sectors; and enhance youth and adult understanding of water availability, use, and scarcity in the study region and of the opportunities and need for water conservation by developing and disseminating a comprehensive state-wide education program.

Impact: The major activities of the hydrologic modeling team during this reporting period address the following Research objectives: (1a) Estimate water availability at the watershed level using a spatially and temporally distributed water balance model. (1b) Identify temporal and spatial variations in water scarcity across the study region. The hydrologic modeling team performed sensitivity exercises to familiarize themselves with the model and its capabilities for simulating the site specific characteristics of Tennessee watersheds. Key parameters proved to be the available infiltration capacity of the soil as a function of its relative saturation, maximum baseflow (which is dependent on hydraulic conductivity), and the soil moisture level at which non-linear baseflow occurs. Initial calibration and validation exercises show that VIC results are comparable with observed flow data producing Nash-Sutcliffe efficiency values between 0.75-0.85. At this time, the only true impact was a change in knowledge for the hydrologic modeling group, as they became more familiar with some of the challenges in developing water budgets for Tennessee. Economic Modeling: Land use model to determine how responsive agricultural producers are to commodity prices, thereby influencing land use decision and crop water demand, was developed and estimated. Crop production budgets for irrigated and non-irrigated crops for the study region were developed. Prototype water withdrawal aggregation scheme for economic sectors for input-output model (IMPLAN) created. Based on water withdrawal aggregation scheme, performed experimental analysis of direct and indirect water use per dollar of output for Tennessee based on methodology from Weber et al, 2010 and Blackhurst, Hendrickson, and Vidal, 2009. Provided prototype GIS analysis for water withdrawal rates by county for the state. Youth and Adult Education: Review of relevant, existing curricula and initial analysis of awareness/knowledge levels of target audience conducted. Coordination with 4H curriculum development specialist established.



2014-51130-22496

A Synthesis of the NIFA Water Portfolio (2000-2013)

O'Neill, M. P.; Prokopy, LI.

Summary: This project will synthesize and summarize the information and knowledge created from the portfolio of investments on water resources made by the National Institute of Food and Agriculture (NIFA) between 2000 and 2013. We will determine the lessons learned, critical findings, and outcomes of the NIFA Water Portfolio and we will demonstrate examples of synergies that led to greater leveraging of NIFA investments. We will evaluate the effectiveness of national, regional, and watershed scale approaches to promote solutions to water problems and we will examine the effectiveness of integrated (research, education, and extension) projects to move stakeholders closer to solutions. We will create a digital atlas that depicts the spatial and temporal patterns of investments from the NIFA water portfolio and we will construct a template for future synthesis efforts on water (and non-water) portfolios. Finally, we will identify water quality and quantity issues that NIFA should address and we will recommend the best functional approach (research, education, or extension) and scale (national, regional, or watershed) to address those science priorities. Upon completion of our project, NIFA will have a comprehensive synthesis of findings from their Water Portfolio (2000-2013) and they will have a template for future investments.

Impact: What was accomplished under these goals? Progress: 9/2014 - 9/2015 We searched the USDA-REEIS database to identify projects funded by NIFA between 2000-2013. In order to identify the most robust set of potential projects, we searched for all projects that included the word "water" in their objectives. For the period of interest, this search produced 2,184 Non-Formula funded projects. Over the same time period, our search produced 3,682 Formula (e.g., Hatch, McIntire-Stennis, Evans-Allen, Animal Health) funded projects. It should be noted that the Smith-Lever (Extension) Formula funds are not reported in REEIS and cannot be searched via REEIS. We hired three undergraduate students from the UConn water program who screened the Non-Formula funded projects to determine if they should be included in the NIFA Water Portfolio. After the students screened the projects, the PI (O'Neill) evaluated their recommendations and made the final decision to include a project in the portfolio. This process produced 772 total Non-Formula funded projects. We are completing the same process for Formula funded projects and anticipate completion in September 2015. We developed a survey instrument and sent it to all portfolio Project Directors (PDs) identified in the database. The survey produced a 54% response rate. Responses to questions in the survey are being compiled and will be analyzed by our project team led by Dr. Linda Prokopy along with Dr. Sarah Church, postdoctoral associate and Laura Esman, Research Associate, at Purdue University. Finally, we are exploring patterns in the NIFA Water Portfolio by mapping both the number of projects in each state and the total funding (dollars) awarded to each state.



2014-67020-21617

Determining the Potential Mitigation of Triclosan Accumulation in Commercial Onion Plants Using Plant-Growth Promoting Rhizobacteria

Monica O. Mendez, Ashely M. Garcia and A. Addo-Mensah
Dept. of Biology & Chemistry, Texas A&M International University, TX

Summary: Triclosan, a broad-spectrum antimicrobial, is one of the seven most prevalent wastewater contaminants found in freshwater streams in the United States. Repeated applications of recycled waters contaminated with triclosan provide a mode of transport for triclosan into terrestrial systems, particularly managed agroecosystems. There is concern that irrigation using recycled waters will not only affect profitability of commercial crops but also increase food contamination. Overall, the goal of this project is to enhance understanding of the role of plant growth-promoting rhizobacteria (PGPRs) on the impact of triclosan, a chemical of emerging concern, by mimicking a natural transmission route via repeated application of contaminated irrigation water. The objectives of this study are to 1) identify PGPRs capable of using triclosan as a carbon source; 2) determine the effect of triclosan-degrading PGPRs on the degradation of triclosan in soils; and 3) examine the impact of triclosan-degrading PGPRs on triclosan uptake by onion plants.

Impact: Project stakeholders include regulatory agencies, agricultural and environmental scientists studying the fate of contaminants within ecosystems, farmers using freshwater streams and reservoirs, and students participating in agricultural research. Data has been disseminated at a regional conference with members of a local water conservation organization invited and at a national scientific meeting. Student participants have gained a greater understanding of microbial techniques, analytical chemistry, and the impact of antimicrobials in the environment as it relates to water quality. Outcomes of this project will be published in peer-reviewed journals and on our forthcoming website to expand our stakeholder audience.

Using agar plate assays, onion rhizobacteria isolated from triclosan-irrigated onions were screened for use of triclosan as a sole-carbon source. Results show that previous exposure to triclosan *in situ* does not determine triclosan tolerance but would impact the ability of bacteria to use triclosan as a sole carbon source. Rhizobacteria exhibiting minimal to moderate growth and plant growth-promoting activity were selected for a subsequent degradation study in a silt loam soil irrigated with triclosan. Inoculation with PGPRs decreased triclosan levels by 30% within a short period and allowed for higher soil microbial counts even when soils were not irrigated with triclosan. A consortium of bacteria enhanced degradation compared to individual bacteria. Further analysis will determine the dominant triclosan by-products from degradation over time and the effect of selected PGPRs on uptake of triclosan and methyl triclosan in onion tissues.

NIFA-BARD Collaborative: Rapid Hydrophobicity Sensing and Computing through MAV-based Hyperspectral Imaging

ZhiQiang Chen, School of Engineering and Computing, University of Missouri-Kansas City, MO

Summary: Soil hydrophobicity (SH) impacts agriculture. SH as an intrinsic soil property affects water runoff, retention, and chemical transport significantly. Therefore, if one attempts to assess water use in order to improve the efficiency, hydrophobicity mapping would provide direct evidence for decision-making. The commonly used method for quantifying soil hydrophobicity is Water Drop Penetration Time (WDPT) test. This procedure or other lab methods are sample based and time-consuming, which, if used in the field in a large area for hydrophobicity investigation, become extremely ineffective. The lack of large-scale SH monitoring and assessment, if not resolved, may ultimately prevent realizing optimal water-use efficiency for crop and farming management. The primary goal of this Seed Grant project is to develop a soil-hydrophobicity analytics system with rapid and cost-effective hyperspectral sensing and computing capabilities, which ultimately aids practitioners for improved and rational decision-making in using agricultural water. Two specific objectives are targeted: (1) proof of the hypothesis that SH can be sensed and identified using hyperspectral imaging methods; and (2) development of a micro-UAV based SH sensing network and analysis system with both laboratory and field verification.

Impact: Due to the SEED grant nature, the US-Israel project team has been focusing on knowledge exploring and technology development. To this date, we have preliminarily proven that using soil samples in the field and through a rigorous verification-validation data mining process, SH can be detected using full-spectrum hyperspectral data (Fig 1.). This paves the way for developing an aerial UAV-based assessment system. Towards developing the sensing infrastructure, we have developed a new concept of aerial-ground networked sensing for integrated imaging, mapping, and ground-truth data collection (Fig. 2). For realizing such a delay-tolerant network, radio frequency (RF) based remote sensor activation has been developed for energy-efficient sensing. A unique hyperspectral ‘snapshot’ camera system has been acquired (through Cubert Inc.) and noise modeling and deep learning-based hyperspectral image analysis are being developed. Fight campaigns will be conducted in both US and Israel in the coming year.

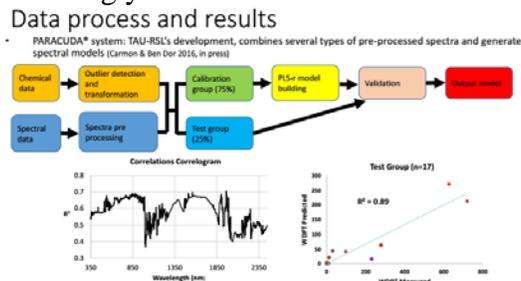


Fig. 1

Aerial-Ground Networked Sensing

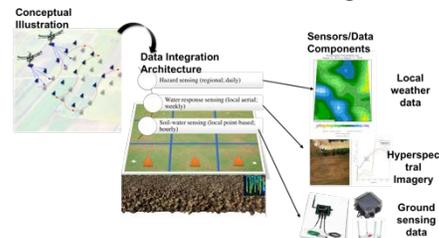


Fig. 2



2015-69007-23190

University of Nevada, Reno

Water for Agriculture Challenge Area: Enhancing Climate Resiliency & Agriculture on American Indian Land

McCarthy, M.; Emm, ST.; Singletary, LO.; Kauneckis, DE.; Phillips, JO.; Colby, BO.; Flint, CO.; Daniels, ST.; Curtis, KY.; Edwards, ER.; Dettinger, MI

Summary: American Indian farmers and ranchers provide an important economic base for rural areas in the Great Basin Desert and arid lands of the American Southwest. Sustaining agricultural production for ceremonial practices, sustenance, and trade is becoming more challenging for American Indian communities due to the scarcity of water resources, rapid change in ecosystem composition and health, and historic land tenure policy arrangements. Climatic change including reduced snowpack and rainfall and increased temperatures, combined with urban and industrial expansion in the American West is increasing demand for a dwindling supply of water from rivers, streams, and underground aquifers. Close cultural ties to natural resources, geographic remoteness, and economic challenges have led some to characterize American Indian agriculturalists as some of the most vulnerable to climate change. Our project seeks to enhance the climate resiliency for agriculture on American Indian lands of the Great Basin Desert and Southwest by building the capacity within tribal communities to develop and implement reservation-wide plans, policies, and practices to support sustainable agriculture and water management. We will analyze past and future climate risks to traditional and production agriculture and test the feasibility of introducing innovative alternative agricultural practices and water management policies to enhance resiliency. We will accomplish this by harnessing the expertise of research and Extension faculty from 1862 Land Grant Universities (University of Nevada, Reno, Utah State University, and University of Arizona) in partnership with the First American Land-Grant Consortium of 1994 Tribal Colleges and Universities, researchers from the U.S. Geological and Desert Research Institute, and tribal community members from Nevada, Utah, Arizona, and New Mexico. Our integrated team of research and Extension faculty will partner with American Indian water specialists, cultural advisors, agriculturalists, and educators to collaboratively develop climate scenarios and water supply projections for the tribal lands and surrounding arid areas. Tribal members and researchers will test the effectiveness of existing and future water infrastructure systems to optimize profits and production efficiencies under these climate scenarios. Researchers will study alternative water management policies being adapted worldwide in rural and agricultural areas and assess how these policies could improve climate resiliency in our area. Policy experts and tribal members will assess the efficacy of the federal government's "trust" land tenure system to support or impede tribal water management and agricultural sustainability under the climate scenarios. Researchers will create a set of time series of paleoecological data of tribal land ecosystems and correlate this with climate data to identify extreme events and periods of prolonged climatic change. Interviews with tribal members will be used to gather traditional knowledge about their community's response to these events and the impacts of these events on tribal culture and agricultural production. Knowledge generated and shared through this project will build understanding among tribal and non-tribal organizations about challenges and opportunities for sustaining tribal agriculture and cultural traditions in a changing climate.

Impact: In 2015, the NWAL team planned, organized, implemented and evaluated the first of five annual summits. The 2015 NWAL Summit included, A Native American Farm Managers Panel for the NWAL Tribal Summit Nov 2015 with representation from three of the largest Native American Farms in Arizona. The survey results also contained therecommendation forthe NWAL Team toengage more youth and students in related research and education. Developed and publishedthe NWAL Project website (<http://nativewaters-aridlands.com>) Developed NWAL Team Research &

OutreachProgramPlan Gathered primary and secondary data needs from all NWAL Team Members and develop plan and schedule for gathering data in future years. Developed 5-year workplan and updated NWAL Logic Model Developed project evaluation methods and instrumentation Obtained IRB Approval through UNR that coversresearch and outreach activities for allpartners Research andData Collection/Analysis Developed a set of socioeconomic criteria to use in building a comprehensive secondary data base for the larger proposed study region. Developed criteria for characterizing tribal reservations involved in agriculturein the American Southwest and collected/analyzed data pertaining to contemporary agricultural production, traditional agricultural practices, and data related to land base and tribal water rights, income, employment, and demographics.. Overall, this work assists with design and implementation of programs to provide adaptive response to hydrologic effects of climate change. Data collection on agricultural water allocation, delivery infrastructure, traditional, and non-traditional tribal irrigation and production practices Year 1Status: Initiated data collection regarding tribal agriculturallands, irrigated acres, water resources, major crops, and irrigation practices to create an inventory of primary crops and irrigation practices for the nine reservations in the research programstudy area. Data collection on feasible low-water or applicable crops in the region Year 1 Status: A catalog of low-water and draught resistant/tolerant crops, livestock, and grazing/erosion control crops/grasses/forbs has been assembled. Additional work will focus on traditional tribal crops and current market demand/pricing to inform a final selection (list) of crops for further analysis. Characterize land tenure and water right structures within the Great Basin. Year 1 Status: Initiated data collection relating to tribal water and land tenure systems.A preliminary database has been completed cataloging quantities of water used and water rights claimed by tribes across the Great Basin. A more completecharacterization of property right institutions for a selection of tribes is anticipated by December 2016. Initiatedcataloging secondary data on paleo-environmental change Developed a research strategy to understand adaptation in response to climatic change Conceptualized an approach to the data management portal. Initiated compiling a database of regional climate reconstructions, catalogued in GIS from a variety of sources, including lake levels, precipitation, streamflow, snowpack, and others. These datasets will be used to assess questions on the impact of climate change on agriculture and ecological production. Created first bibliography for traditional knowledge,ecological data, and GIS imagesfortribal reservations in the study area. Leveraged other sponsored programs to developapproach to modelling agricultural activity and productivity. The NWAL team will use measures of net primary productivity (NPP) in the past, present and future to identify climatological conditions or events that have triggered past adaptation or may trigger future adaptation. The team has been cataloging paleo-environmental data from past research that will help in identifying these climatological conditions or events. Members of the team have also been collaboratingwith thesocial science team membersto determine which physical secondary data will be needed to inform futureresearch and primary data collection surveys. Tribal College Research, Education and Outreach Recruited, hired and mentored a Native American graduate student through UNR Graduate Program in Hydrologic Sciences Retained Virgil Dupuis (Salish Kootenai College) as water specialist and Benita Litson (Dine' College) as cultural advisor to NWAL Team. Ensured their participation in team conference calls and email communications. Recruited Mike Durglo, Antony Berthelote (SKC), and Amy Redhorse (Dine) as tribal partners participating in the 2015 Tribal Water Summit. Administered a 1994 water survey to determine the level of activity and interest in NWAL related opportunities. Working with several members of project team to develop 1994 student engagement with NWAL.

2015-68007-23213

ThinkWater II: Growing Knowledge to Solve Water Problems

Project Director: Dr. Jennifer Kushner (University of Wisconsin)

Co-Project Director: Dr. Derek Cabrera (Cabrera Research Lab)

Co-Project Director: Dr. Laura Cabrera (Cabrera Research Lab)

Co-Project Director: Dr. Art Gold (University of Rhode Island)

Co-Project Director: Dr. Doug Parker (University of California)

Co-Project Director: Dr. Reagan Waskom (Colorado State University)

Summary: ThinkWater seeks to improve U.S. agriculture by transforming water research, education and extension by embedding the universal patterns of thinking into existing programmatic efforts. These patterns--making Distinctions and recognizing Systems, Relationships, and Perspectives (DSRP)--are both the building blocks of cognition and the four rules underlying systems thinking.

There are five core objectives of this project:

1. Develop materials and resources for integrating systems thinking into water research, education and Extension
2. Implement and research a national fellows program focused on the application of systems thinking to research of wicked water problems
3. Implement and research a state-based demonstration of systems thinking applied to water outreach/Extension and education, network development and multiplication of effort
4. Provide outreach and public awareness about systems thinking applied to water
5. Implement and develop resources related to systems evaluation

Impact: Our research program investigates the impact of exposure to systems thinking resources and capacity building on water-related initiatives in Extension, education, and research. In terms of knowledge gained thus far, in a preliminary study of teaching systems thinking skills to middle-school students, statistical analysis demonstrated that supplementing top national water lessons with brief instruction in systems thinking increased students' deep understanding of water content (compared to a control group not taught systems thinking). Not only did students educated in DSRP show more mastery of water content, they also developed awareness of their own thinking processes and evidenced some indication of increased caring about water.

Following this study, ThinkWater partnered with Arizona Project Wet (APW). We intensively trained 3 educators in DSRP to enable them to train other teachers how to (1) become systems thinkers and (2) embed these new DSRP/ST skills into their teaching of the Water Investigations Program. In total, 80 teachers received 3 days of professional development facilitated by the 3 educators. ThinkWater learned valuable lessons from this experience about what type of professional development materials and tools are most useful.

The 2016 USDA ThinkWater Fellowship is designed to assess whether relatively short exposure to training in systems thinking can demonstrably improve high-level water research of import to researchers, practitioners, educators, and policymakers. The 2016 ThinkWater Fellows have received intensive training in DSRP and one-on-one guidance concerning applying systems thinking to their research.

At a more macro level, ThinkWater aims to establish what type of efforts and resources are necessary to introduce the initiative to other US states and geographic regions, using Wisconsin as a

demonstration site. This initially entailed meeting with potential partners to identify needs in the state and working to integrate systems thinking into their water education programs. We are currently detailing our Wisconsin experiences to create a toolkit of instructions and online resources for ThinkWater implementation elsewhere.

In terms of stakeholder impact, we are assessing for APW the impact of DSRP on learning water-related lessons. 283 students responded to a survey to assess DSRP-boosted water lessons. 80-90% of students agreed or strongly agreed with the following statements:

- I am a more capable learner as a result of the Water Investigations Unit.
- After the Water Investigations Unit, I better understand the importance of differentiating ideas when learning a new concept.
- I paid more attention to what I was thinking during lessons in the Water Investigations Unit.
- It was clear what we were trying to learn in the Water Investigations Unit.
- The Water Investigations Unit taught me that relationships exist between and among ideas.

With additional external funding, we formed the Wisconsin Water Thinkers Network (WWTN) and launched a successful kick-off event in spring 2016 with 55 attendees. Ensuing meetings have focused on establishing the vision and mission of the group and agreeing on strategies to strengthen the network and create opportunities for critical dialogue about systems thinking based water education. Monthly WWTN webinars began in September with 23 participants. Introduction to systems thinking workshops have been held in partnership with 3 organizations including 67 educators, supplemented by consultation to help integrate systems thinking into their programming and research.

On the research front, ThinkWater Fellows run the gamut of disciplinary, methodological, and topical approaches in water and have benefited from the unifying language DSRP provides to enhance the interdisciplinarity of their work. On December 6, 2016, Fellows will present at a live broadcast Cornell Systems Thinking Symposium, explaining how DSRP affected their work.

ThinkWater strategy is to employ previously developed, cutting-edge systems thinking concepts and technologies with our constituencies (water education, research, and Extension), using intensive scholar and practitioner feedback to expand, modify, and enhance our products. These include systems thinking models of evaluation, instruction, and organizational design and change. APW uses our instructional models and online course “Teaching Thinking 101;” WWTN uses our organizational design models. We have also developed a free online DSRP training for broad use and tested it with student populations. We expect it to be available by the end of the year. Finally, we are currently testing and validating an instrument to assess deep understanding of DSRP, which entails metacognition and systems thinking.

2015-68007-23210

Towards a Near Real-time Agricultural Drought Monitoring and Forecasting

Mishra, A.

Summary: Our research objectives, which align with the NIFA objectives is quite relevant due to recent drought situations nationwide in that it will help to improve agricultural water management under drought scenarios. The funding will be used to improve technologies to provide near real-time drought forecast information for farmers, ranchers, forest owners and managers, public policy experts, public and private managers and citizens to improve water resource quantity. Currently two major limitations that exists in agricultural drought monitoring/forecasting are: (i) soil moisture derived from hydrologic models or remote sensing products provide aggregated information at coarse resolution and often witness larger uncertainty, however, the agricultural drought relies on finer/local scale information; (ii) the agricultural drought is monitored and forecasted using available soil moisture at a uniform (constant) depth, which may not be suitable in real world scenarios.

Impact: Technological advancements (e.g., remote sensing, weather/climate forecasts), has greatly improved drought identification, monitoring, and with reasonable accuracy in forecasting at a regional scale. We proposed to forecast agricultural drought based on surface and sub-surface drought information generated by using a crop model-data assimilation framework using a combination of multiple data sets. Previous agricultural drought research considered uniform depth of soil moisture for all types of available crops to quantify agricultural drought scenarios. However, as discussed above, the moisture available in different layers and root zone depth will play an important role for the quantification of agricultural drought. In this period, we developed a multi-layer soil moisture prediction model using a data-driven model (SVM) and a sequential DA method known as EnKF technique. The data used in this study is from the Blackville experiment site located in South Carolina of United States. Blackville experimental site (latitude 33°21'18", longitude 81°19'40", elevation 317ft) is located in South Carolina, United States. In addition to the real time sensor based soil moisture monitoring station, this site also includes a state of the art NOAA U.S. Climate Reference Network station (SC Blackville 3W) with automated measurements of air temperature, humidity, solar radiation, rainfall, soil temperature and moisture at different soil depth from 5-100cm. With a group of sensitivity experiments, we found that the combination of SVM and dual EnKF is a robust statistical tool suitable for the multi-layer soil moisture prediction. Based on the sensitivity experiments, the main findings are listed as follows: (a) The SVM is good at simulating the soil moisture at different layer from surface to root zone at the training process but the performance for predicting lacks confidence especially for the deeper soil layers. (b) The performance of SVM relies most on the initial training ensemble size compared with other factors (e.g., cost function, regularization parameter, and kernel parameters). The ability of SVM can be improved with enough training ensemble members and the deeper the soil layer, the more ensemble members are needed. (c) Compared with the precipitation, the soil moisture predictions have a distinctive relationship with the precipitation pattern, where the soil moisture predictions at each layer tend to overestimate when there is little precipitation while underestimate when there is more precipitation. (d) The dual EnKF technique for the model state and parameter state is better than the DA update at the model state or parameter state only. (e) The EnKF technique can reach its maximum efficiency when the updating ensemble size approaches around 15, which is consistent with the previous findings, and (f) The EnKF technique can improve the SVM even with limited initial training ensemble members. This study proves the prediction of root zone soil moisture with data assimilation technique, which would benefit for the future soil moisture predictions over a large study area.



2015-68007-23130

Sustainable Water Resources for Irrigated Agriculture in a Desert River Basin Facing Climate Change and Competing Demands: From Characterization to Solutions

W.L. Hargrove, Center for Environmental Resource Management (CERM)
J.M. Heyman, Center for InterAmerican and Border Studies (CIBS)
The University of Texas at El Paso
El Paso, TX

Summary: The objectives of our integrated research, extension, and education project are: 1) model medium to long-term climate scenarios and their impacts; 2) improve and integrate existing simulation models, including climate change impacts, surface-subsurface interactions, and changing water demands; 3) integrate existing models into a spatially explicit, dynamic systems model that can inform participatory stakeholder meetings; 4) implement a stakeholder participatory approach to modeling activities, and reflection/synthesis meetings where solutions will be formulated to: a) augment water supplies available to agriculture; b) optimize water allocations among competing demands; and c) improve water use efficiency and conservation, while reducing environmental impacts; 5) disseminate solution technologies and management practices through traditional extension methods; and 6) strengthen our capacity to train water resources professionals.

Impact: Research. In Year 1, our research program focused on stakeholder engagement and their identification of key issues and research questions to be addressed by our modeling work. Through the engagement process, we learned what a wide range of stakeholders, including direct users, not just organizational water professionals, care about with respect to the future of water. Stakeholder input in Year 1 informed the design of our research agenda and our modeling approach, introducing unanticipated questions of keen interest to stakeholders. Beyond specific questions identified by stakeholders, our stakeholder engagement activities forged relations of mutual respect and open dialogue in a region fragmented by jurisdictional borders, underlain by intense levels of competition for water.

These findings have impacted our research agenda in the following ways: 1) we are constructing a large scale “bucket model” for the portion of the basin in our study area that connects surface and groundwater; 2) we have initiated research to quantify urbanization and its impacts on water supply and demand; and 3) we co-sponsored a workshop on water banking in southern New Mexico at the request of agricultural stakeholders to examine how water banking could improve water conservation and management.

Education. We provided four undergraduate students with internships during the summer of 2016. These four students were significantly impacted in the following ways (documented through a focus group discussion with them): 1) they were able to “put into practice” things that they had learned through classroom education, apply knowledge; 2) they learned valuable laboratory techniques and analytical skills like GIS; 3) they learned about the applications and impacts of research at a local regional scale. At least one student confirmed that they will pursue graduate training in water resources management as a result of their internship.

2014-67019-21718

Colloid Mobility in Soils, Fundamental Pore Scale Mechanisms, Simplifications and Practical Relevance for Risk Analysis

M.G. Schaap and J.D. Larsen, Department of Soil, Water and Environmental Science, University of Arizona, AZ

Summary: Soil colloids are biotic or abiotic nano- to micron-scale particles that have the potential to migrate through the subsurface and pose risks if they are pathogenic micro-organisms, or facilitate transport of typically immobile chemicals of emerging concern (e.g. antibiotics, hormones and other pharmaceuticals used in farm operations). Several fundamental physical-chemical colloidal interaction mechanisms have been identified at the pore-scale. However, implementation of colloid transport into practically usable soil water models suitable for risk-based predictions is still at its infancy because of the complexities involved. Key questions are whether current column and field-scale models accurately represent colloid transport mechanisms that fundamentally occur at the pore-scale, but also whether all pore-scale mechanisms are relevant. Can valid simplifications be imposed that effectively enhance a soil water's model practical applicability regarding colloid transport? The research meets these challenges by resolving colloidal particle distributions within idealized porous systems, using near real-time 3D computed x-ray microtomography and pore-scale lattice-Boltzmann modeling in which we turn on or off the various colloidal interaction mechanisms and derive column-scale transport relations.

Impact: Analysis of the model results will lead to practically useful simple relations for colloid transport in soil water models. We subsequently carry out a number of variably saturated column-scale studies for simplified media as well as real soils and quantify the appropriateness of a range of model approaches. The novel datasets and results will be shared with practitioners who develop or carry out risk analysis relevant for farm operations.

2014-67019-21628

Improved N Retention through Plant-Microbe Interactions

Guillaume Bay¹, Will Overholt³, Chiliang Chen¹, Cassi Wattenburger¹, Kirsten Hofmockel²,
Michael Castellano³, Matthew Liebman³, and Larry Halverson¹,

¹Department of Plant Pathology & Microbiology, ²Department of Ecology & Evolutionary
Biology, ³Agronomy

Summary: Excessive nitrogen (N) application to agricultural soils coupled with loss of soil organic carbon (SOC) has incurred substantial environmental damage, including eutrophication and hypoxia in coastal waters, loss of biological diversity, increased NO₃⁻ in drinking water, and increased emissions of greenhouse gases. To address these issues, our research will identify agricultural management systems that balance the N source versus sink capabilities of agricultural soils, in an effort to maximize crop yield and minimize soil N loss. In this project, we will identify how cropping system diversification influences plant-microbe regulation of coupled C-N processes. We hypothesize that, as compared with simpler cropping systems, soils in diversified systems foster different microbial assemblages resulting in tighter coupling of available N supply and demand, and smaller inorganic N pools. The specific objectives of our research are to (1) quantify how differences in organic C inputs influence N transformations, (2) quantify effects of C inputs on N mineralization, and (3) characterize the composition, abundance and metabolic potential of microbial functional guilds in a long-term field experiment comprising three crop rotation systems differing in crop species and organic matter inputs. We utilized a combination of molecular analyses, soil laboratory incubations, and in-field measurements to assess how C inputs influence microbial functional guilds and N transformation rates.

Impact: We show that the diversified cropping system (corn-soybean-oats/alfalfa-alfalfa) with organic (manure) amendments compared to the 2-year conventional rotation (corn-soybean) have more biologically active soil nitrogen transformable (mineralizable) by the soil microbial community in a depth-dependent manner. Similarly we observed a depth-dependent pattern in potentially mineralizable N, which is greater at lower depths in the diversified compared to the 2-year rotation cropping system. Root systems of maize grown in soil from diversified cropping system soils are more ramified, finer, and longer than those of maize grown in soil from 2-year rotations, likely a consequence of lower inorganic N pool sizes in the diversified system.

Soil microbial communities are influenced by cropping systems. Soil bacterial communities in diversified cropping systems differ in terms of total diversity and in the abundance and composition of metabolically active members. Moreover, our findings indicate that the maize plant is not the sole determinative factor but that the plant interacts with the soil microbial community to shape the rhizosphere and root-endophytic microbiome. Cropping system diversification influences nitrifier communities in an organism-specific manner, with fewer ammonia-oxidizing Bacteria in the soil and rhizosphere in the diversified than the conventional system with no effect of cropping system on the abundance of ammonia-oxidizing Archaea.

These findings are consistent with our hypothesis that increased soil C inputs of the diversified cropping systems soils foster different microbial assemblages resulting in tighter coupling of available N supply and demand, and smaller inorganic N pools. This work will contribute towards developing sustainable agricultural management practices that are deployable in the Midwestern US.

2014-67019-21716

Nitrogen Synchrony at the Crop-Soil Interface: Optimizing Root-Microbe Interactions to minimize Environmental Nitrogen Losses

A.S. Grandy, E. Hobbie, R. Smith, and K. Broders, University of New Hampshire

Summary: Crops need access to sufficient nitrogen to meet food production demands for our world's growing population, but excess nitrogen (N) from agricultural systems is polluting our air and water. Past efforts to improve nitrogen delivery through improvements to fertilization regimes and crop varieties have failed to fully alleviate the problem of nitrogen losses, probably because greater than 50% of crop nitrogen comes from organic sources native to the soil rather than from applied synthetic fertilizer. Thus we must improve our understanding of the biological mechanisms that make organic nitrogen available to crop plants, processes that should depend on the interactions between the soil microbes that break down organic N, the stoichiometry of plant material inputs to soil that influences microbial N-processing behavior, and the soil mineral interface that strongly regulates the turnover of amino acids, proteins, and other forms of organic N. To develop strategies that more efficiently deliver nitrogen to crops without negative environmental consequences, we will need to better understand how N mineralization is driven by the response of microbial communities to input stoichiometry, and how this response is influenced by soil mesofauna.

Goals and objectives.

1. Mineral associated organic matter is a critical reservoir and mediator of plant-available N. We propose that in rhizosphere hotspots, the concentrated interaction between plants, microbes and the soil solution facilitates the release and subsequent degradation of MAOM. We aim to critically examine how plant-soil-microbe interactions in the rhizosphere—specifically the soil-microbial response to root exudate inputs—influences N dynamics in agricultural soils. We believe there are critical but poorly examined questions regarding the mechanistic controls and potential role of priming in agricultural soils.
2. The relative importance of organic input stoichiometry versus microbial community structure and function for N mineralization processes
3. Determine how greater crop rotational diversity, i.e. the diversity of crops in time, affects the plant-soil-microbe interactions that build beneficial microbiomes and soil health, and in turn lead to greater resilience of crop productivity to droughts and heat waves.

Impact:

1. We have developed new conceptual models arguing that while depolymerization is a critical first step, mineral-organic associations may ultimately regulate the provisioning of bioavailable organic N, especially in the rhizosphere. Mineral-associated organic matter (MAOM) is a rich reservoir for N in soils and often holds 5-7x more N than particulate or labile fractions. However, MAOM is considered largely unavailable to plants as a source of N due to the physicochemical forces on mineral surfaces that stabilize organic matter. We argue that in rhizosphere hotspots, MAOM is in fact a potentially mineralizable and important source of nitrogen for plants. Several biochemical strategies enable plants and microbes to compete with mineral-organic interactions and effectively access MAOM. In particular, root-deposited low molecular weight compounds in the form of root

exudates facilitate the biotic and abiotic destabilization and subsequent bioavailability of MAOM. We believe that the competitive balance between the potential fates of assimilable organic N — bound to mineral surfaces or dissolved and available for assimilation — depends on the specific interaction between and properties of the clay, soil solution, mineral-bound organic matter, and microbial community. For this reason, the plant-soil-MAOM interplay is enhanced in rhizosphere hotspots relative to non-rhizosphere environments, and likely strongly regulates plant-microbe competition for N. If these hypotheses are true, we need to reconsider potential soil N cycle responses to changes in climate and land use intensity, focusing on the processes by which management and other anthropogenic stressors can alter MAOM's N-supplying capacity.

2. We have carried out a series of experiments that to examine the ability of corn roots to accelerate microbial activity and stimulate the release of needed N. We show that roots and their associate mycorrhizal fungi stimulate microbial activity in the rhizosphere and that this increases N turnover. The potential for crop plants to regulate internal N cycling has the potential to reduce the need for external N applications, and improve the synchrony of plant N needs and soil N availability.
3. It is widely assumed that microbial activity and respiration rates respond linearly to substrate concentrations, irrespective of substrate chemical characteristics, but this assumption remains largely untested. We know that microbial decomposition of soil organic matter (SOM) and the amount of CO₂ respired from soil depends on substrate availability. While soils with high SOM concentrations will have higher respiration rates than soils with low SOM concentrations, the specific relationship between substrate quantity and CO₂ respired and its underlying mechanisms has robust theoretical, modeling, and management implications. In a series of lab incubation experiments, we show that across substrates CO₂ production increased with increasing organic carbon (OC) content following a sigmoidal curve function instead of the expected linear one. A breakpoint analysis for the respiration curve of rye revealed two significant break points at 1.3 and 3.8 % OC. The three individual linear relations might be shaped by spatial separation of substrate and microbes and the interaction of the microbes themselves. Our findings of a non-linear decrease of CO₂ production with decreasing OC content indicate that spatial separation as an inherent property of SOM content is an important control on decomposition of soil organic matter and mineralization of N. Knowledge of this controlling effect might be beneficial in many ways. For example, even small additions of plant residues to agricultural systems might strongly enhance N availability to microbes and plants. Further, the spatial distribution of new C inputs may regulate its potential to be decomposed or stabilized. Finally, our results will help to improve model parameterization and predictions about microbial limitations and potential changes in decomposition under a future climate.

2014-67019-21614

Unveiling Fungal Contributions to Agricultural Soil Nitrogen Cycling Following Application of Organic and Inorganic Fertilizers

Miguel Semedo and Bongkeun Song, Department of Biological Sciences, Virginia Institute of
Marine Science, College of Williams & Mary

Rebecca Phillips, Ecological Insights Corporation

Craig Tobias, Department of Marine Science, University of Connecticut

Carl Crozier, Soil Science Department, North Carolina State University

Summary: Nitrogen used for plant fertilizers comes from inert di-nitrogen (N_2) gas in the atmosphere. Much of the fertilizer nitrogen (N) applied is not used by plants and moves into waterways to disrupt ecosystem chemistry. Some excess N is converted to a greenhouse gas, nitrous oxide, which also destroys the ozone layer. Returning excess N to the atmosphere in its original form (N_2) would be the most effective way of removing excess N. Formation of N_2 in natural ecosystems is considered a biological process, denitrification, involving micro-organisms and anoxic conditions. Recent studies showed fungi are capable of denitrification producing N_2O and N_2 . As part of evaluating fungal denitrification, abiotic production of nitrogen gases was examined. We found that nitrite can be reduced to N_2O and N_2 without microorganisms under oxic and anoxic conditions.

Our research objectives were to (1) quantify biotic and abiotic production of N_2O and N_2 in an anoxic and 20% O_2 atmosphere and (2) determine if measured N_2 was formed by reducing N_2O to N_2 or by combining two N sources, thus forming hybrid N_2 . We report abiotic hybrid N_2 formation under both oxic and anoxic conditions. This discovery calls into question what we know about anammox and codenitrification and opens up new avenues for N removal. Abiotic N_2 production in aquatic and terrestrial ecosystems could explain important gaps in the global N budget.

Impact: Our results will reshape how we consider formation of gaseous N_2 and N_2O and how we partition isotopic fluxes of N_2 into anammox, codenitrification and denitrification. Researchers that investigate oceanic and terrestrial fluxes of nitrogen and modellers that create nitrogen and greenhouse gas budgets will now need to consider abiotic N_2O and N_2 production in oxygenation ecosystems.

These results represent a foundation for abiotic N_2 and N_2O production research that should lead to new terrestrial-N removal and greenhouse gas mitigation strategies and technologies, particularly relevant in aerated soils.

2015-68007-23136

Lake Ontario Basin Agriculture in the Coming Decades: Room for Expansion or Imminent Future Water Conflict

Stephen Shaw, Dept. of Environmental Resources Engineering

Theresa Selfa, Dept. of Environmental Studies

SUNY College of Environmental Science and Forestry, Syracuse, NY

Summary: While irrigation is mostly used supplementally in humid regions, when irrigation water is needed it typically coincides with hydrologic drought that can limit its availability. Because irrigation in humid regions is largely unregulated, there has been little evaluation of whether there is sufficient water during these sporadic, but critical dry periods. However, especially with the potential for climate change to modify regional and national water use patterns, there is the need to understand whether there is excess capacity in humid regions.

In this study, we have focused on understanding irrigation water use in Western New York State. While there are some field crops, there is also extensive vegetable and fruit production. Many farms growing these high value fruit and vegetable crops have irrigated for decades.

The primary goal has been to collect detailed information on grower water application rates and the source of water being used. While there is some usage rate information available from the USDA Farm and Ranch Irrigation Survey, virtually no existing data includes the source of water. 31 growers were interviewed during the winter of 2016.

Impact: The grower interviews have provided a clearer picture of water sources being used in the region. It appears that the natural geographic distribution of farms and the presence of multiple small streams keeps any one waterbody from being a primary source. However, it appears one source is possibly underutilized. Namely, the Barge Canal (the former Erie Canal) provides a direct conveyance of water from Lake Erie westward across the state. The canal was designed with a 1000 million gallon per day capacity (to allow for filling of multiple locks along the route), but only a fraction of this capacity is used. A mapping analysis of farmland within 1 km of the canal or its linked tributaries reveals that approximately 50% of the land is open but not used for agriculture, indicating the possibility of expanding irrigation from a reliable and low cost water source. This past summer has been one of the driest years in decades in the region. We plan to conduct additional interviews once the growing season ends to provide information specific to drought conditions.



2015-68007-23133

Developing and Promoting Water-, Nutrient-, and Climate-Smart Technologies to Help Agricultural Systems Adapt To Climate and Societal Change

Basso, Bruno¹, Hyndman; David W.¹; Zhao, Jinhua¹; Robertson, Phillip G.¹; Andresen, Jeffrey¹; Parker, Joyce¹; Rice, Jane¹; Brozovic, Nicholas²; Butler, Jim J.³; Hatfield, Jerry⁴; Winter, Jonathan⁵
Michigan State University¹
University of Nebraska²
USDA-ARS, NL³
Dartmouth College⁴

Summary: The first year of the *PreCiSA* project has been very productive. We made significant progress in data synthesis, new data collection across scales, crop system model validation and multi-model ensemble runs, landscape hydrological simulations coupled with economic models and analysis.

The different teams have generated a wealth of new data, models simulations results and information on the interactions between climate, hydrology, and socioeconomic drivers of agricultural practices across the Upper Midwest and High Plains regions that lay the foundation for a successful continuation of the project.

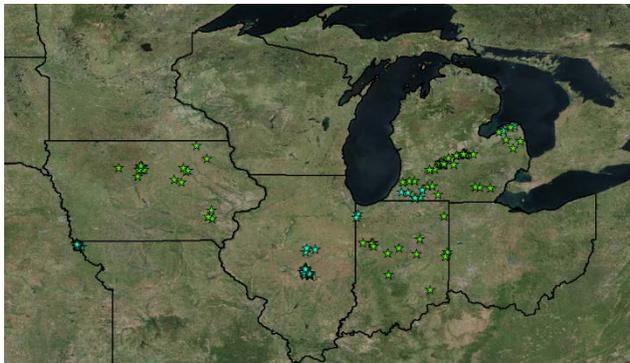


Figure 3. Locations of farmers' fields being monitored and modelled.

We have collected over 8000 images over 220 fields across the Midwest to monitor and model spatial and temporal variation of crop growth, water and nitrogen use, and yield at the field level (Fig. 1).

Field data have been collected to validate the model and to ground truth remote sensing images. These results along with yield map analysis are being assembled into research reports and papers to provide a base for developing water and climate-smart agricultural systems for the Midwest.

The objectives of our project, named **PreCiSA** (from the linkage between **Precision Agriculture** and **Climate Smart Agriculture**) are to: i) develop and improve management strategies for a water-, nutrient-, and climate-smart agriculture; ii) create and disseminate decision-support tools to help farmers use “Big Data” (e.g., yield maps and UAV sensors) to adapt to climate variability and increase their resiliency; iii) evaluate the economics of smart agriculture technologies and practices. Our research will integrate and experimentally test a novel suite of biophysical and socioeconomic systems models to quantify interactions between climate, hydrology, and socioeconomic drivers of agricultural practices across the Upper Midwest and High Plains regions. Research, education, and extension activities in this project will provide accurate information for practical use by the general public, students, farmers, and decision makers to enable sustainable adaptation to and mitigation of temperature extremes, drought, and flooding.

Impact: We have presented the results of the first year at various stakeholders meeting. The results were received well as most of our research is conducted on farmers' fields, and with the goal of scaling up to county and region.

Each research unit within the project has been engaging with stakeholders (farmers, extension, teachers/students, commercial companies, state agent, policy makers) with different level of participation.

Data have been compiled into a database for both long-term field and plot-scale experiments in order to evaluate the effects of management practice, corn hybrids, and soybean cultivars on water use and radiation use efficiency. The plot-scale research has quantified the effect of different management practices and genetic diversity on yield components and the response over multiple seasons with varying weather conditions. The field scale research integrates flux and energy balance measurements over corn and soybean canopies and has been used to evaluate the changes in water and carbon dynamics of these crops since 2000. Data from this site has been used to determine gross primary productivity and the interaction with soil water availability.

We have initiated the work that describes the role of agricultural management in providing groundwater recharge across the High Plains; the coupled effects of climate change and irrigation water demand on depletion of the Central High Plains aquifer, and how this may feedback to limit regional production, and what strategies may be employed to more sustainably use groundwater resources. Initial work has been done in evaluating the consequences of shifting from less efficient flood and center pivot irrigation systems to more efficient Low Energy Precision Application (LEPA) systems on the hydrologic budgets of irrigated regions.

We have been assembling key datasets on field-level agricultural water use in Nebraska, and Kansas. We have published some of the first results and others ready to be submitted. We also worked on the development and promulgation of methods to help assess the impact of climatic- and anthropogenic-induced changes on the groundwater resources of the High Plains aquifer.

The team will continue to collect yield mapping sensors data collected over a large number of fields, crops and locations across the Midwest to integrate them in a system approach to adopt cropping systems to climate variability and change. Data from existing and new field studies, combined with crop simulations, will be used to evaluate sustainable management options to enhance resource use efficiency of agricultural systems.

2015-68007-23137

Evaluating the Presence of Pathogenic Bacteria in Fecal Sample of Feral Pigs and Their Transport to Surface Waters

Dave Bachoon, Department of Biology & Envir Sciences, GCSU, Georgia

Summary: The primary goal of this project is to improve our understanding of what types of pathogenic bacteria are present in Georgia's feral pig communities in cattle framing areas and the potential for these pathogens to contaminate water used for agriculture. Another goal of this project is to give me an opportunity to develop my expertise in metagenomic analysis of fecal bacterial community.

Specific objectives:

1. To evaluate the presence of pathogenic bacteria in fecal samples from feral pigs on cattle farms in relation to BMP's and transport to surface waters.

Develop my expertise in metagenomic analysis of bacterial population of fecal samples from feral pigs.

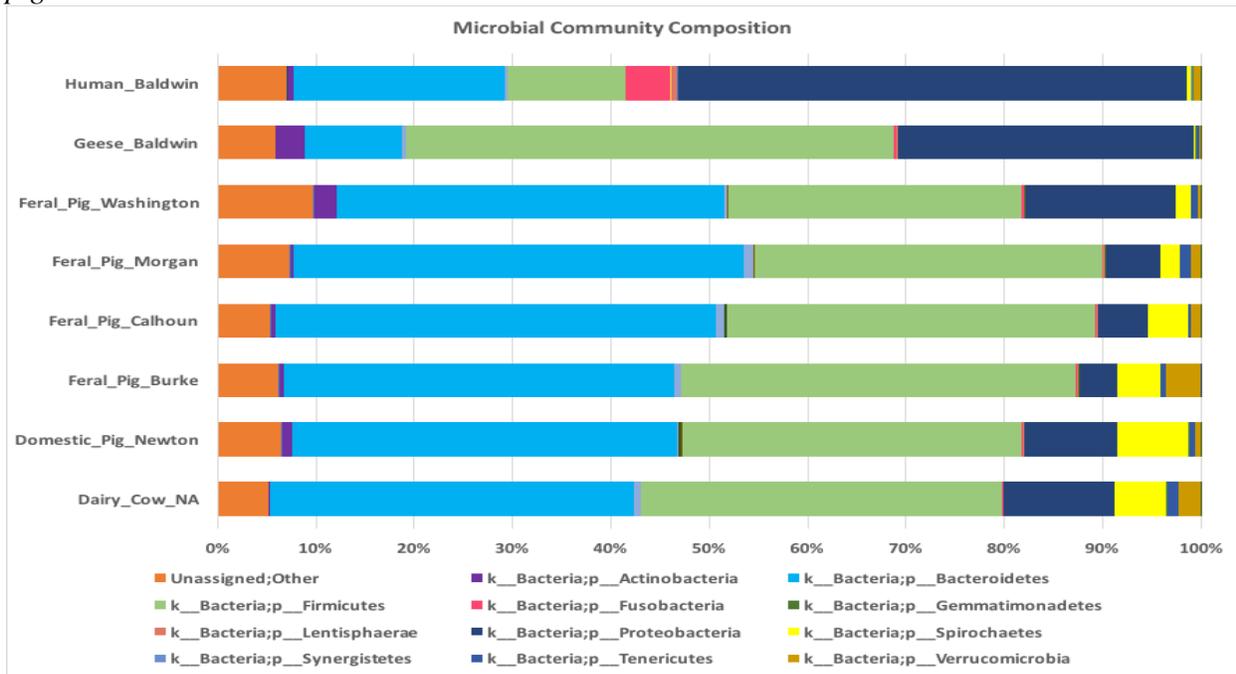


Figure 3. Taxonomic composition of the fecal bacterial community of feral swine, cattle, geese and humans at the Phylum level

Table 1. qPCR detection of *Brucella suis*, *Campylobacter jejuni*, and *E. coli* O157:H7. However, *C. jejuni* have not been detected in any sample.

County	No. of Samples	<i>Brucella suis</i>	<i>E. Coli</i> O157:H7
Burke	4	2	0
Calhoun	15	2	0
Chatham	4	0	0
Dooly	18	0	3
Elbert	1	0	0
Morgan	19	8	4
Oglethorpe	1	0	0
Randolf	3	0	1
Sumter	8	1	3
Terrell	8	0	0
Washington	2	1	0
Wilkinson	1	0	0
Total	84	14 (16.67%)	11 (13.09%)

Impact: Across the U.S. feral swine are rapidly increasing in population size (> 6 million) and range. These invasive animals pose threats to agriculture, human safety and surface water quality because they harbor a wide range of zoonotic pathogens and feast on field crops (e.g. corn, soy beans, watermelon, peanuts, etc.). As part of a 2015 mini-sabbatical grant, we have data on the level of swine fecal pollution in water samples in Georgia and have determined the presence of *Brucella suis*, *Campylobacter jejuni*, and *Escherichia coli* in the fecal samples of 84 feral swine from twelve counties in Georgia. DNA was extracted from the fecal samples and used for metagenomic analysis of the fecal bacterial community. The taxonomic composition of the fecal bacterial community of feral swine, cattle, geese and humans at the phylum level were determined and indicated clear differences in the fecal bacteria microbial profile of each host. In addition, qPCR was used to detect the presence of pathogenic bacteria; *Brucella suis*, *Campylobacter jejuni*, *E. coli* O157:H7, and *Yersinia enterocolitica* carried by feral pigs. Out of 84 feral pig samples analyzed, *B. suis* and *E. coli* O157:H7 were detected in about 16% and 11% of the feral pigs respectively. However, *Campylocater jejuni* and *Yersinia enterocolitica* were not detected in any of the samples. Feral pigs represent a growing threat to public health and agriculture in the U.S. More microbiological is needed to understanding the health risk

2015 Healthy Soils for Healthy Waters Symposium

Ward, A. D.

Summary: Experts at The Ohio State University and Greenleaf Advisors are launching a Symposium series entitled Healthy Soils for Healthy Waters dedicated to whole system management practices for agricultural lands that impact the Nation's waters. The focus is on the Great Lakes Region and the Mississippi River Basin and will bring together top researchers, scientists and policy makers from government, the agricultural community, and other stakeholders to tackle one of the most pressing natural resource issues of our time. We intend to have one Healthy Soils for Healthy Waters Symposium annually for 3 years or longer. This collaborative multi-year effort will be organized around the development of data-driven, region-specific case studies highlighting state-of-art BMP strategies to promote agricultural production while reducing nutrient exports to water resources throughout the Great Lakes and Gulf of Mexico watersheds. The 2015 Symposium, that is the focus of this funding request, will be held in May and will be held in conjunction with meetings of the Federal Hypoxia Task Force (HTF) and a Land Grant University team that has formed to assist the HTF. The long term goal will be to create an integrated science, education, economic, and extension-based framework that results in agricultural producers using adaptive systems management approaches that maintain or enhance productivity and profitability while reducing the nutrient exports that cause adverse water quality impacts such as hypoxia and harmful algal blooms. The Symposium series will bring together producers, industry, leading practitioners, scientific researchers, community leaders, agency personnel, and environmental groups who are committed to advancing improved agronomic practices for soil and water health. We will be looking across a range of practices and toward the integration of disciplines to advance sustainable use of water and land resources. An online portal for information sharing will be developed that will contain proceedings and materials shared at all of the Healthy Soils for Healthy Waters events.

Impact: The long term goal will be to create an integrated science, education, economic, and extension-based framework that results in agricultural producers using adaptive systems management approaches that maintain or enhance productivity and profitability while reducing the nutrient exports that cause adverse water quality impacts such as hypoxia and harmful algal blooms. We will be looking across a range of practices and toward the integration of disciplines to advance sustainable use of water and land resources. We envision that this could become an annual series of gatherings to cultivate an ongoing commitment to integration of talents and approaches to address the challenge of responsible use of water and soils for sustainable agricultural production and ecosystems. Results and end products become living documents that can be updated with the latest science, policy, economic, climate, and cultural shifts. Specific objectives will be to: 1. Develop practical conceptual solutions at different scales that identify what combination of practices and resources it would take to reduce nutrient exports below target nutrient levels. 2. Identify what incentives, strategies, tools, knowledge, and outreach education would be needed to implement the proposed conceptual solutions. 3. Identify the time frame and cost associated with meeting the water quality objectives. 4. Identify the transferability of the conceptual solutions to other watersheds in the Great Lakes and Mississippi River Basins. 5. Identify knowledge, technology, and education gaps. 6. Consider how climate change and a potential need to increase productivity might influence these water quality strategies and water use for multiple purposes including agriculture. 7. Build frameworks where different organizations and different disciplines work better together, and with producers and industry, to more effectively solve problems associated with nutrient impacts on water resources.

Thursday, October 13, 2016

Poster Session II



2015-67019-23602

Adaptive Management for Phosphorus to Improve Economic and Water Quality Outcomes

Peter Scharf, University of Missouri, Deanna Osmond, North Carolina State University, Steve Culman, The Ohio State University, Greg LaBarge, The Ohio State University, John Lory, University of Missouri, Harold Watters, The Ohio State University

Summary: Phosphorus is required for plant growth and is widely used in crop agriculture. It has become a water-quality issue by fueling excess plant growth in water. Fixing this problem will require reducing phosphorus fertilizer movement to water.

We propose that phosphorus fertilizer should only be applied where it gives a profitable yield response. Existing management practices and tools do not meet this standard.

On-farm tests measuring yield response to phosphorus fertilizer gives farmers a way to find out where those applications were profitable, and discontinue application where they were not. Continued testing of areas where P applications are discontinued is a key part of this strategy, protecting yields as soil P reserves decline.

Key Informant interviews with farmers have been conducted but analysis is not yet complete. They will soon be in the 'Impact' section.

Impact: Phosphorus fertilizer use was found to be profitable in only 2 of 21 fields where on-farm responses trials were carried out in 2015. Most trials used field-length strips as the experimental unit.

Participating farmers and farmers attending educational events learned that phosphorus fertilizer usually does not give profitable yield response, and that opportunities for more information-intensive management can save them money while protecting water resources.

Protocols were developed, as were experience bases, for conducting on-farm phosphorus response trials as an ongoing decision support tool about when and where phosphorus fertilizer will be profitable and should be applied to the whole field.

Fertilizing only a few strips per field will reduce environmental impact of phosphorus while providing a robust decision tool to protect farmer profitability and make sure that phosphorus fertilizer is used when it is needed.



2015-67019-23584

Nitrogen Emissions Associated with Nutrient Management Practices: Measurements, Modeling, and Microbial Communities

J. L. Zilles, A. D. Kent, and S. Koloutsou-Vakakis, Civil & Environmental Engineering and Natural Resources & Environmental Science, University of Illinois Urbana Champaign, Illinois

Summary: Nitrogen fertilizers are essential for agricultural productivity, but their use causes public health and environmental problems due to atmospheric reactive nitrogen emissions and aquatic nitrogen pollution. Many management strategies are available for control of aquatic nitrogen pollution. However, there is limited information about the effects of these strategies on atmospheric emissions of nitrogen, preventing a holistic assessment of the nitrogen problem and identification of locally appropriate solutions. There is also considerable uncertainty about the role of microbial community composition in controlling nitrogen transformations and emissions. We hypothesize that management strategies will vary in their emissions of nitrogen species. We further assert that a better fundamental understanding of the microbial processes contributing to nitrogen cycling in agricultural ecosystems will contribute to improved models, especially for alternative management strategies, and are testing several hypotheses about the roles of different microbial functional groups. These hypotheses are being tested through a broad and interdisciplinary suite of analyses conducted in conjunction with multiple ongoing field studies of different management strategies.

Objective 1. Measure N_2O and NH_3 emission fluxes in situ and across seasons for different agricultural and nutrient management practices (no till, ridge till, and chisel plow with and without cover cropping; wetlands; and denitrifying bioreactors).

Objective 2. Model nitrogen cycling in soil, water, and air using the Denitrification Decomposition (DNDC) model and compare results with measurements from Obj. 1.

Objective 3. Characterize nitrification and denitrification potential and contributions of bacterial and fungal denitrifiers in soil or bioreactor woodchip samples from each management regime using activity assays and domain-specific inhibitors.

Objective 4. Characterize the microbial community associated with production and consumption of N_2O and NH_3 in each management regime using functional gene markers for nitrifiers, denitrifiers, and N_2O -consuming microorganisms.

Impact: The first year of the project has focused primarily on method development and field measurements. The measured emissions are now being compared to DNDC-based predictions of emissions to provide a basis for applying these results on a broader scale. Microbial activity and composition measurements are ongoing. The results will improve models of alternative management strategies, allowing a holistic assessment of the impacts of management on atmospheric and aquatic nitrogen emissions.



2015-67019-23604

Mitigating Nutrient Losses from Agroecosystems: Biotic and Abiotic Mechanisms of Nitrogen Cycling Under Conservation Agriculture Management

Sean Schaeffer, Jennifer DeBruyn, Donald Tyler, University of Tennessee, Knoxville, TN
Virginia Jin, USDA-ARS, Lincoln, NE

Summary: Conservation practices such as no-tillage and cover crops are recommended to maintain or improve the accumulation of soil organic matter, minimize the risks of soil erosion or loss in soil productivity, decrease system fertilizer nitrogen (N) input requirements and N losses, and reduce direct soil emissions of various GHGs. Although some studies have shown that conservation practices decrease leaching and atmospheric N losses, the use of both no-tillage and cover crops in other production systems have shown that N losses via leaching or gaseous emissions increase. These contrasting findings suggest that selection of conservation practices and how best to implement them are site-specific. This highlights the need for improved understanding of the soil microbial and physical processes driving N transformations that affect system N retention. In this project, researchers will measure soil biological and physical pathways of N transformation and loss from fields under long-term conservation management treatments (zero-tillage, winter cover crops, reduced N fertilizer application). Results of the field study will be used to improve a predictive model (APEX) of agroecosystem function.

Production systems may take years before changes in management practices manifest in crop yield changes or soil properties. Therefore, long-term studies of these management practices, such as the researchers propose to utilize, provide critical data to producers, stakeholders, and regulatory agencies towards the common goals of optimizing crop yields while balancing societal demands for food/fiber and for the maintenance or improvement of air and water quality. Identifying the specific microbially mediated processes that affect soil N transformations can inform how conservation management practices can be implemented more effectively to increase N retention and build SOM. The proposed research will provide mechanistic explanations for the observed effectiveness of nutrient loss mitigation strategies. The researchers will use the knowledge gained to engage model development and testing, and provide methodological transparency to improve understanding of the key biogeochemical processes affecting agricultural production and the environment. The results of this work will benefit environmental health in this region because nutrient exports from agroecosystems have severe health and ecological impacts including stream eutrophication and low dissolved oxygen which can extend from local watersheds to oceans. This is of particular concern for agroecosystems in West Tennessee as they are part of the Mississippi River Basin.

The goal of this project is to identify the key controls, and quantify the biogeochemical mechanisms that regulate the storage and transformations of soil N, and to more accurately estimate N losses using existing computer models and assess the effectiveness of mitigation strategies. Mitigation strategies to be assessed are zero-tillage, winter cover-cropping, and reduced fertilizer input. To conduct this project, we will use established, fully replicated, long-term (>30 y) continuous cotton experimental plots in West Tennessee.

Objectives of this project

1) Determine seasonal changes to the structure and function of microbial assemblages involved in soil N transformations as a result of conservation management practices.

- 2) Assess management practices in terms of mitigating gaseous and leaching N losses.
- 3) Predict the long-term management consequences for nutrient retention using process-based model simulations.

Impact: Field sampling and data collection for this project is still in the first year. The results of first summer of data collection will be presented by at the tri-societies (ASA/CSA/SSSA) meetings in Phoenix in November. Project director Schaeffer has incorporated the initial findings from this project into his graduate course (ESS 515 Soil and Environmental Biogeochemistry) which averages 13 students and is taught every other year. In addition, project objectives and results have been disseminated to international audiences at four separate universities in China in June, 2016, and to El Centro Internacional de la Papa in Lima, Peru in October 2016. These seminars reached scientists, graduate and undergraduate students at NGOs and academic institutions working in the areas of soil science, agronomy, and environmental science.

2015-67020-23454

Linking Topography, Changing Snow Regimes, Nitrogen Dynamics, and Forest Productivity

Yuriko Yano¹, Jia Hu¹, Claire Qubain^{1*}, Kelsey Jensco²

¹ Department of Ecology, Montana State University, Montana

² College of Forestry and Conservation, University of Montana, Montana

*Graduate Student

Summary: In the montane ecosystems of the western US, winter snowpack plays a critical role in forest productivity through two major pathways; 1) snowpack is the major source of water and 2) it insulates soil for N mineralization over winter. However, winter snowpack is predicted to continue to decline with increasing air temperature. Thus, it remains unclear how declining snowpack would alter forest productivity in the western US, because 1) our understanding of spatial and temporal controls on current N availability across complex mountain topography is limited, and 2) we lack clear understanding of whether trees can synchronize their N uptake with the timing when N availability in the soil is highest. The goal of this study is to first identify how topography controls N availability across season and second, quantify how much available nitrogen trees are actually using. Our project is located at the Lubrecht Experimental Forest in western Montana and during our first year of the funding, we investigated how elevation, aspects (north-facing vs. south-facing), and microtopography (slope vs. hollow) affect the distribution of plant-available N across the season and between years. We hypothesize that N availability is highest following spring snowmelt and fall, when soil moisture is highest, and that sites with a deeper snowpack (high elevation, north aspect sites) results in higher N availability throughout summer than those with thinner snowpack. We measured ammonium (NH_4^+) and nitrate (NO_3^-) in soil KCl-extracts and in soil water collected by lysimeters for over a year, immediately following the spring snowmelt of 2015. Soil temperature and moisture were recorded continuously during this time using data loggers.

Impact: Our results showed heterogeneity in soil N across our watershed; soil N availability was generally greater at higher elevation sites and in the hollows, where the winter snowpack is deepest and soil moisture is higher relative to the slopes. Moreover, we found that the effect of microtopography can be more pronounced in the south-facing slopes compared to the effects of elevation.. While N availability changed greatly across season, the seasonal patterns differed between high vs. low elevation sites as well as hollow vs. slope. Our findings thus far suggest that seasonal N availability in the western montane forests differ greatly across elevation and microtopography. Currently, we are investigating whether trees' N uptake synchronizes with the temporal shifts in soil N availability, using young Douglas Fir trees in the field and Douglas Fir seedlings in a greenhouse.

2015-67020-23603

Bioavailability and Fate of Particulate and Colloidal Phosphorus Released From Agricultural Sources: Case Study Chesapeake Bay Watershed

Deb Jaisi and Yan Jin

Department of Plant and Soil Sciences, University of Delaware, Newark, DE 19716

Summary: Understanding the sources, cycling, and transformation of P is not straightforward, compared to many other nutrients, because of low concentration of dissolved P (compared to colloidal and particulate P and soil/sediment P), active but variable transformation of organic and inorganic P forms, and organisms' variable strategies to uptake and store P. These complexities hamper the understanding of sources, cycling, and transformation of P in different forms, thus restrict accurate assessment of the accountability on nutrient loads released to the different open waters and ecosystems. To address question on fate and bioavailability of P in the continuum from source to sink, this project aims to realize three objectives: i) quantify the relationship of organic and inorganic particulate and colloidal P along the physicochemical and hydrodynamic gradients in two estuaries in the Chesapeake Bay; ii) identify biological recycling of particulate and colloidal P in waters, and iii) examine remobilization of particulate and colloidal P fractions from soil/sediment under environmentally relevant physicochemical and biogeochemical perturbations.

Impact: For the suspended particulate P (PP, >100 nm size) from East Creek, bioavailability and potential sources were analyzed using phosphate oxygen isotope ratios. NaOH-P_i and HNO₃-P_i pools were found not to be available to microorganisms during transport in the creek. This means that a considerable amount of PP is not an immediate environmental concern. On the other hand, a significant fraction of other PP pools were both available and cycled even when the concentration of dissolved P was above stoichiometric nutrient requirements. It means bioavailability of PP pools cannot be ignored when calculating P loading and export out of this watershed.

In the Deer Creek-Susquehanna River watershed, speciation of P in different size fractions (>0.45 μm to 10 kDa) showed that particulates (>1 μm) and colloids (1 μm–10 kDa) constitute ~75% and 25% of the total mass of particulate matter, respectively. In general, both inorganic and organic P concentrations varied in the same order as: NaOH-P > NaHCO₃-P > HNO₃-P > H₂O-P in Hedley extracted P pools. Small colloids especially nanoparticles had higher P content in all P pools suggesting these sizes play an appreciable role on the transport of P although their total masses are relatively low. These findings bring up further possibility of differentiating the bioavailability of P pools in different size fractions in environmental samples.

Key impacts of the first year of this project include training of two postdoctoral associates, graduate student, submission of two major grant proposals (based on the preliminary data generated from this project), three peer reviewed publications, and six presentations in professional society meetings.

2015-67020-23585

Large Runoff Flux and Transformation of Particulate Nitrogen Following Large, Large Storms: A Critical but Unexplored Component of N Cycling

Inamdar, S.

Summary: While dissolved species may compose a major portion of the nitrogen (N) transport in watersheds during low flow conditions the amounts of particulate N (PN) in runoff can increase dramatically with large storms such as those associated with tropical depressions and hurricanes. We hypothesize that the export, deposition and transformation of PN in the fluvial network following large storms will yield substantial dissolved and bioavailable N and thus constitute a significant component of N cycling in watersheds. We will test this hypothesis in well-studied and intensively instrumented nested, forested watersheds (12 and 79 ha) and with a novel combination of watershed-, reach-, and laboratory-scale experiments. PN flux and composition in the watershed during storms will be mapped using physical, chemical, isotopic, and molecular techniques. Laboratory incubation assays will track the transformations (mineralization, immobilization, nitrification, and denitrification) of sediment end-members and deposited PN with chemical, molecular, and gas flux measurements. Incubations will be performed for contrasting moisture regimes - continuously moist versus wet-dry. This study will produce a comprehensive, coupled (solid-aqueous-gas phase and carbon-N) model for PN fate and transport in watersheds and further our understanding and quantification of N cycling and fate in agroecosystems. Understanding these changes is especially important considering that climate-change scenarios indicate increased intensity of hurricanes and tropical storms and thus potentially a greater role for PN in watershed N fluxes and cycling. This study will also enhance our ability to develop better management practices and decision tools to regulate N exports from watersheds.

Impact: What was accomplished under these goals? Objective 1: Sampling locations for runoff water and sediment were established at multiple (five) drainage scales (12 to 79 ha). Sampling of water, sediments, C, and N has been performed for multiple storm events (more than 20). These samples have been analyzed for - sediment concentrations of OC and N, isotopes of ^{13}C and ^{15}N , and particle size distribution. Stream discharge or flow rates are also available for all sampling times. Sediment source sampling has also been performed to characterize potential end-members and include - stream bed, stream bank, upland A and B horizons, wetland A and B horizons, and forest floor or O horizons. Currently three publications are in preparation that characterize - (a) the change in sediment sources with spatial drainage locations and streamflow rates; (b) the change in particulate C and N composition with stream flow rates using isotopic, nutrients, and biomarkers; and (c) the ability of in-situ continuously logging sensors to characterize particulate OC concentrations. The assessment includes - principal component analyses, regressions, and flux computations. Objective 2: In addition to physical (particle size) and chemical characterization of the sediments, microbial character of the sediment is being determined using PCR-DGGE and 16s rRNA. Incubation experiments to follow the fate of stream deposited sediment N has also been initiated. These incubations will track how stream sediment N cycles evolve over a given time period. We will also investigate and identify which microbes play in role altering the sediment N transformations. Objective 3: A conceptual model for the objective 1 portion - "spatial and temporal evolution of POC and PN in a stream network" is currently in development and will be completed in the next few months.

2015-67019-23496

Impacts of Tree Species and Harvest Regimes on N Retention in Northeastern U.S. Forests

Lovett, G. M.; Crowley, K.

Summary: Northeastern forests are likely to experience future shifts in tree species composition due to selective harvesting, climate change, and introduced pests and diseases. It is known that there are large differences among tree species in wood production, carbon storage, and nitrogen retention (efficiency of nitrogen use), yet no existing forest ecosystem model incorporates the effects of tree species on nutrient cycling and retention. Species-specific ecosystem modeling is essential to planning long-term, sustainable increases in nutrient use efficiency in managed forest systems, and to understanding how forest management interacts with other changes such as atmospheric nitrogen pollution, invasive pests, and climate change. Our overall goal is to elucidate how these multiple environmental changes interact to influence wood production, nutrient retention, and carbon storage. We will achieve this goal by completing the development of a new forest ecosystem simulation model (called Spe-CN) that allows the user to set scenarios of changes in tree species composition, and using this model to predict biomass production and nutrient retention under conditions of changing tree species composition, silvicultural practices, atmospheric nitrogen deposition, and climate in Northeastern forests. Spe-CN differs fundamentally from other process-based forest ecosystem models in incorporating species-specific effects, thus providing a major step forward in simulating forest nutrient cycling and predicting the effects of future environmental change.

Impact: We have developed, tested, and published a version of the Spe-CN forest ecosystem model with which the user can simulate changes in tree species composition over time, changes in atmospheric nitrogen deposition, and different forest harvest practices. We are currently incorporating water dynamics and climate effects on tree growth into the model as well. To begin to address Objective 2, we have used the Spe-CN model to analyze the effects of tree species change due to invasive forest pests on carbon and nitrogen dynamics in Northeastern forests. We are also working on an analysis of the effects of different tree species and scenarios of tree species change on nitrogen retention, nitrogen leaching, and therefore critical loads of nitrogen to waterways from forests dominated by different species.

2015-67020-23453

Process-based Nutrient Modeling of Integrated Beef Cattle Finishing and Crop Production Systems in the Northern Great Plains

E. Cortus and J. Darrington, South Dakota State University, SD

A. Chatterjee and S. Rahman, North Dakota State University, ND

M. Spiels (NE), C.A. Rotz (PA) and D.B. Parker (TX), USDA-Agricultural Research Service

Summary: The research project goal is to investigate the systematic effects of different scenarios of beef cattle housing, manure management and crop production in the Northern Great Plains on nitrogen (N) and phosphorus (P) losses and use efficiencies. The integrated analysis of beef cattle and crop production systems will identify strategies for improved N and P cycling.

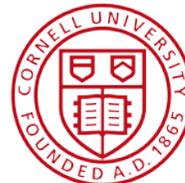
The specific objectives are to: (1) adapt and evaluate a process-based model that estimates the fate of N and P for confined beef cattle housing/manure management methods of the Northern Great Plains region, including bedded manure pack and deep pit manure storage; (2) adapt and evaluate a process-based model that estimates the fate of N and P availability and losses from land applied solid beef cattle manure (with and without bedding); and (3) evaluate housing, manure management and crop production scenarios for N and P fate and farm profitability under variable climatic conditions. The approach uses collected and other available data to adapt and evaluate the process-based “Integrated Farm System Model”. The national-scope farm model will then be used to investigate the effects of variable climatic conditions and alternative management scenarios for integrated beef cattle and crop production in the region and beyond.

Impact: Airflow and environmental monitoring of cattle barns provides producers with critical environmental information, especially for sidewall curtain management decisions, related to airflow.

Plot scale land application study sites situated in North Dakota, South Dakota and Nebraska demonstrate the variability of corn production from weather, soil characteristics and farm management practices (i.e. irrigation), providing a wide range of conditions for model evaluation of N and P cycling. Common monitoring techniques and multiple years of data will facilitate comparative analyses of crop and soil characteristics in coming years.

The Integrated Farm System Model (Version 4) now includes representation of beef cattle production systems in the Northern Plains, which facilitates analysis of their environmental impacts.





2015-67019-23588

Managing N and C Cycling Processes at Multiple Scales to Improve Nitrogen Use Efficiency in Grains

Drinkwater, L.; Buckley, D.

Summary: Plant microbial interactions occurring at the root-soil interface (known as the "rhizosphere") influence the complex set of transformations that regulate nitrogen release, flow, and loss in agroecosystems. The linkages among the activity of soil biota and nitrogen availability occur at various scales, affecting plant productivity and nitrogen use efficiency and, ultimately determine how much nitrogen is lost or retained in the soil. These processes thereby contribute to the provision of ecosystem services, i.e., ecological functions and processes by which the environment provides for human needs, such as food and fiber, soil quality, reduction of greenhouse gas emissions and clean water. Plant-microbial interactions and resulting nitrogen transformations can potentially play a larger role in the provision of ecosystem services in agricultural ecosystems. We identify three inter-related requirements for harnessing the beneficial microbes that regulate internal carbon and nitrogen cycling processes to improve nitrogen use efficiency: i) management regimes that supply adequate crop nitrogen, replenish soil organic matter reserves and minimize nitrogen loss pathways, ii) crop cultivars that can collaborate with beneficial soil microbes in the rhizosphere, and iii) high-functioning microbial communities in the rhizosphere that conserve nitrogen and contribute to nutrient acquisition by the crop. Our research approach addresses these key requirements through studies of cycling processes at multiple scales using stable isotope methods for tracking nitrogen in conjunction molecular methods that enable us to characterize the microbial community that is associated with crop roots. By applying these techniques to study maize, the US crop which accounts for a majority of the applied nitrogen fertilizer, we will produce new knowledge that can be used to improve nitrogen efficiency and reduce environmental losses. The project will contribute to our understanding of the strength of maize genetic controls on rhizosphere microbial communities in varying soil backgrounds and their contribution to plant nitrogen uptake. The information gained can also be applied to breeding maize cultivars that interact with beneficial microorganisms in ways that improve the efficiency of N uptake, and reduce the need for surplus applications of fertilizer and contribute to agricultural sustainability. Thus, the research has the potential to improve farm profitability by reducing input costs, while also providing larger societal benefits in terms of ecosystem services such as improved water quality for recreation and drinking.

Impact: Too early to report impact.



2015-67019-23600

Measuring and Modeling Denitrification Hot spots on Agricultural Landscapes

Miki Hondzo, Department of Civil, Environmental, and Geo- Engineering, St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN

Liu Gang Logan, Department of Electrical and Computer Engineering, Micro and Nanotechnology Laboratory, University of Illinois at Urbana-Champaign, Urbana, IL

Jessica Kozarek, St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN

Michael Sadowsky, Department of Soil, Water and Climate, University of Minnesota, St. Paul, MN

Summary: Small areas of enhanced denitrification activity, termed denitrification hot spots, frequently account for a high percentage of denitrification activity of denitrifying bacteria. An overall hypothesis of this research is that the specific range and combination of physical, chemical, and microbiological conditions generate denitrification hot spots with enhanced nitrate removal and minimal nitrous oxide emission in waters and floodplains on the agricultural landscape. We propose a combination of fundamental microbiological and engineering research both under controlled outdoor conditions and in the field to quantify nitrate removal and nitrous oxide emission in agricultural surface waters. To investigate the proposed hypothesis, we will conduct following objectives:

- 1) Quantify physical, chemical, and microbiological variables that determine enhanced denitrification rates (hot spots) in the waters of Minnesota agricultural landscape;
- 2) Explore the applicability of recently developed MoboSens technology, a smartphone based sensor, for portable nitrate concentration measurements with processing algorithms for two-way mobile-cloud-mobile sensor data processing and exchange;
- 3) Design and implement a spatially distributed network for nitrate and nitrous oxide field measurements and document the spatial and temporal distributions of denitrification hot spots and nitrous oxide emissions;
- 4) Formulate prediction models of denitrification hot spots that can guide farmers on how to design, operate and maintain engineered surface water features to maximize nitrate removal and minimize nitrous oxide emission on the agricultural landscape.

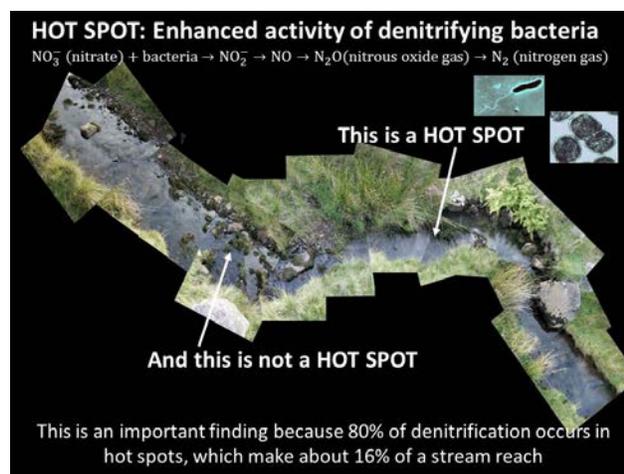


Figure 1. Graphical depiction of denitrification hot spots

Impact: We examined denitrification rates and the abundances of denitrifier genes and total bacteria at three sites in an agricultural watershed and in an experimental stream in Minnesota. Sampling was conducted along transects to determine how rates and abundances varied under different water regimes, with a gradient from always inundated (in-channel), to periodically inundated, to never inundated conditions. Results indicate a coupling between environmental parameters, gene abundances, and denitrification rates at the in-channel sites, and limited to no coupling in the periodically inundated and never inundated sites, respectively. Potential denitrification rates for the nutrient amended in-channel sites were significantly correlated ($\alpha = 0.05$) to five of six measured

denitrifying gene abundances, whereas the periodically inundated and never inundated sites were each only significantly correlated to the abundance of one denitrifying gene. Results suggest that abundances of denitrifier genes alone cannot be used as a proxy for denitrification rates, especially in studies with varying hydrologic regimes. A scaling analysis was conducted to formulate predictive functional relationships relating environmental parameters to denitrification rates for in-channel sites and the periodically and not inundated sites. This method could be applied to other geographic and climatic regions to predict the occurrence of denitrification hot spots. This finding has implications for agricultural remediation strategies such as two-stage ditches, where if high nitrate water could be delivered to the restored floodplain bench, nitrogen uptake would be increased.



2015-67019-23586

A New Landscape Based Approach to Optimize Riparian Zone Nitrogen and Phosphorus Management in Glaciated Settings

Philippe Vidon (PI) and Colin Beier (co-PI) – SUNY-ESF

Art Gold, Kelly Addy, Soni Pradhanang – University of Rhode Island

Richard Lowrance – USDA-ARS

Graduate Students: Yasi Hassanzadeh (SUNY-ESF) and Marzia Tamanna (URI)

Summary: Riparian zones are widely used best management practices to mitigate the impact of agriculture on water quality with respect to nitrogen (N) and phosphorus (P). However, their intense biogeochemistry also affects groundwater P concentration, and N₂O emission. Few studies nevertheless integrate N, P, and N₂O data across a range of landscape conditions to help understand the role of riparian zones with respect to NO₃⁻ and PO₄³⁻ fluxes and N₂O efflux. For this project, we will develop a database of riparian zone attributes in relation to N removal, P losses to streams, and N₂O emission using original data from 36 riparian sites in agricultural areas of the US Midwest and US Northeast where riparian zones are commonly used as best management practices. We will use multivariate statistical approaches to reduce data dimensionality, and build statistical models to predict riparian function. We will also improve the usability of the commonly used Riparian Ecosystem Management Model (REMM) by developing default model parameters for dominant riparian geomorphic types in these regions. We will then assess the accuracy of our model predictions at new sites using short field campaigns and compare REMM simulation results to our statistical models results, including during low and high precipitation periods as those are forecasted to become more common. (Program Area #A1401).

Impact: This work will benefit academics, local, state, and federal agencies involved in riparian ecosystem management and increase our fundamental understanding of the role riparian zones in N and P cycling in agroecosystems of the US and beyond. Analysis is ongoing.



2015-67019-23601

Improving Life-Cycle Nitrogen Use Efficiency and Environmental Performance of Corn Production through Improved Fertilizer Timing and Rate

Robert Anex, Biological Systems Engineering, University of Wisconsin-Madison

Peter Scharf, Division of Plant Sciences, University of Missouri

Summary: Loss of reactive nitrogen from agriculture has negative impacts on water and air quality, human health and biodiversity. Matching the timing and amount of N fertilizer with crop demand is the single most effective measure for reducing reactive N loss, but to make adoption choices farmers want to understand the variability in performance and the probability of undesirable outcomes. From a policy perspective, it is essential that we understand the full impacts of the fertilizer nitrogen life cycle, and what impacts to expect under a changing climate.

Project goals are to provide corn growers with a detailed evaluation of current and long-term costs and benefits of N timing options by evaluating location-specific impacts of timing and rate of nitrogen fertilization on corn yield, production cost, and reduction in reactive nitrogen loss across the US Corn Belt. We will also provide policymakers with an evaluation of the full life cycle benefits of reductions in reactive nitrogen loss achievable through policy incentives by quantifying the frequency and probability of achieving different levels of reduction in nitrogen loss through increasing use of in-season (i.e., later) N fertilization.

Impact: First year field trials showed better N availability with sensor-based sidedress did not translate into a yield benefit, however, both it did produce favorable life-cycle outcomes due to reduced nitrous oxide flux and nitrate loss in drainage water (and associated off-site N₂O flux reductions).

Preliminary regional simulations under future climate projections indicate that warmer, wetter spring conditions and hotter summer temperatures are likely to depress corn grain yield 2-6% and increase nitrate loss as much as 40% by 2050. In general, split N fertilization can reduce, but not reverse these impacts, although effectiveness depends on soil type, N rate and location. Split N may reduce N₂O emissions under future climate by around 20%.



2015-67019-23573

Reducing Nitrogen Losses from Agricultural Systems: Incorporating Biochar into Farmstead Management Strategies

R.A. Larson and T. Runge, Biological Systems Engineering, University of Wisconsin-Madison, Wisconsin

Summary: Managing nutrients at livestock facilities is complicated, particularly as there are many environmental impact factors affected by each individual management decision. This project aims to evaluate biochar additions to runoff treatment systems to reduce nitrate leaching, and to manure storage and digestion systems to reduce N emission losses, primarily ammonia, while maintaining the other environmental benefits these systems have been designed to achieve. The proposed research will measure subsurface nitrate concentrations from biochar amended filter strip plots, and evaluate various biochar amended manures during digestion, storage, and land application to assess N losses. This will allow researchers to make recommendations on amending these systems with biochar to limit N losses and increase N use efficiency.

Impact: Over the course of the first year, it was found that biochar can decrease ammonia losses from digested manure storage by up to 94%. In addition, modification of biochar can be used to increase nitrate uptake, additional data will be gained over the next year to apply this to runoff and runoff water treatment systems. Biochar added to anaerobic digestion systems were found to also significantly reduce the H₂S production in biogas, digester operators are already testing biochar additions to full scale systems in an attempt to reduce costs associated with biogas cleanup for use in a generator. Additional work is planned to further enhance the potential of biochar to reduce H₂S in biogas when added to the digester while also evaluating the impacts of that addition downstream.

N₂-fixing Cyanobacteria Harnessed for Biosolar Production of Nitrogen Fertilizer

Shengni Tian, Huillan Zhu, Ruanbao Zhou

Biology & Microbiology Department, South Dakota State University, SD57007

Summary: Nitrogen fertilizer is a primary driver in agricultural productivity, and thus impacts food, feed, fiber, and fuel production. Unfortunately, current fossil fuel-dependent ammonia production is energy intensive and damaging to the environment. Economic and eco-friendly methods to produce ammonia are urgently needed. Fortunately, N₂-fixation by cyanobacterial heterocysts offers such a unique opportunity. When combined nitrogen becomes limiting, the cyanobacterium *Anabaena* sp. PCC7120 responds by the formation of terminally differentiated, specialized nitrogen-fixing cells called heterocysts. However, mankind has largely ignored its potential application for this solar-powered, oxic N₂-fixation in heterocysts.

This seed project is focused on harnessing heterocysts, the specially differentiated nitrogen-fixing cells of *Anabaena*, for efficient biosolar production of ammonia. The specific objectives for this seed project are:

1. Engineering *Anabaena* to produce and secrete ammonia (Fig. 1)
2. Creating a desired mutant with higher frequency of functional heterocysts;
3. Genetic shunting *Anabaena*'s nitrogen flow from producing nitrogen-enriched storage polymers to production of excreted ammonia.

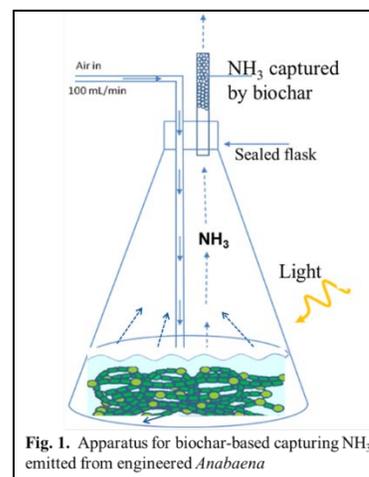


Fig. 1. Apparatus for biochar-based capturing NH₃ emitted from engineered *Anabaena*

Impact: Today's unstable supplies and volatile prices of fossil fuels have dramatically increased the price of ammonia fertilizer produced by the Haber-Bosch process, which is both energy intensive and environmental degradation. This seed project is seeking for a sustainable, eco-friendly method for production of ammonia. The long-term goal of this project is to use synthetic biology to harness the N₂-fixing cyanobacteria for efficient, sustainable production of ammonia in oxygenic photosynthetic cells, eventually transforming this solar-powered, oxic N₂-fixing capability into crops.

New Awardees



2016-67020-25275

Enhancement of Nitrogen Usage Efficiency and Mitigation of Nitrous Oxide Emission in Agricultural Fields

Gang Chen and Yuch-Ping Hsieh, Department of Civil and Environmental Engineering and Center for Water and Air Quality, Florida A&M University, Florida

Summary: Expanded global population and the consequent need for more food production have inevitably led to both an increase in the usage of synthetic fertilizers and a wider application of animal waste in agricultural soils. Most importantly, the applications of such nitrogen-based fertilizers and animal waste in many areas are excessive, with large proportions of the added nitrogen providing no benefit to crop yield, but elevated nitrogen loss (i.e., leaching or conversion to N_2) and environmental impact (i.e., N_2O emission). In this research, a combination of laboratory and field approaches will be adopted to evaluate biochar, hydrogel, nitrification inhibitor and slow-release fertilizer applications in increasing the efficiency of nitrogen assimilation. This project is designed to (1) improve the nitrogen utilization efficiency of nitrogen fertilizers and animal waste in agricultural fields, while minimizing nitrogen loss and environmental impact and (2) increase the understanding of nitrogen cycling in agricultural processes.

The goal of this project is to potentially provide long-range improvement in maintaining the sustainability of U.S. agriculture and food systems. Our objective of this project is to evaluate various approaches (i.e., biochar, hydrogel, nitrification inhibitor and slow-release fertilizer applications) in increasing the efficiency of nitrogen assimilation as measured by nutrient usage efficiency criteria in the production value chain and by improvement in impaired natural resources. We will develop prediction tools to accurately estimate nitrogen assimilation and loss from agricultural soils as well as environmental impact under different nitrogen conservation conditions.

Impact: This is the first year of this project (06/15/2016-06/14/2020).

Conference: Extreme Climate Event Impacts on Aquatic Biogeochemical Cycles And Fluxes

Inamdar, S. P.

Summary: Climate change projections indicate increasing magnitude and intensity of tropical storms, hurricanes, heat waves, and droughts. The events could have significant consequences for aquatic ecosystems with potential for large changes in ecosystem processes, response and functions. Such changes could also impair the important services that these ecosystems provide and thus affect the well-being of our environment and society. We propose a much-needed Chapman conference that will focus on: (a) water-driven exports of C, N, and P in particulate, dissolved, and gaseous forms from terrestrial to aquatic ecosystems; (b) changes in biogeochemical cycles of C, N, and P in aquatic ecosystems following extreme climate events; and (c) changes in aquatic ecosystem functions and services as a result of extreme events. Specific questions will be addressed across six sessions which will include invited talks from leading scientists from various disciplines. The meeting will occur over five days and will include oral presentations and posters. One day will be devoted to a field trip to study first-hand the impact and recovery of watersheds and aquatic ecosystems from hurricane damage. Session leaders will foster discussion among participants and synthesize the key lessons and advances in science from the meeting. We anticipate multiple review/opinion/perspective papers from this conference that will be submitted to peer-reviewed and high-impact journals.

Impact: Too early to report impact.



2016-68007-25066

Sustaining Agriculture through Adaptive Management to Preserve the Ogallala Aquifer under a Changing Climate

Meagan Schipanski, Department of Soil and Crop Sciences, Colorado State University, Colorado

Reagan Waskom, Colorado Water Institute, Colorado State University, Colorado

Brent Auvermann, Department of Agricultural Engineering, Texas A&M University, Texas

Prasanna Gowda, Forage and Livestock Production Unity, USDA-ARS, Oklahoma

Bridget Guerrero, Department of Agricultural Business, West Texas A&M University, Texas

Eugene Kelly, Department of Soil and Crop Sciences, Colorado State University, Colorado

Mark Marsalis, Department of Plant and Environmental Sciences, New Mexico State University,
New Mexico

Chittaranjan Ray, Nebraska Water Center, University of Nebraska, Lincoln, Nebraska

Charles Rice, Department of Agronomy, Kansas State University, Kansas

Kevin Wagner, Texas Water Resources Institute, Texas A&M University, Texas

Jason Warren, Department of Plant and Soil Sciences, Oklahoma State University, Oklahoma

Charles West, Department of Plant and Soil Science, Texas Tech University, Texas

Summary: The Ogallala Aquifer, one of the largest freshwater aquifers in the world, supports 30% of U.S. crop and animal production, increases agricultural production by more than \$12 billion annually, and impacts global food supplies. However, much of the Ogallala is rapidly declining and climate change will only compound this challenge. *Our long-term goal is to optimize use of groundwater in the Ogallala Aquifer Region (OAR) to sustain food production systems, rural communities and ecosystem services.* Achieving this goal requires integrated management to improve use of the right water (blue and green) at the right time in the right place across the OAR. Our specific objectives are to:

1. Integrate hydrologic, crop, soil, and climate models and databases to provide baseline data for evaluating management and policy scenarios.
2. Develop and identify the best irrigation technologies, cropping system management practices, and decision support tools to improve water use efficiency.
3. Analyze current social, policy, and economic frameworks in the OAR and identify incentives and policies to increase the adoption of adaptive strategies.
4. Enable the adoption of tools and recommended strategies for improved water use through integrated and effective communication among the project team and transfer with stakeholders.

Approach

Our approach utilizes a network of six sites that span the climatic, hydrogeologic, and management gradients across the OAR (Fig. 1). Site locations include agricultural research and extension centers in: 1) North Platte, NE; 2) Akron, CO; 3) Tribune and Garden City, KS; 4) Goodwell, OK; 5) Clovis, NM; and 6) Lubbock, TX. These sites already serve as knowledge ‘hubs’ in their region and have established producer and stakeholder networks. Each of our specific research and extension activities will include a minimum of 3 hub sites to ensure an integrated, aquifer-wide approach.

Research approach: We are identifying a suite of management and policy scenarios through input from our team, advisory board, and producers across the OAR. Scenarios will be used with validated models to simulate management systems, groundwater hydrology, and policy options. Research activities will also include data synthesis to identify best management practices and field research on cutting edge irrigation technologies. Research findings will inform the development of decision support tools, extension activities, and extension products.

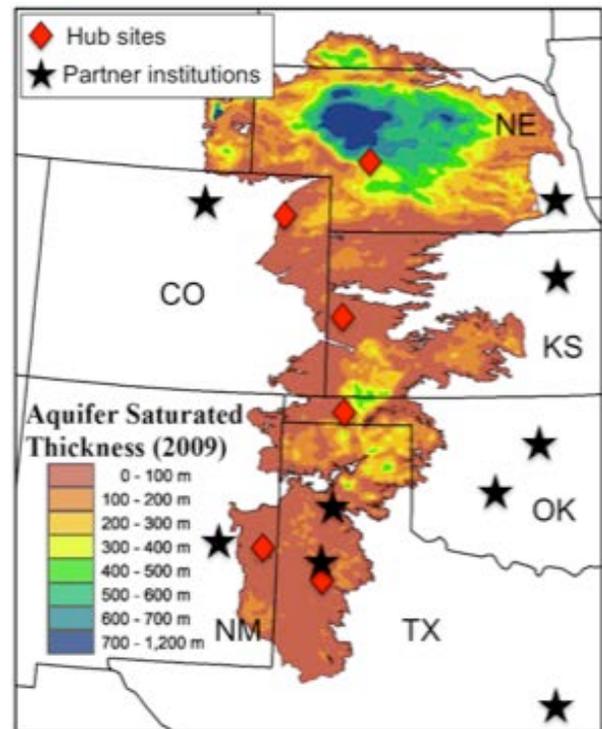
Extension approach: We are working in close collaboration with our advisory board that includes producers, policy makers, and local groundwater management district managers. We will employ high impact methods such as hands-on workshops and on-farm demonstrations to educate users on new decision support tools and irrigation methods. Producers' experiences will be tapped to strengthen tools and the credibility of extension information.

Impact:

This is a newly funded project. Our expected outcomes are:

Major Research Outcomes: 1) Improved understanding of climate change impacts on water resources and the identification of emerging technologies and management practices that could extend the life of the aquifer; 2) Science-based road map for policy makers and stakeholders to evaluate groundwater policy for balancing water use and the sustainability of rural communities; and 3) Synthesized research databases made accessible to research and extension communities.

Major Extension and Outreach Outcomes: 1) Extended life of the aquifer through the adoption of water-efficient irrigation strategies and crop management technologies; 2) Development of policies that reduce water use and sustain agricultural economies across a diverse set of groundwater districts; 3) Formation of new communication networks for integrated management across groundwater districts through coordinated outreach across the OAR; 4) Integration of private and public sectors in delivering objective, research-based recommendations and commercial products; and 5) Informed non-farm consumers about the role of water in food production.



2016-67026-25067

Understanding The Hydrologic and Socioeconomic Impacts of Water Use And Resource Allocation Under Different Climate and Policy Scenarios

Maneta, MP¹, Gardner, WP¹, Jencso, KG², Kimball, J³, Cobourn, K⁴, Ewing, S⁵, Maxwell, B⁵¹Geosciences, University of Montana, Missoula, MT²Forestry and Conservation, University of Montana, Misoula, MT³Numerical Terradynamic Simulation Group, University of Montana, Missoula, MT⁴Forest Resoruces and Envir. Conservation, Virginia Tech, Blacksburg, VA⁵Land Resources and Environ. Sciences, Montana State University, Bozeman, MT

Summary: The management of water resources among competing uses presents a complex technical and policy challenge that is amplified by economic and population growth and by climate change. Across the western U.S., future water management options will shift from developing new water supplies to better operating existing ones. This requires new operational water management tools that integrate models with new earth observation technologies. Integrated hydro-economic models capable of simulating the hydrologic system in irrigated and non-irrigated regions and the response of water users, especially farmers, to hydrologic constraints and economic and policy incentives, provide a framework to understand the biophysical and socioeconomic implications of changing water availability. This project proposes an innovative approach that blends satellite-based observations of agricultural activity (land allocation, crop rotations, yields, evapotranspiration), hydroclimatologic information, and spatially explicit, hydro-economic models using advanced data assimilation methods. The resulting integrated model will enable scientists, managers, and policy-makers to assess the full impact of different climate, economic and policy scenarios on agricultural water use, and on the hydrologic and socioeconomic conditions of agricultural regions To achieve these overarching goals the project has the following specific objectives: 1) use satellite-based measures of agricultural activity (crop acreage, productivity) to condition spatially-explicit hydro-economic models, 2) use the calibrated models to simulate and evaluate impact of droughts on agricultural water use, 3) apply calibrated models to determine how farms of different size and location react to a wide range of climatological conditions under current policy, 4) in collaboration with partnering state water management agencies we identify the hydrologic and socioeconomic impacts of a suite of climate and water policy scenarios. To take advantage of the high temporal frequency of remote sensing information we will leverage algorithmic enhancements that permit to recursively assimilate remote sensing information into agro-economic models capable of capturing farmer's economic behavior (e.g. how the allocate land and water when facing limited access to water). Our novel technology self-calibrates against satellite-based information and generates predictions of resource allocation in terms of probability distributions that reflect the quality of the calibration and the uncertainty in the observations of agricultural activity (Figure 3a,b). Because the model self-calibrates to reflect a blend of current and past conditions, it can be used operationally to predict how farmers are likely to reallocate resources under various scenarios of crop prices and costs of agricultural inputs, or under different levels of water and land restrictions due to environmental or policy factors (Figure 3b)

Impact: This project will develop a long-term cooperation platform between water resources professionals in state government agencies and University researchers in Montana. Permanent collaboration between university researchers and practitioners in state agencies will ensure that resource management in Montana and water policy recommendations to guide investments and water related legislation is conducted with the best information and tools available. Specifically, we are partnering with the Water Resources Bureau of the Montana Department of Water Resources to

develop cost-effective tools that will help them understand the impact of exogenous drivers (climate, markets, policy) on water use and agricultural productivity in the state of Montana. Once vetted, these tools will be integrated in their operational decision-making.

Additionally, this project has also important technical and scientific impact through the development of new technologies that capitalize on the wealth of operational remote sensing data products and algorithms that are becoming available at little to no cost. These products are currently underutilized for decision making. This includes new and long-running earth observation missions that permit to observe, at unprecedented spatial and temporal scales, how farmers allocate water and land when confronted with water shortages. This will lead to scientific impact through improved understanding of the options that farms of different size and different locations prioritize to adapt to new environmental, market or policy conditions, what incentives they are sensitive to, and the hydrologic and economic impacts of their decision.

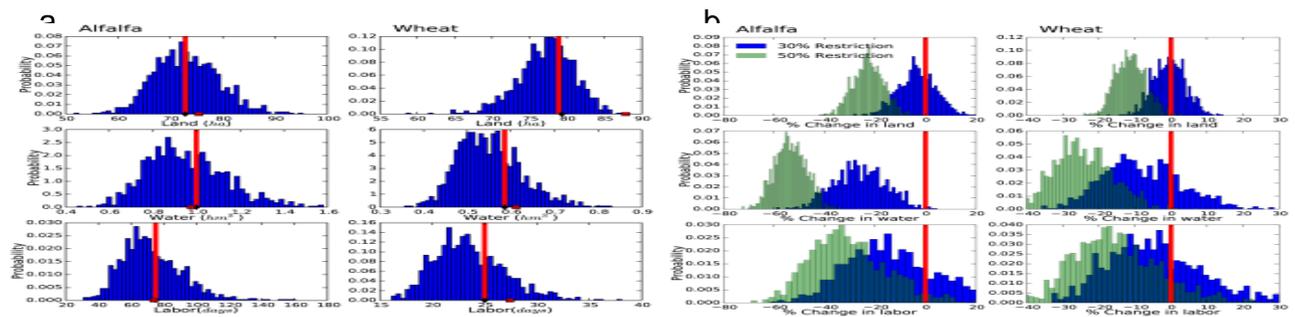


Figure 4.- a) Probability distribution of simulated allocation of land (top row), water (middle row) and labor (bottom row) to alfalfa and wheat (columns 1 and 2, respectively) for a farm in California. Vertical red line indicates actual observed allocation; b) Probability distribution of reallocation of land (top row), water (middle row), and labor (bottom row) when access to water is reduced by 30% (blue histogram) and 50% (green histogram). Reallocation is expressed as a percent of baseline values (0% change indicated with vertical red line). Adapted from (Maneta and Howitt, 2014)

We also foresee impact in the following technical fields:

Remote sensing - This project will improve existing global operational satellite remote sensing algorithms and data products for effective assessment and monitoring of vegetation dynamics and underlying environmental drivers for agricultural regions. It will also generate advances in methods to retrieve crop yield and water use information over heterogeneous agricultural landscapes.

Applied economics - This project will generate new methods that permit a rigorous analysis of coupled agronomic and hydroclimatic systems that can take into account the inherent uncertainties in climate and hydrologic predictions.

Hydrology and earth system modeling - This project will provide methods to investigate the impact that human choices have on our predictions of the impacts of climate change and will quantify the error incurred by our models by not taking into account private adaptation.



Municipal Wastewater Application to Forests: Participatory Science to Understand Human Exposure and Risks to Contaminants of Concern.

Nichols, E.; Shea, DA.; Rashash, DI, M.; Delborne, JA.

Summary: Our project goals are to characterize chemical contaminants of concern (COCs) and their human health risks for land-applied, secondary municipal wastewater onto forested lands and to better understand community values and perceptions of alternative wastewater reuse to agricultural lands. The proposed work will identify human health COCs for secondary, municipal wastewater that is currently land-applied to mature forests but could be land-applied to other agricultural lands. The study site is a 7,200 acre managed forest irrigated with secondary-treated municipal wastewater at agronomic irrigation rates of 50 inches per acre per year in Jacksonville, North Carolina. Population growth and non-existent land-expansion opportunities within the city are driving municipal discussions for alternative means to expand the land application system (LAS) capacity in rural Onslow County. Because municipal wastewater LAS are an undefined source of COC entry into soils and waters, non-targeted screening and targeted screening will provide characterization of chemicals in the wastewater for hazard identification. Field measurements in the watershed will define wastewater composition in groundwater and surface waters around the facility and off-site of the facility. These data will be used to estimate risk to humans from exposure to groundwater or surface waters. Project activities will be developed with a community Participatory Leadership Group (PLG). Findings will be shared with this group as well as a Community Involvement Group (CIG) to understand public perceptions of current, non-traditional wastewater use and risks, public values and perceptions for alternative water reuse in the future, and appropriate strategies to communicate these findings to the broader public. Project findings will be integrated as modules into graduate and undergraduate capstone courses. Requested funds will support community engagement training for a post-doctoral researcher and undergraduate research internships as shared appointments between the USEPA and NC State.

Impact: Too early to report impact.

2016-69007-25084

Addressing Community Perceptions and Concerns on Wastewater Use for Agriculture in Puerto Rico

María Calixta Ortiz, PhD

School of Environmental Affairs, Universidad Metropolitana, Puerto Rico

Summary:

Problem. Although Puerto Rico’s water resources are considered sufficient, in 2015 the agricultural sector, and the population as a whole, faced serious challenges as the island went through a severe-to-extreme drought, mainly in the eastern part of the Island (Figure 1). The population was under water rationing during four (4) months, and the agricultural sector lost nearly \$12 million due to heat stress from high temperatures and desiccation from lack of water, thus decreasing crop yields, increasing mortality in both crops and livestock, and increases in costs for animal feed, irrigation water, and energy. The US Department of Agriculture declared a Drought Disaster in Puerto Rico on July 15, 2015. On the other hand, treated wastewater generation on the island is estimated about 228 millions of gallons per day, but mostly downloaded to the ocean, streams and rivers. This volume of water is a significant resource that could be reused for agricultural irrigation and aquifer recharge to minimize saline intrusion. Currently, the State Wastewater Reuse Plan only includes golf course irrigation.

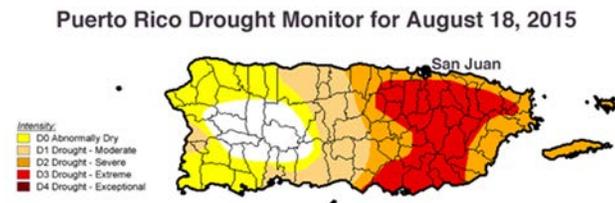


Figure 1. *Puerto Rico drought map during August 2015*

Goal and objectives: The project was developed around a Community-Engaged Research framework (Figure 2) and proposed two main objectives: 1) to collect baseline information on public perceptions on wastewater reuse for agriculture, and 2) to inform professionals and the general public on wastewater reuse guidelines and the possibilities of projects in Puerto Rico.



Method: To meet the first objective, we conducted a cross-sectional study on community risk perceptions and concerns among the audience attending the conference on Wastewater Reuse for Agriculture on June 1, 2016. The protocol followed for the poll among a convenience sample was approved by the Institutional Review Board as a “pre-treatment” before any activity or learning process (conference). The instrument included multiple choice and three Likert-scale questions grouped by previous awareness on wastewater concepts; perceptions on wastewater reuse for agriculture, confidence in local and federal agencies, willingness to support wastewater reuse, and sociodemographic profile. To meet the second objective, we launched a one-day conference



Figure 3. Participants in the



Figure 4. Hearing community

to transfer knowledge from state and federal agencies on *Food & Agricultural Guidelines and Challenges in Wastewater Reuse*; a plenary to discuss *Key Elements for Public Support on the Reuse of Wastewater: Case of San Diego*; and a second panel of local experts to discuss *Puerto Rico Realities of Wastewater Reuse for Agro-industrial Projects*, such as reinjection of aquifers; irrigation of pastures for swine or cattle; irrigation of golf courses, as well as their lessons learned. Finally, we had an open session to engage the community to share their questions, concerns and recommendations.

Impact: This was the first conference on wastewater reuse held on the island and the first research project to attempt to establish a scientific baseline of Hispanic community perceptions on this topic in Puerto Rico. The conference attendance included representation from 54% of the municipalities of the island, mainly (51%) from the metropolitan area. Total attendance at the conference was 177, with 84% voluntary participation in the poll. The sample was greater represented by male gender (F=45%; M=55%) and highly educated (master/doctorate) as compared to the general population; mainly composed by engineers, planners, agronomists, and university faculties. Participants from the private sector (60%) was higher than from public sector or governmental agencies (40%). Most of the poll responders perceived they are something updated in wastewater treatment. It was significant that female gender perceived that are least informed than male gender ($p < 0.05$). Participants perceived they were more familiar with terms such as “drinking water” and “sewage system”, and less familiar with the term “gray water.” But this latter term was significantly associated ($p < .05$) with the private sector who perceived it knew the meaning well. Responders were highly agreed to support wastewater reuse for indirect contact uses (e.g. irrigation of forests, flowers, grass, golf courses), rather than irrigation for high contact uses fruit tress (e.g. avocado and citrus), even for car wash activities. The conference generated a lot of interest and had significant media coverage on the local radio, TV stations and newspapers. Additionally, a well-known broadcaster in Puerto Rico filmed the activities at the conference and interviewed stakeholders, producing an impacting film available on the Internet. Stakeholders are empowered with accurate information that can strongly influence the support for the use of treated wastewater in Puerto Rico. Thus, the most level educated group and those in the private sector need to be the early adopters of these strategies on wastewater reuse and disseminate the information to other groups.



2016-67019-25281

Rhizosphere Priming Effects on Legacy Organic Phosphorus (Po) In Winter Wheat/Corn Rotation Systems

McNear, D. H.

Summary: The primary goals of this proposal are to quantify how much of the fixed organic P (Po) in the roots of a previous cover crop (e.g. winter wheat (WW)) is available to successive crops in reduced or no-till systems, uncover the mechanisms involved in this process, and ultimately develop management practices to maximize Po utilization from these sources. An interdisciplinary approach, combining a broad array of scientific techniques spanning multiple scales, will be used to screen historic WW genotypes for plant characteristics favorable for soil exploration and P acquisition that enhance the plants ability to immobilize inorganic P (Pi) in its roots as P(o), and then elucidate the extent and mechanisms used by successive target crops (e.g. corn) to access the root Po reservoir.?

Impact: Too early to report impact.



2016-67019-25283

Can Induced Rhizosphere Hydraulic-Redistribution Be Engineered To Enhance Macronutrient Uptake Efficiency?

McNear, D. H.

Summary: The primary goals of this proposal are to quantify how much of the fixed organic P (Po) in the roots of a previous cover crop (e.g. winter wheat (WW)) is available to successive crops in reduced or no-till systems, uncover the mechanisms involved in this process, and ultimately develop management practices to maximize Po utilization from these sources. An interdisciplinary approach, combining a broad array of scientific techniques spanning multiple scales, will be used to screen historic WW genotypes for plant characteristics favorable for soil exploration and P acquisition that enhance the plants ability to immobilize inorganic P (Pi) in its roots as P(o), and then elucidate the extent and mechanisms used by successive target crops (e.g. corn) to access the root Po reservoir.?

Impact: Too early to report impact.

2016-67019-25277

Combining Electrical Resistivity Imaging and Conservative Tracers to Characterize and Model Subsurface Phosphorus Losses from Drained Soils

Shober, A.

Summary: Maintaining nutrient balance is critical to improving and sustaining US agriculture. From a phosphorus (P) management perspective, this means using P more efficiently on the farm to promote crop growth while simultaneously preventing runoff P losses that further exacerbate freshwater and coastal eutrophication. Controlling subsurface P losses from artificially drained agroecosystems is a complex problem affecting the sustainability of agricultural production in the US. Adding to the complexity of this problem is the fact that subsurface P losses are often driven by historical or "legacy" soil P in areas of intensive animal production with a long-term history of manure applications at rates exceeding crop P removal. This issue continues to challenge nutrient management efforts (including P loss risk assessment) on the Delmarva Peninsula, and nationally. The science supporting P risk assessment tools has generally focused on managing surface hydrologic flow pathways at the expense of subsurface flows, which until recently, have been assumed to be less important, and therefore, largely ignored. This project seeks to improve P management in ditch-drained agroecosystems by combining time-lapse near-surface geophysics with conservative tracers to characterize subsurface hydrologic flow pathways linking legacy soil P sources with surface waters. The research will take place on Maryland's Lower Eastern Shore, an intensely ditch-drained region of the Delmarva Peninsula that exemplifies the challenges of minimizing runoff P losses in areas where subsurface flows drive P transport. We will: (1) pair conservative salt tracers with time-lapse electrical resistivity imaging (ERI) to examine the spatial extent, structure and connectivity of subsurface hydrologic flow paths tied to P loss; (2) use stable water isotopes and conservative tracers in simple mixing models to determine the proportional contribution of subsurface flow to ditch discharge; and (3) leverage results from the geophysical investigations and isotope analysis to improve the representation of subsurface flow pathways in P risk assessment tools and watershed simulation models. The objective is to gain a better understanding of hydrologic, soil, and management factors that determine the timing, extent, and duration of shallow subsurface hydrologic connectivity in ditch-drained systems with P-enriched soils. Our long-term goal is to provide better information on subsurface hydrologic connectivity in artificially-drained landscapes that will enable refinements to P risk assessment tools and an improved representation of subsurface P transfers in watershed simulation models.

Impact: Too early to report impact.



2016-67019-25278

Translating on-Farm Research into Farmer-Relevant Nutrient Risk Assessments Using Advanced Hierarchical Methods

Lory, J.

Summary: This is a proposal to dramatically expand the predictive value of data collected in on-farm experiments by applying the newest methods of data analysis based on spatial statistics, hierarchical modeling and Bayesian analysis. Ultimately, a new analytical approach will increase the value of strip trials to farmers and allow for a more effective adaptive management process for improving nitrogen and phosphorus management. On-farm strip trials are adaptive management tools that allow farmers to evaluate new and innovative practices side-by-side with current practices using on-farm equipment. Almost all strip trials have been analyzed using classical statistical tools, discarding information about variability within strips. The resulting analyses frequently succumb to weaknesses of classical statistical designs, including finding no difference where differences exist. This study will facilitate adoption of an assessment strategy that will transform the utility of these studies to improve management of nitrogen and phosphorus fertilizers. A unique benefit of the hierarchical Bayesian statistics proposed here is the ability to estimate conditional probabilities of unobserved situations or future events based on observed data. This is fundamentally different information than provided by a classical statistics analysis; Bayesian analysis instead estimates risk, in the form of probabilities of potential outcomes, allowing farmers to assess risk when considering changes in management. This project will develop the research and extension infrastructure needed to translate a promising approach into a viable option for scientists working with farmers to increase the value of nitrogen and phosphorus on-farm strip trials.

Impact: Too early to report impact.



2016-68007-25064

CONSERVE: A Center of Excellence at the Nexus of Sustainable Water Reuse, Food and Health

Amy R. Sapkota, Maryland Institute for Applied Environmental Health,
University of Maryland School of Public Health, Maryland

Summary: Climate variability is placing severe stress on high-quality agricultural irrigation sources such as groundwater. As a result, water reuse and the exploration of nontraditional irrigation water sources (e.g., reclaimed water) have become national priorities for agricultural water security and the sustainable production of our food supply. At the same time, the recent Food Safety Modernization Act is shifting the focus of food safety from responding to foodborne contamination to preventing it. This places great responsibility on agricultural producers, who must meet stricter guidelines for the quality of irrigation water used on food crops. Hence, at this critical juncture in food production, sustainable on-farm solutions are needed to enable agricultural producers to conserve groundwater through the safe use of emerging nontraditional water sources.

We are addressing this need through CONSERVE (**CO**ordinating **N**ontraditional **S**ustainable water **U**se in **V**ariable climat**E**s): A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health. CONSERVE **research, extension and education** activities are being implemented by a leading team of bioscientists, engineers, economists, social-behavioral scientists, law and policy experts, extension specialists, educational media developers and computer scientists. We extend our findings to stakeholders, including farmers, communities, educators, students, and federal, state, and local governments through **outreach and engagement**. CONSERVE is focusing on two key regions, the Mid-Atlantic and Southwest, thereby highlighting two diverse climates that are in different stages of need for nontraditional irrigation. Specifically, the Mid-Atlantic is currently not experiencing serious water shortages, and the integration of new on-farm water treatment technologies at this time represents a proactive approach to climate change. In contrast, the Southwest region is experiencing severe water shortage crises, and thereby represents a need for reactive solutions to climate change. *Through our innovative efforts, our mission is to facilitate the adoption of transformative on-farm solutions that enable the safe use of nontraditional irrigation water on food crops and effectively reduce the nation's agricultural water challenges that are exacerbated by climate change.*

Our CONSERVE activities address the following five integral objectives:

Objective 1, Nontraditional Irrigation Water Sources: Evaluate the availability (quantity and quality) of nontraditional irrigation water sources that can be used to conserve groundwater (*Research*).

Objective 2, Societal Context: Identify the social, behavioral, economic and regulatory factors that impact the current use of nontraditional irrigation water sources and might impact the integration of new on-farm water treatment technologies developed to treat these sources (*Research*).

Objective 3, Next-Generation On-farm Technologies: Develop, implement and evaluate the effectiveness and sustainability of next-generation on-farm water treatment technologies that can improve the chemical, microbial and physical quality of nontraditional irrigation water sources and irrigated food crops (*Research*).

Objective 4, Innovative Extension and Outreach: Integrate the knowledge generated through Objectives 1, 2 and 3 into preeminent extension and outreach programs for agricultural and nonagricultural communities (*Extension*).

Objective 5, Experiential Education: Translate the knowledge generated through Objectives 1, 2 and 3 into high-quality, experiential educational programs that will teach, train, and inspire the next generation of leaders engaged in sustainable water reuse on food crops (*Education*).

Impact: CONSERVE was recently initiated in March 2016. In our first quarter, we have made excellent progress regarding our research, extension and education goals. For example, we have initiated field sampling and water quality testing at our Mid-Atlantic field sites (Objective 1), as well as research on consumer acceptance of produce grown with reused water and research into the laws, regulations and policies relating to water reuse (Objective 2). We have also initiated greenhouse studies pertaining to the water treatment technologies that we will implement through CONSERVE (Objective 3). Finally, we are preparing for our initial extension needs assessment (Objective 4) and are in the process of launching our CONSERVE Scholars program for undergraduate and graduate students (Objective 5). Though still in the early stages, we anticipate that the CONSERVE transdisciplinary research, extension and education activities will shift agricultural water usage paradigms towards an effective sustainable system that conserves groundwater through the successful adoption of nontraditional irrigation water sources, with the following outcomes:

Change in Knowledge:

Advanced understanding of nontraditional irrigation water sources through the generation of the most comprehensive chemical, microbial, physical and geographic characterization of these sources that has ever been carried out in the U.S.

Increased awareness and understanding of opportunities and barriers to nontraditional water use with regard to: 1) motivations of consumer behavior concerning foods produced with nontraditional irrigation water; 2) feasibility, costs, and benefits of using these water sources; 3) feasible approaches for implementing nontraditional irrigation under existing laws, regulations and policies; and 4) achievable opportunities for shaping future laws, regulations and policies.

Advanced knowledge among food crop growers, agricultural service providers, extension faculty, and non-agricultural communities that will facilitate the implementation of nontraditional irrigation water sources and the subsequent conservation of groundwater.

Change in Action:

The successful adoption of irrigation and process water treatment systems on working food crop farms that cost-effectively and sustainably reduce and manage risks due to contaminants in nontraditional irrigation water.

Increased acceptance and understanding of nontraditional water sources and the complex issues surrounding them among a diverse group of undergraduate and graduate students, K-12 teachers and 4-H groups--leading to the eventual transfer of this comprehension to the future agricultural workforce.



2016-68007-25076

The 3rd International Conference on Hydropedology: Promoting Breakthrough Collaborations among Agro-,Hydro-,Geo-,and Bio-Sciences

Lin, H.

Summary: The International Union of Soil Sciences' Working Group on Hydropedology proposes to organize the 3rd International Conference on Hydropedology to be held on August 16-19, 2016 at Beijing Normal University in Beijing, China. As a promising interdisciplinary science emerged in recent years, hydropedology offers a renewed perspective and an integrated approach to understanding interactive soil and water processes and their properties in various ecosystems. Funds are requested to provide travel supports to young scientists (students, postdocs, and junior faculty) from the United States to attend this once-in-every-four-years conference. This will stimulate young people to pursue and advance this interdisciplinary science and its synergistic collaborations across scientific disciplines, including soil science, hydrology, ecology, agronomy, forestry, geology, biogeochemistry, and others. In particular, various sub-disciplines of soil science and hydrology will be linked across spatial and temporal scales to significantly advance our understanding and management of natural resources and the environment, including water for agriculture. The specific objectives of this conference are: 1) to take stock and analyze what has been accomplished since the 2nd conference held in 2012, to identify remaining knowledge gaps and key scientific and management issues, and to charter a roadmap for international and interdisciplinary collaborations for the next 4 to 10 years; and 2) to promote exciting breakthrough collaborations among soil science, hydrology, ecology, agronomy, forestry, geology, and other related agro-, bio-, and geo-sciences through the holistic studies of the Earth's Critical Zone (from the top of vegetation down to the bottom of aquifer, upon which nearly every life-sustaining resource and all human activities depend). We propose a 4-day meeting that will include invited and volunteer oral and poster presentations, plus a field trip. A wide range of cutting-edge issues from theories to practices are proposed, with eight main targeted sessions. Expected deliverables include a proceedings, a summary report, a dedicated web site, a book, and two special issues of scientific journals (Ecosystems and Vadose Zone Journal). We expect lasting impacts from this conference that will foster global sustainability as well as contributions to water in agriculture.

Impact: Too early to report impact.

2016-69007-25149

Sustainable use of Dairy Farm Anaerobic Digestate: from Environmental Pollutant to New Source of Water, Energy, and Nutrients

Sharon L. Walker¹, David Jassby¹, Jefferson William Tester², Largus Angenent³

¹Dept. of Chemical and Environmental Engineering, Univ. of California, Riverside CA)

²Dept. of Chemical and Biomolecular Engineering, Cornell Univ. (NY)

³Dept. of Biological and Environmental Engineering, Cornell Univ. (NY)

Summary: It is estimated that the United States produces ~180-190 million cubic meters/year of anaerobic digestate from liquid dairy waste effluent. This project investigates a new process integration of two technologies – hydrothermal liquefaction (HTL) and membrane distillation (MD) in a unique and efficient configuration for extracting energy, nutrients, and water for agriculture from anaerobic digestate.

HTL is an emerging technology for energy recovery which also produces a stream of aqueous phase by-product and additional heat. MD is a process by which separation of the residual organic matter and nutrients from water may be optimized using the waste exchanged heat. Experiments using these processes will establish the feasibility of the technologies and inform future pilot scale development and ongoing life cycle analysis efforts.

Our main goal was to integrate HTL and MD treatment processes to maximize nutrient recovery, in addition to the recovery of purified water and renewable energy products.

This project had the following educational and research objectives:

1. Educational Objective: Training of students at UCR and Cornell at the food-energy-water nexus, an emerging, critical area to the nation.
2. Research Objective: Test the feasibility of hydrothermal processing and membrane distillation for the recovery of energy, water, and nutrients.

Impact: The following knowledge and impact to stakeholders has been achieved:

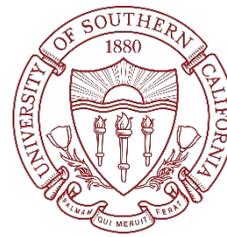
- Characterization of digestate from dairy manure and yogurt whey clearly indicates the need for post-treatment. Moreover, biochemical methane potential tests verify that the highest addition of yogurt whey to dairy manure may enhance the methane production but slow down the process, and thus might not be practical.
- The ability of a small scale HTL reactor to reduce COD from the liquid effluent of AD was confirmed.
- Temperature was found significant in oil production under subcritical conditions.
- COD removal from the aqueous phase is also affected by temperature, with the lowest COD removal of 10–20% at 200–225°C, moderate levels of 50–60% for 250–300°C and highest levels of 80–90% for 325–350°C.
- At the optimal thermal conditions, 67% of the organic carbon from a model feedstock was converted to oil, 20% as soluble carbon in the aqueous phase (mostly sugars and short chain

carboxylic acids) and there was a small amount of gas production (no solids were produced for this feedstock).

- HTL produces bio-oil with a higher high heating value (HHV) of 35–40 MJ/kg compared to the HHV of the feedstock (20–25 MJ/kg).
- Experiments with dairy manure digestate as a feedstock for HTL demonstrated the potential of both acid and base catalysts to improve the oil production.
- These findings suggest that for manure, acidic conditions during HTL are more advantageous than and alkali conditions, in terms of minimizing char and gas production.
- Ample residual heat was available for the MD process

The following new concepts and technologies were achieved from this work:

- Biomass conversion into biocrude oil and an aqueous by-product under elevated temperature (200–350°C) and pressure (2–20 MPa) was demonstrated. The optimal thermal condition was identified as 300°C and 60 minutes.
- This reaction temperature allows the recovery of heat from the HTL process — ~1200kJ/ kg water.
- This heat can be therefore integrated with downstream MD process to recover clean water and nutrients.
- The positive effect of acidity on HTL performance indicates that the use of acidic co-substrates such as yogurt and cheese whey may favor oil production from manure with relative low yields of char and gas.



2016-68007-25044

Mitigating Human Health Risks and Enhancing Water Sustainability: Evaluating Antibiotic Resistance in Anaerobic Wastewater Treatment

Adam L. Smith, Civil and Environmental Engineering, University of Southern California, CA
Lauren B. Stadler, Civil and Environmental Engineering, Rice University, TX

Summary: Reclaimed water from wastewater can be used in agriculture to reduce our stress on traditional water supplies. Anaerobic membrane bioreactors (AnMBR) are an emerging technology for wastewater treatment that recover energy in the form of biogas and produce reuse water rich in nutrients for irrigation. However, antibiotic resistance is a potential human health risk of critical concern in the use of reclaimed water and the fate of antibiotics, antibiotic resistant bacteria (ARB), and antibiotic resistance genes (ARGs) is poorly understood in agricultural reuse and has not yet been studied in AnMBRs. This project is evaluating these concerns by studying lab-scale water reuse systems and devising strategies to minimize potential human health risks. Stakeholders are being engaged during the project via an advisory panel to maximize project outcomes.

Objectives of the project include (1) characterization of antibiotics, antibiotic resistant bacteria (ARB), and antibiotic resistance gene (ARG) fate in AnMBR, development of strategies to improve removal, and assessment of impacts from animal manure addition to AnMBR; (2) evaluation of disinfection processes on ARG inactivation and the effluent microbial community; and (3) development of a decision support tool and an online Community of Practice for stakeholders (utilities, developers, farmers, engineers, and consumers) interested in implementing agricultural water reuse.

Impact: The project is in the initial stages with the team focusing on method development (e.g., quantification of ARGs via qPCR) and fabrication of bench-scale AnMBR systems.

2016-67019-25279

Transforming Denitrifying Bioreactor Research and Applications: Unveiling the Inside of the Blackbox

François Birgand, Mohamed Youssef, George Chescheir, Bio&Ag Eng., NC State University

Laura Christianson, Department of Crop Sciences, University of Illinois

Matt Helmers, Agricultural & Biosystems Engineering, Iowa State University

Louis Schipper, School of Science, University of Waikato, NZ

David Williams, US EPA

Summary: Thousands of woodchip bioreactors will be needed at the agricultural field edge to significantly decrease nitrate concentrations and loads on a regional scale. Currently, very simplistic design and management limit their nitrate removal capacity and their acceptability.

The ultimate goal of this project is to provide novel scientifically-informed design and management tools to optimize and maintain woodchip bioreactor N removal performance in the field, with a knowledge of the collateral aqueous and gaseous emissions.

To achieve this goal, we have proposed to use transformative technology to describe and quantify the role of key variables in the movement of water and N removal rates inside bioreactors. We have started measuring measure the aqueous and gaseous emissions associated with identified treatments. We will integrate this new knowledge into 2D biogeochemical computer models to reconstruct apparent nitrate removal observed at the bioreactor scale. We will use the models to define novel and optimized design and management guidelines, across a gradient of substrate, climate and hydrological functioning.

Impact: This project has just started in May 2016, so the impact is limited. Two approaches are being pursued: a series of laboratory experiments completed with a continuous measurement of flow and water quality in, within and out of four field bioreactors. Our preliminary experiments suggest that it is possible to rejuvenate woodchip bioreactors by creating temporary aerobic conditions through wetting and drying cycles. There does not seem to be a clear relationship between the duration of aerobic conditions (6 to 72 hours tested), but the repetition of drying experiment seem to matter too. Continuously monitoring of water quality in and out of bioreactors proves to be a rather arduous task as the reduced conditions of the water tend to foul the optics of the instruments used.



2016-67020-25264

Enhancing the Nutrient Use Efficiency in Crop Plants By Tailoring The Nitrogen and Phosphorous Release Rates From Rendered Animal Materials

Tharayil, N.

Summary: Faced with a steadily dwindling cropping area, current agricultural practices overly rely on chemical fertilizer inputs to boost crop productivity. Present-day agriculture relies heavily on nutrient rich inorganic and chemical forms of nitrogen (N), including urea, ammonium salts, and nitrate salts. This approach results in high nitrogen delivery over a short time that exceeds the capacity for plant uptake, thus resulting in diminished nutrient use efficiency and greater environmental pollution. The reserve of phosphate rock, which currently accounts for 75% of the phosphorous (P) fertilizers, is dwindling at an alarming rate due to the burgeoning demand for P fertilizers. Moreover, the current production practices of nitrogen and phosphorous are highly energy intensive and not sustainable. The proposed approach is to revisit a historically employed fertilizer matrix; rendered animal proteins. The proposed research will develop new formulations of fertilizers, focusing on maximizing the nutrient use efficiency while employing economically feasible source materials. The proposed approach will utilize rendered animal proteins that are unsuitable for feed applications as a base matrix for supplying nitrogen and phosphorous to crops, thus recapture and reuse the nutrients from a resource which otherwise will be discarded. The project will employ various natural plant-based amendments that are spent-waste, to tailor the nutrient release rate from these RM so as to match the nutrient uptake rate of the crops, thus facilitating higher nutrient use efficiency. The project team proposes to produce a pelletized material of varying formulations of RM and amendments and test the nitrogen and phosphorous use efficiency on food crops in greenhouse and field conditions. The proposed recycling of reactive forms of nutrients in animal and plant byproducts will enhance the long-term sustainability of crop production systems by promoting the biological health of soils that is diminished by long-term, exclusive use of inorganic fertilizers. Results from this work will be applicable to other organic fertilizers that include agricultural and municipal wastes.

Impact: Too early to report impact.



Reducing Gaseous Nitrogen Losses from High Temperature Agricultural Systems

Jenerette, D

Summary: High temperature environments have accelerated nitrogen cycles that loose unexpectedly large amounts of nitrogen (N) from gaseous emissions. However, we propose that emissions management using readily achievable practices may reduce these gaseous N losses and thereby improve N use efficiency and reduce the downstream negative consequences of reactive N. To meet the goal of reducing global reactive N, our objectives are: (1) Identify management practices that limit gaseous losses of reactive N in high temperature agricultural systems, (2) Evaluate improvements in air quality and GHG concentrations derived from implementing N emission management, and (3) Develop a GHG offset protocol in the California Cap and Trade program that provides financial incentive to farmers using practices that limit N trace gas emissions. In meeting these goals we will conduct automated chamber measurements of N₂O and NO_x continuously deployed in fields of alfalfa and sudangrass under conventional and emissions management. These measurements will identify emission reductions readily achievable in a high temperature agricultural system. Data will be used to refine GEOS-Chem, a field-scale biogeochemical model and a regional atmospheric chemistry and transport model. This improved model will contribute to decision support tools for evaluating the downstream impacts of N to air quality and greenhouse gas emissions. Through a new financial mechanism, payments from Cap and Trade, we will provide a novel approach to facilitate the adoption of emission reduction management - this system can be a model for other high temperature agricultural systems.

Impact: Too early to report impact.

2016-67020-25320

Phosphorus Management in Forested Ecosystems

Mariana Dobre¹, Erin S. Brooks¹, Daniel Strawn²,
Department of Biological and Agricultural Engineering¹, Department of Chemistry²,
University of Idaho, Idaho

Summary: Forests have received less attention than agricultural lands in terms of nutrient management as they are considered to act as sinks for nutrients rather than sources. However, forest management activities, have the potential to increase nutrient concentration in streams through increased runoff and soil erosion. Even undisturbed watersheds with old forest cover can generate large nutrient concentrations, which is attributed to natural causes. Fire suppression over the last century has led to an excessive accumulation of forest floor biomass, which not only increase the risks for more intense and severe fires, but also has the potential to increase the concentration and load of sediments and nutrients in the downstream water bodies. Our project aims to improve the current understanding of the phosphorus (P) generation and transport in forest ecosystems and to enhance the ability of a process-based model to predict P delivery to water bodies. Our project will transform the understanding of P loading in watersheds by wedding new knowledge of P generation and transport with a versatile model (the Water Erosion Prediction Project) in order to create a decision-support tool for land managers to evaluate cumulative effects of P loadings from forested watersheds.

This study is focused on the forests from the Lake Tahoe Basin. We hypothesize that within the Lake Tahoe Basin there exists "hot spot" areas that are at greater risk for P transport by runoff and erosion. To identify these areas we will be leading an extensive field campaign where soil samples will be taken across multiple watersheds within the Basin. Using spatial geostatistics we will identify the key factors driving the distribution of soil P in these watersheds. Key variables considered include geology, soil texture, topography, land cover, and total forest floor biomass. We will then use these relationships to map the spatial distribution of the total soil P. These maps will help us identify and evaluate the spatial variability of P in "hot spots" through the Basin. Once these hot spots are determined, we will then follow up with field sampling to identify the extent to which the soil P distribution is driving spatial patterns in dissolved and total P concentration in surface water and groundwater flow paths. These data will augment the existing long-term P loading dataset that has been collected at multiple stream gauge stations throughout the Tahoe Basin over the last 42 years and help parameterize and assess the ability of a watershed hydrologic and soil erosion model, the Water Erosion Prediction Project (WEPP), to simulate P loading from these watersheds. This decision-support tool will assist land managers in evaluating the effects of management on cumulative P loading from forested watersheds. This project will broaden our current understanding of the distribution of soil P in forested landscapes and provide insight into the regions within a forested ecosystem which will likely be more sensitive to management and disturbance.

Impact: Our project is expected to start on 1st of July, 2016, therefore no results or impacts are available at this moment.



2016-67019-25263

On-Farm Research on Drainage Water Management to Reduce Nitrogen and Phosphorus Leaching: Trade-offs with N₂O and CH₄ Emissions

Davidson, E. A.

Summary: Humankind faces a vexing problem of nourishing about 9.5 billion people by 2050 while still maintaining the integrity of the soil and water resources and the global climate system that food production requires. The early 20th century invention of the Haber-Bosch industrial process to synthetically create nitrogen (N) fertilizer has transformed our modern agricultural system and has enabled the current human population to swell to over 7 billion people. However, this transformation of 20th century agriculture came at considerable environmental cost, calling into question the future sustainability of this model. Indeed, the use of N and phosphorus (P) fertilizers has already reached a level of high risk for exceeding "a planetary boundary for a safe operating space." Averaged globally, about half of the fertilizer N applied to farms is typically removed with the crops, while the other half either remains in the soils or is lost from the farmers' fields. Losses occur largely as nitrate leaching into groundwater and surface waters, which contributes to unwanted eutrophication and harmful algal blooms in downstream aquatic ecosystems and is a regulated pollutant in drinking water. While much is already known and many technologies already exist for improving nutrient use efficiency in agriculture, thus reducing N pollution, the goals of producing more food with low pollution will not be achieved by technological developments alone. An understanding of the economic and social factors affecting farmer decision making is also needed, and the effectiveness of technologies developed on experimental farms must be evaluated on private operational farms. Engaging farmers in dialogs and in participatory research can help identify social and economic impediments for the adoption of existing and new technologies for improving nutrient use efficiency and their real-world effectiveness. We hypothesize that controlled drainage will increase denitrification, leading to reduced nitrate losses, but possibly also measureable increases in emissions to the atmosphere of greenhouse gases such as nitrous oxide and methane. Adding to this concern of pollution swapping are a number of socio-economic trade-offs that must also be addressed for implementation of DWM. The primary goal of the proposed project is to obtain sufficient data from on-farm research to answer these questions: Three aspects of this research project will provide novel contributions beyond the analysis of the effectiveness of a particular N mitigation technology (drainage water management, DWM) and will contribute to societal benefits: First, the research will be conducted on operating farms with farmer engagement, including their evaluations of costs and effectiveness. We acknowledge that monetization of pollution impacts is highly uncertain, but we believe that sensitivity analyses of underlying assumptions of valuation will permit a holistic approach to analysis of nutrient loss and pollution accounting. Such novel approaches are needed to ensure that effective mitigation of nutrient losses to groundwater and surface water does not create larger problems with greenhouse gas emissions. Third, novel measurements of N₂ in groundwater will provide at least a lower-limit estimate of the soil microbial process called denitrification as the fate of reduced N runoff, thus providing one of the first quantitative estimates of denitrification in farm level N balances. Quantifying denitrification has been an important but elusive goal in agricultural and ecological research for many decades.

Impact: Too early to report impact.



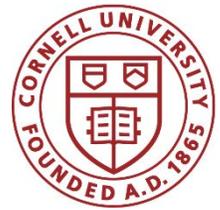
2016-67019-25268

Sources and Transport of Phosphorus in Tile Drained Agricultural Watersheds Using Advanced Chemical Analysis

David, M. B.

Summary: Phosphorus loss from agricultural fields in the Midwestern US occurs through surface runoff and tile drainage. Illinois has just developed a Nutrient Loss Reduction Strategy, which develops a plan for reducing P loads by 45%. Many management practices are proposed to reduce P losses, but there is great uncertainty about sources, transport, and forms. We will: 1) develop a rapid and simple method for determining which fields have large P losses through tile lines; 2) identify the forms of colloidal P (CP) and particulate P (PP) in tile and river water; 3) understand how soil P pools in fields control the dissolved reactive P (DRP), CP, and PP losses; and 4) assess the contribution of various P sources, including tiles, surface runoff, and riverine sources to overall watershed export of P. We will apply cutting edge chemical techniques including zetasizer (surface charge properties), dynamic light scattering (particle size distribution), high-resolution transmission electron microscopy (morphology, structure, and elemental distribution with P), synchrotron based XRD (characterization of amorphous or crystalline materials), and microfocused X-ray microprobe spectroscopy (solid state P speciation) to better understand and determine sources and transport. In addition to automatic and grab sampling of tile and river water, we will install a continuous DRP sensor in the watershed outlet. Samples will be primarily collected in the Embarras River watershed of Illinois. This knowledge will allow for better targeting and application of management practices, helping us reduce P losses by the large amounts needed in nutrient loss reduction strategies.

Impact: Too early to report impact.



2016-67019-25265

Decadal Nitrogen Partitioning and Retention: Insights From Whole-Ecosystem, Laboratory and Molecular Studies

Carmen Enid Martínez and Christine Goodale

Soil and Crop Science Section and Department of Ecology and Evolutionary Biology
Cornell University, Ithaca, New York

Summary: This work will leverage a long-term ^{15}N tracer study and conduct a series of new laboratory incubation experiments and molecular analyses to substantially improve understanding of how soils retain N. These studies will trace the fate of added $^{15}\text{N}\text{-NO}_3$ over a range of environmental conditions (soil oxygen status: redox range; microbial activity: biotic/abiotic) and timescales (hours to decadal), and will examine the form of N retained in soil as well as the long-term potential for redistribution of this N to plants.

Impact: Too early to report impact.



2016-67019-25267

Influence of Preferential Flow on Coupled Colloid, Nitrogen, and Phosphorus Transport through Riparian Buffers

Garey Fox and Todd Halihan - Oklahoma State University

Derek Heeren – University of Nebraska-Lincoln

Rafael Munoz-Carpena and Bin Gao – University of Florida

Summary: The design of conservation practices such as vegetative filter strips and riparian buffers typically focuses on surface runoff with subsurface nutrient transport usually assumed to be negligible. However, subsurface transport can become significant with preferential leaching and can negate the intended benefits of widely adopted control practices like riparian buffers. To limit degradation of ecosystem services and improve resource use efficiency, foundational research is needed on surface/subsurface transport mechanisms and techniques to simulate these pathways. Through both theoretical development and application-based research (Figure 1), this future project hypothesizes that (i) if gravel outcrops and macropores are prevalent in riparian areas, then nutrients will rapidly leach through the surface to subsurface pathways, be rapidly transported to streams, and limit the effectiveness of conservation practices; and (ii) if mechanistic processes of preferential leaching and subsurface transport are incorporated into decision-support tools, then prediction of the performance of conservation practices such as riparian buffers will be improved. Simultaneous injection experiments using tracers, colloids, nitrate, and phosphorus will be performed in laboratory tests and at six riparian sites to identify surface and subsurface transport mechanisms through state-of-the-art monitoring techniques in the next three years. Experimental data will test and refine decision-support tools for riparian buffers through the use of an innovative model (VFSmod) and new theories (source-responsive model) on the effect of macropores and preferential pathways.

Impact: We rely on riparian buffers and vegetative filter strips for preventing transport of colloids, nitrate, and phosphorus to adjacent surface waters, but are currently neglecting a potentially significant process in terms of preferential flow. Riparian areas are particularly susceptible to preferential flow. Limited advancements in theoretical model development for preferential flow and application to vegetative filter strips/riparian buffers have been achieved to date. This research project hypothesizes that that if gravel outcrops and macropores are prevalent in riparian areas, then nutrients (dissolved and colloidal) will rapidly leach through the surface to subsurface pathways, be rapidly transported to streams, and limit the effectiveness of conservation practices; and if mechanistic processes of preferential leaching and subsurface transport are incorporated into decision-support tools, then prediction of the performance of conservation practices such as riparian buffers will be improved. Decision-support tools for the design of vegetative filter/riparian buffers will be improved to better analyze preferential leaching and subsurface colloid, nitrate, and phosphorus transport.

This research will have wide reaching implications. First, the effectiveness of conservative practices will be better understood and more appropriately implemented, ensuring that funds utilized to prevent nutrient and colloid transport are successful in providing long-term agricultural sustainability. Second, the research will support graduate and undergraduate education at three major land-grant universities. Finally, the research will be widely disseminated through presentations and publications, proposed updates to conservation standards, and by providing access to the decision-support tool for national and international use.

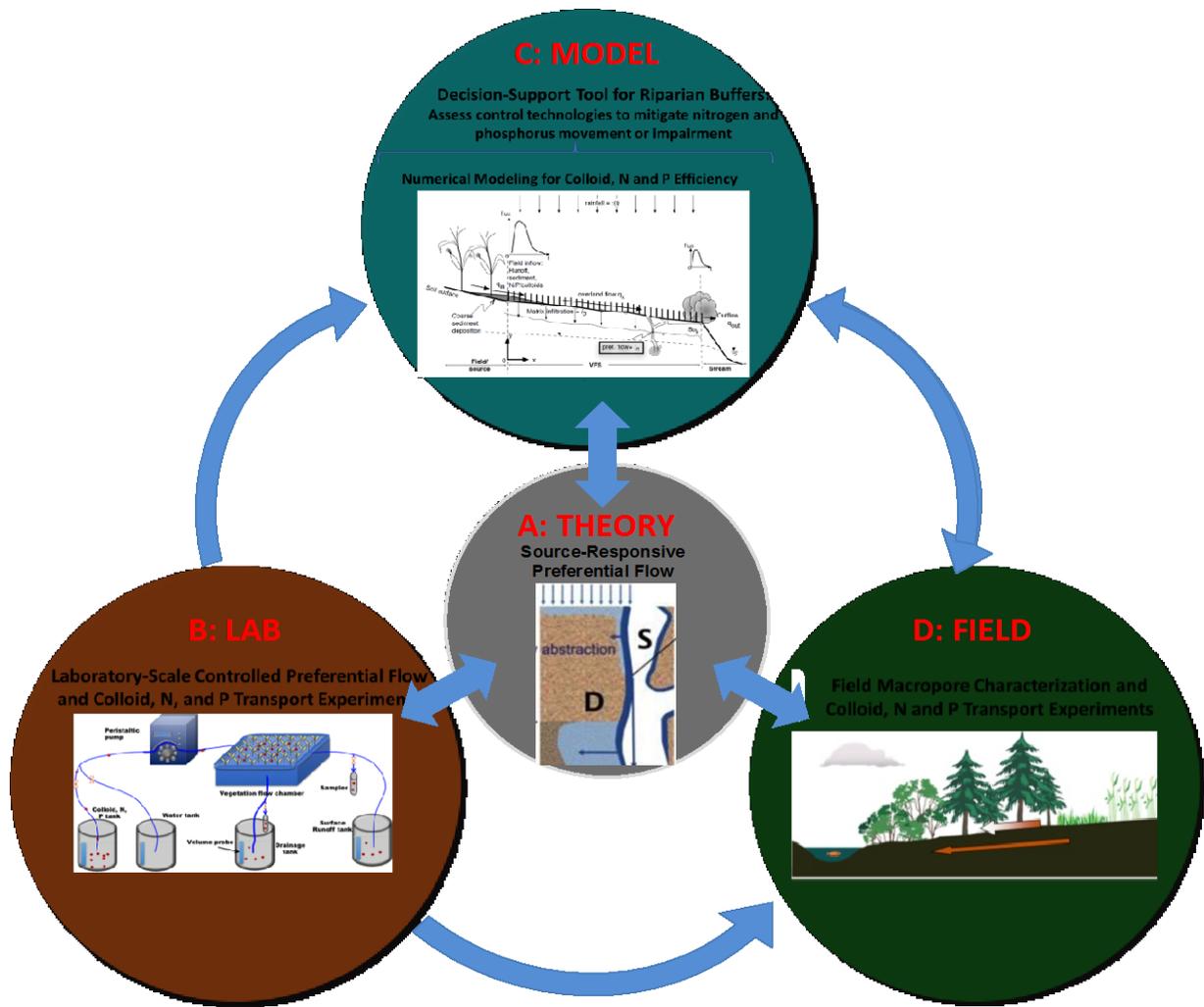


Figure 1. Diagram depicting integration of the theory, laboratory, field, and modeling components of the research project aimed at the development of an improved riparian buffer decision-support tool.



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2016-67019-25271

Reactive Nitrogen Cycling and Impacts On U.S. Dairy Farms: The Feasibility of Sustainable Milk And Agro-Ecosystems

Peter Vadas, Mark Powell, Kristan Reed; USDA-ARS, Madison, WI; Al Rotz, USDA-ARS, University Park, PA; April Leytem, USDA-ARS, Kimberly, ID, John Baker, USDA-ARS, St. Paul, MN, Victor Cabrera, Dairy Science, University of Wisconsin-Madison, WI, Richard Gaillard, Nelson Institute, University of Wisconsin-Madison, WI

Summary: Modern agricultural systems face immense pressure to feed a growing population, but do so without environmental impacts. Dairy farms are challenged to produce more and minimize off-site impacts of reactive nitrogen (N) on air and water quality. A systematic analysis of existing and possible dairy farm systems across the U.S. is needed to design high productivity, low impact farms. This project is using the Integrated Farm Systems Model (IFSM) to analyze and quantify the farm-scale air and water quality impact and economic viability of integrated, dairy production farms in four geographically distinct regions (PA, WI, MN, and ID). Surveys and site visits will be conducted to compile information for a spectrum of farm typologies that will be simulated. Model sensitivity will be conducted to identify the farm-scale practices and processes that have the greatest impact on reactive N cycling, use, and loss. Subsequent activities will identify alternative practices that can substantially improve N use efficiency on different farm types. Qualitative research will be conducted to explore the role that biophysical simulations models play in improving researcher/farmer communication and education, with a view to developing decision support tools that can be used on farms. The project will identify the major points of N use inefficiency and loss on dairy farms, develop alternative systems to substantially improve N use, and provide information on how models can provide realistic enough “experiences” for farmers to implement new management practices.

Impact: Our project will analyze and document differences in reactive N cycling, use, and loss to the environment across a spectrum of current and future U.S. dairy production systems. Our analysis will identify and describe alternative dairy practices and systems that can transform reactive N economy, and analyze their feasibility by exploring impacts on farm production costs and revenues. Results will establish research and development priorities to envision the nature of future dairy production. The project will also generate information to support and apply modeling tools that can be used for decision-making, research, and policy evaluation. We will identify model improvements specific to IFSM. For example, there may be limited management strategies important for N cycling that we can impose to the cow herd simulations in IFSM (e.g., reproductive or culling changes), to the number of cow feeding groups, or to diet formulations. We will document these limitations and develop strategies to overcome them, either through direct model modification, or developing an external model that could use parts of IFSM and combine them with a more compatible herd module. Finally, the project will provide information to researchers on how to develop models so they can be used to engage farmers and farm advisors, provide realistic learning experiences for farmers, and lead to changes in decision-making and practices. Such information will increase the ability of models to influence N management in dairy agroecosystems. Discourse analysis from farm visits will provide a detailed understanding of common themes and potential conflicts present in farmer-researcher interactions, and will identify key language barriers and bridges to understanding. The phenomenology of farmers interacting with researchers will help researchers better understand how farmers view the interactions and allow researchers to be aware of and sensitive to ways in which they are perceived. It will also document how farmers learn and how farmers and researchers generate knowledge together. Describing this experience is a necessary first step in learning how to improve communication and leverage what we learn from this investigation.

2016-67019-25262

Quantitative Approach for Recovering Legacy Phosphorus while Minimizing Crop Nutrient Deficiency Risk

Vimala Nair, Soil and Water Sciences Department, University of Florida, FL

Lynn Sollenberger, Agronomy Department, University of Florida, FL

Willie Harris, Soil and Water Sciences Department, University of Florida, FL

Andrew Sharpley, Crop, Soil, and Environmental Sciences Department (CSES), Division of Agriculture University of Arkansas System, AR

Peter Kleinmann, USDA - Agricultural Research Service Pasture Systems and Watershed Management Research Unit, University Park, PA

Dorcas Franklin, College of Agriculture and Environmental Sciences, University of Georgia, GA

Summary: Global phosphate reserves are being depleted at an alarming rate even as excess phosphorus (P) application to land has resulted in surplus (“legacy”) soil P. We are evaluating an approach based on a threshold soil phosphorus saturation ratio (PSR) that can be used across a broad geographic range as an “agronomic and environmental P monitor” for sustainable management of P application for plant uptake. The soil phosphorus storage capacity (SPSC), calculated from a threshold PSR, will be used to assess the needs of a crop for P fertilization on a site-specific basis. When SPSC is positive, there will be minimal P release from the soil. However, when SPSC is negative, the crop will be able to mine P from the soil. The amount of P that can be mined will depend on the SPSC value; more P can be mined from a soil as SPSC becomes increasingly negative (Fig. 1).

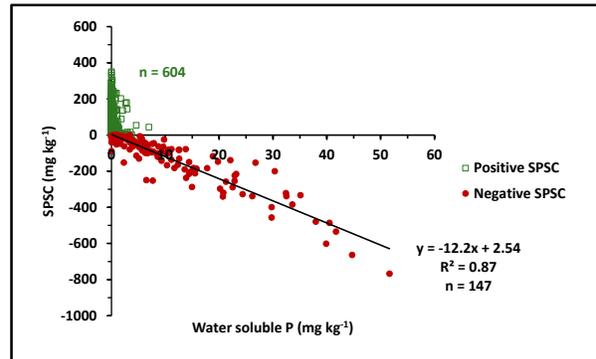


Fig. 1: Relationship between soil P storage capacity (SPSC) and water soluble P for surface horizons of manure-impacted soils.

Objectives are to: i) Obtain a threshold PSR value (or values for groups of soils) across a geographic diversity for soils within the Southern Region /Midwest/ Chesapeake Bay areas, focusing on soils for which secondary iron and aluminum forms have significant control over P retention, ii) Conduct field experiments with and without P applications for a typical regional cropping system at three sites to relate plant response to SPSC values, and iii) Evaluate the potential for using the SPSC equation to estimate the amount of P that can be mined from a soil when SPSC is negative without jeopardizing crop quality or yield.

Impact: Too early to report impact.



2016-67020-25276

Biochar and Poultry Litter Amendments in Highly Weathered Soils: Phosphorus Availability, Transformation and Dynamics

Thilini D. Ranatunga, Biological & Environmental Sciences, Alabama A&M University, Normal,
AL 35762

Summary: Biochar generated from pyrolysis of various biomass substrates is a carbon rich material that can be utilized to sequester carbon and improve soil fertility. Biochar amendments have effects on enhancing soil chemical, physical, and microbial properties. This seed grant project is focused on investigating the behavior of mixed hardwood derived biochar amendments in highly weathered phosphorus (P) deficient soils. This study will generate preliminary information pertaining to availability and transformation of P forms in wood derived biochar amended P deficient soils, due to changes in soil chemical properties including soil pH, and activity or availability of cations such as aluminum, (Al), iron (Fe), and calcium (Ca). In addition, the study is also focused on use of this biochar for mitigating P in poultry manure applied highly weathered soils due to the high P sorption capacity of biochar substrates. Findings from this preliminary study will be utilized to generate conditions for future field studies to evaluate the efficacy of biochar as a soil amendment in P deficient soils or utilization of biochar in poultry litter applied soils to control leaching of soil P. A laboratory based incubation study will be utilized to evaluate the temporal changes in soil properties (physical, chemical, and microbial) and soil P pools in two Alabama soil types amended with biochar. The study will provide valuable information pertaining to developing technologies to enhance P in P deficient highly weathered soils or mitigate P levels in poultry manure applied soils. Major objectives of this study are to utilize P deficient Alabama soil types (with or without prior poultry litter application) to conduct a laboratory based studies to: 1. Evaluate the efficacy of hardwood derived biochar in enhancing soil physical, chemical, and microbial properties in highly weathered soils; 2. Determine changes associated with P pools in biochar amended soil; temporal variations in P availability, transformation, and dynamics 3. Determine the effect of biochar on soil phosphatase enzyme activities and organic P mineralization 4. Understand the effect of soil pH changes on free Fe and Al oxide bound P in highly weathered biochar amended soils; 5. Examine the potential for biochar to reduce P leaching in P deficient soils to which poultry litter has been applied.

Impact: Potential impacts: Improve fertility of highly weathered soils by application of biochar amendments, utilize environmentally sound soil amendments as nutrient sources in highly weathered soils for crop production.

2016-67026-25045

Implementing California's Sustainable Groundwater Management Act: Farmer Perceptions and The Balance of Groundwater and Economic Sustainability

Young, C.; Howitt, RI, .; Niles, ME, T.; MacEwan, DU, .; Mehta, VI

Summary: This project's goal is to develop and apply a decision making framework that can be widely used to reconcile decisions and behaviors made at farm level with policy driven by natural resource concerns. The context is California agriculture's response to the 2014 Sustainable Groundwater Management Act (SGMA). With a focus on a high priority groundwater basin in Yolo County, the objectives are (i) to understand farmer behavior in light of the SGMA, (ii) develop a shared mental model for the study area using quantitative models embedded within formal participatory processes, and (iii) to develop a program of outreach and communication to increase the impact and scale-ability of both process and outputs. The overall approach utilizes the principles of Robust Decision Making (RDM). Specific tools used in implementing RDM include integrated water resources and economic models that are developed and driven by a stakeholder process involving farmer surveys, focus groups and an advisory committee. This project is well aligned to the AFRI grant program's priority area (agricultural economics and rural communities), and the Water for Agriculture's program priority area "Understanding Decisions and Behaviors Concerned with Agriculture and Post-harvest processing industry water use". It responds most directly to two of the program area priority objectives, namely "concerning competing water demands, individual and societal behaviors, and drivers in the context of limited water resources"; and "better understanding and prediction of human behavior changes with government incentives and regulations".

Impact: Too early to report impact.

2016-69007-25093

Future Water Quality Challenges to Aquaculture and Influences on Product Safety

Jeremy L. Conkle, Department of Physical & Environmental Sciences, Texas A&M University Corpus Christi, Texas; John Scarpa, Department of Life Sciences, Texas A&M University Corpus Christi, Texas; Bryan Brooks, Environmental Science Department, Baylor University, Texas

Summary: Decreasing water availability and its quality are growing threats to global stability, human health, economic development and food supplies. Simultaneously, aquaculture, which relies on inexpensive, safe water, is rapidly expanding (worldwide 9.2% yr⁻¹ 1990-2000 & 6.2% yr⁻¹ 2000-2012; vs U.S. agriculture 1.86% yr⁻¹ 1990-2000) to meet global protein demands and now accounts for ~50% of all fisheries consumption. As water resources tighten, aquaculturists will be forced to knowingly or even unknowingly utilize lower quality, “nontraditional water” supplies. This would include the direct use of reclaimed water (treated wastewater effluent) from wastewater treatment plants (WWTPs) or indirect use of effluent diluted in surface waters. This effluent contains trace levels (ng L⁻¹) of a group of pollutants known as contaminants of emerging concern (CECs), which include but are not limited to pharmaceuticals, personal care products, flame retardants and plasticizers. Many CECs are ionizable compounds that behave differently than non-ionizable compounds, which are the basis for most bioaccumulation models. These models, while accurate for some CECs, may result in “unexpected” levels of accumulation in aquacultured species, potentially creating a human exposure route. Due to this concern it is important to quantify the susceptibility of U.S. aquaculture farms to reductions in water quantity and quality, determine factors that influence bioaccumulation of CECs to improve existing models, determine troublesome CECs that bioaccumulate and eliminate those that will not in an effort to improve our understanding of human exposure pathways and provide data to proactively mitigate potential human health risks and product safety concerns associated with nontraditional water usage.

The overall objective of this project is to improve our understanding of human exposure to contaminants from consumption of aquacultured fish as this industry becomes increasingly influenced by and dependent on “nontraditional water,” specifically wastewater effluent containing micropollutants. To accomplish this objective we will:

1. Quantify the vulnerability of U.S. aquaculture production to declines in freshwater quality using existing and modeled data, specifically from higher relative volumes of wastewater effluent in surface waters supporting this industry.
2. Assess the role of pH and biotransformation in the bioaccumulation of ionizable CECs (e.g., aryl phosphate ester (APE)-based flame retardant, a perfluorinated surfactant, a calcium channel blocking pharmaceutical, and an antibiotic) in two dominant aquacultured fish (tilapia and channel catfish) to improve existing uptake models.
3. Increase stakeholder and general public awareness of water quantity and quality projections, its implications for the aquaculture industry, establish best management practices to reduce contaminant accumulation and risk/non-risks related to the increased influence of nontraditional water.

Impact: Too early to report impact.

Oral Session III
(Salon I & II)

2013-67019-21374

Algae for Conversion of Manure Nutrients to Animal Feed: Evaluation of Advanced Nutritional Value, Toxicity, and Zoonotic Pathogens

Shelton Murinda, Animal and Veterinary Sciences Department, College of Agriculture,
California State Polytechnic University, Pomona, CA.

Marcia Murry, Biological Sciences Department, College of Science,
California State Polytechnic University, Pomona, CA.

A. Mark Ibekwe, USDA Agricultural Research Service, U. S. Salinity Laboratory, Riverside, CA.

Gregory Schwartz, BioResource and Agricultural Engineering Department, College of Agriculture,
California Polytechnic State University, San Luis Obispo, CA.

Summary: The need to control manure-derived nutrient pollution is straining the confined animal production industry. California is the top milk producing state and has some of the strictest nutrient regulations. But in the San Joaquin Valley, many dairies do not have affordable access to more land for manure application. A highly productive crop is needed that will convert manure nitrogen into feed but in smaller land areas than crops such as corn. Algae are a candidate feed with annual yields typically 7-13 times greater than soy or corn. With beyond 40-50% protein content, algae contain fatty acids, amino acids, pigments, and vitamins that are valuable in animal feeds, especially for adding value to milk. Advances in molecular biology allow us to gather needed information on the risks and benefits of algae-based animal feeds.

The goals of this project are:

1. **Generate Experimental Field Data and Calibrate Optimization Models.** Cultivate algae in dairy freestall barn flush water, treating this wastewater, while producing algae feedstock at a high annual rate, at least 10-times greater than corn. Algae will be cultivated in 30-cm deep raceway ponds. For treatment, expected removals are 85-95% biochemical oxygen demand (BOD) and soluble Nitrogen (N) and 40-80% soluble Phosphate (P), depending on culturing technique and season.
2. **Maximize the Nutritional Value of Produced Algae for Animal Feed.** The cultures will be optimized to produce biomass with favorable nutritional characteristics at a high rate while also having the highest value nutritional composition for feed in terms of: digestibility, lipids, essential fatty acid and amino acid profiles, including balanced protein and carbohydrate concentrations.
3. **Optimize Pathogen Inactivation Methods.** Pathogens from manure will die-off in the ponds and during disinfection processing of the harvested algal biomass. Inactivation rates for representative pathogen indicators will be determined under various algae cultivation conditions and during trials with several biomass disinfection techniques. The optimal combination of pond conditions (e.g., high pH) and biomass processing (e.g., pasteurization) will be determined to achieve needed log inactivation of pathogens, which is typically 1 log₁₀ to greater than 4 log₁₀ reduction.
4. **Quantify and Control any Cyanobacterial Toxins.** Monitor pond contamination by cyanobacteria ("blue-green algae") and cyanobacterial toxins. qPCR assays will be used to detect and quantitate cyanobacteria and their toxins. If cyanotoxins are detected, measures will be taken to control invasion of the ponds by cyanotoxin-producing microalgae strains.

Impact: Attainment of steady-state in the algal bioreactors/ponds has enabled continuous manipulation of experimental variables and data collection. During this past year seasonal data were verified or enhanced with more data, to continue to compile data for the development of a model to predict nutrient uptake as well as biomass production potentials. Research Protocols: Standard operating research protocols have been developed and are being refined for conducting analyses routinely: e.g., pond analysis (pH, BOD, N, P), algal biomass compositional analysis (N, P, amino

acid and fatty acid profiles), and detection of cyanobacteria and their toxins, and DNA extraction for use in metagenomics/microbial community studies using NGS. Physical Collections: We purified and cryopreserved (at -80°C) algal species isolated from the bioreactors/ponds that have been and are being further characterized for potential application in our model development using strains with favorable growth and nutritional profiles for subsequent use in biomass synthesis/feed manufacture. Microbial isolates were curated for future use in algae-based feed production. Furthermore DNA has been isolated from the ponds and will be employed for deeper analysis of microbial communities using NGS. Seasonal samples from the ponds have also been preserved for future analyses.

Extensive databases have been initiated and are being further developed for pond data, compositional analysis, and metagenomic analysis of pond microbiota (microbial communities) using Illumina's MiSeq next generation sequencing (NGS) platform. For example, the databases developed using MiSeq will be analyzed to enable genus and species identification of bacterial (including pathogens) and algal species resident in the ponds in different seasons, providing data on the fate, prevalence and relative abundances of the targeted organisms.

Research results have been disseminated to communities of interest. Two Annual Technical Reports were submitted to USDA. Additional disseminations will be conducted in 2016-2017 and beyond in the areas of annual reports, final report, conferences/abstracts, peer-reviewed publications, including book chapters. Two book chapters were published and two chapters were written and submitted for review. Twenty one conference poster and/or oral presentations and their abstracts were disseminated at local and regional conferences. At least 11 students from diverse backgrounds: undergraduate and graduate, e.g., underserved students, minorities, and first generation college students, have been/or are being trained. A graduate student working on this project received a PPOHA-MENTORES Fellowship for Energy- or Water-related projects.

Lab-based Phenometrics Bioreactors (PBR 101) are being used to mimic production conditions at the ponds to complement model development. DNA isolated from the ponds is being employed for deeper analysis of identities, dynamics and relative abundancies of microbial communities (i.e., pathogens and microalgae) using NGS. At completion of the study we anticipate adoption/integration of new knowledge and/or products generated from our study into practice by the dairy and bioremediation industries that will employ algae-based methods.

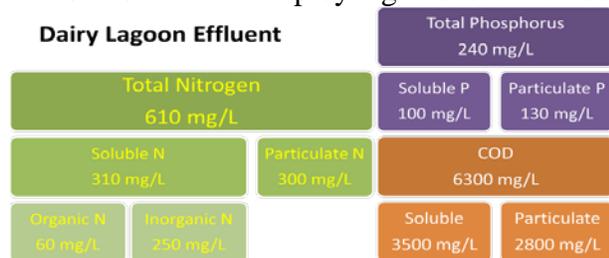


FIGURE 1: Dairy lagoon effluent characteristics 2015

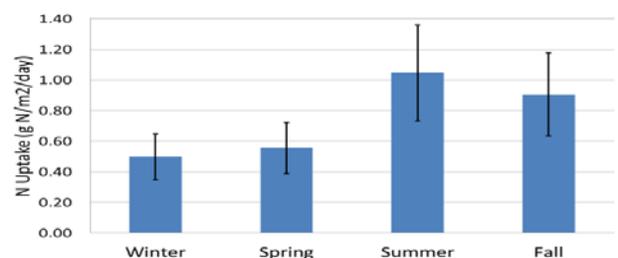


FIGURE 2: Seasonal nitrogen uptake rates for 2015



2013-51130-21488

Farms, Floods and Fluvial Geomorphology: Making the Most of Our Natural Resources

Christine Hatch, Department of Geosciences & UMass Extension, University of Massachusetts, Amherst, MA

Summary: Agricultural and undeveloped rural forested lands play a crucial role in diminishing the destructive power of floodwaters by receiving, spreading, and slowing the flood wave as it moves through a watershed. Climate scientists predict (and have already observed) that in the Northeastern U.S., individual storms may be more intense, and that there will be more precipitation on an annual basis. The long-term goal of *Farms, Floods and Fluvial Geomorphology: Making the Most of Our Natural Resources* is to address the needs of farmers in floodplains specifically relating to fluvial geomorphological hazards and healthy riparian zones along the river corridor by building an integrated support system for farms and rural communities dealing with the uncertainties and destructive power of rivers in extreme weather events. To those ends, we apply a multifaceted research and outreach approach that includes the use of LiDAR and fluvial geomorphological assessments to delineate the river corridor for the Deerfield River in Massachusetts and Vermont, where considerable activity and excitement surrounding responsible whole-watershed management is underway, and existing funded projects are leveraged for maximum benefit. We pair GIS and flood prediction analysis with the corridor maps to produce educational materials highlighting the role farms play in floodplains.

We integrate our knowledge developed through our prediction analysis with the basin's agricultural stakeholders in an effort to provide them with needed tools and support, including factsheets for flood preparedness, strategies for riparian land management to maximize overall watershed/river health and minimize damages, sources for relief and post-disaster assistance, and pro-active measures for riverfront property management (and potential for profit). While we focus on a single bi-state basin as a test bed, these techniques are readily transferrable throughout New England.

Impact: Currently in the development of our project, we have assessed erosion and deposition hazards along all rivers in the Deerfield River watershed in Massachusetts and Vermont. This assessment takes the form of a GIS model and delineates fluvial hazard levels from one reach to the next across the watershed. This map is now being used as an educational tool for agricultural service providers and producers. We have also designed and hosted multiple stakeholder workshops with river and land managers in Massachusetts and Vermont to define the policy dimensions of fluvial geomorphic assessments. Through these workshops, we have worked to create a methodology to delineate river corridors that incorporates the needs and values of different stakeholder groups. In a second project development, which consists of educational outreach events, we present our modeling and mapping results to agricultural stakeholders; we present best management practices that may be used to mitigate the impacts of flooding on agricultural lands in New England, as shown in our modeling outputs.



2013-51130-21485

Advancing Agricultural Water Security and Resilience Under Nonstationarity And Uncertainty: Evolving Roles Of Blue, Green And Grey Water.

Rees, P. S.

Summary: The production of food and other forms of biomass for human uses is the largest component of the human freshwater budget. Addressing the millennium development goal of reducing by half the proportion of malnourished people in the world by 2015 is an extraordinary agricultural and water management challenge. To meet this challenge, there is an urgent need to focus water management investments into rain-fed and irrigated agriculture through the management of the blue, green and grey water. The primary objective of our proposal is to develop a series of conference sessions which provide a global view of the challenges and the opportunities for future research, education and extension via presentation of a wide range of forward-looking perspectives on blue, green and grey water issues related to agriculture. We will leverage the 2014 National UCOWR/NIWR/CUAHSI Conference, to be held June 18 - 20, 2014 at Tufts University, just outside of Boston. The joint conference organizers have enthusiastically embraced our suggestion to devote one track of the conference to this timely topic. Anticipated outputs include the establishment of a working group (WG) to fulfill post-conference tasks, including: 1) publication of an issue(s) of the Journal of Contemporary Water Research & Education (JCWRE) based on the conference track presentations, discussions, and findings, 2) development of a white paper outlining challenges and opportunities, and 3) development of a position paper outlining future potential collaborations with CUAHSI to provide farmers and water managers with real-time, spatially explicit management recommendations based on available data, models, and tools.

Impact: Implement a conference to provide state-of-the-science concepts and stakeholder input to USDA-NIFA regarding global challenges and opportunities in water-related research, extension programming and education related to food and agriculture. 2. Conference planning, including program development, identification of invited speakers and panelist, and abstract review, will be guided by a conference SAB, which will include university researchers, agency scientists, Extension educators, and stakeholders from across the nation. 3. The USDA-NIFA sponsored conference will be held as a track within the 2014 joint UCOWR/NIWR/CUAHSI conference focused on "Water Systems, Science, and Society Under Global Change", to be held June 18 - 20, 2014 at Tufts University outside of Boston. 4. We anticipate that the USDA-NIFA conference track will include two sessions for all conference participants, a series of invited and ad-hoc technical presentations, listening sessions, and several networking opportunities. One plenary will compare and contrast the state-of-the-art in blue, green, and grey water use in the U.S., Europe, Asia, and South Africa. A second plenary will consist of a panel discussion on the challenges and opportunities in water-related research, extension programming, and education. 5. In addition, we will host a lunch for track invited and ad-hoc participants, utilizing this time to begin to identify challenges, opportunities, and needs from a variety of views. 6. The UCOWR welcome reception and awards banquet will provide networking opportunities. 7. We will add to the conference track virtual webinar technology, such as live webstreaming, to facilitate the remote participation of a broader group of university, Federal, State, and local scientists, educators, and administrators. We believe the virtual webinar technology will be particularly useful for enabling the participation of Extension educators and stakeholders from across the nation. 8. A working group will be charged completion of post-workshop outputs.



2014-67019-21568

Characterizing the Fate and Transport of Chemicals of Emerging Concern (CEC's) From Animal Manures During Waste to Energy Processes

Schideman, L.

Summary: The long-term goal of our research is to develop technologies and tools for livestock manure management that can simultaneously provide significant environmental benefits and valuable bioenergy products. For this project, we plan to investigate the effects of two emerging waste-to-energy processes on the removal of bioactive CECs and then roll that information into a process model that can demonstrate novel treatment approaches to increase environmental and bioenergy benefits. Our central hypothesis is that manure treatment systems that synergistically integrate biological, adsorptive, and waste to energy processes can provide enhanced removal of CECs and increased bioenergy production. In essence, the novel integrated treatment systems to be studied in this project can capture residual CECs into valuable bioenergy products rather than releasing them to the environment, which provides a cost effective reduction in water pollution, and increased opportunities for water reuse after treatment of the aqueous fraction of manure.

Impact: To investigate the effects of GAC on the biomass properties in each bioreactor, the biomass composition was analyzed. Protein, fiber, and sulfur in the biomass from the MABB were increased by 26, 27 and 25%, respectively, when GAC was present, and the CAS reactor with GAC saw smaller increases in these parameters of 9.3, 19.5 and 9.1%. In contrast, the ash content decreased when GAC was present in the MABB (-7.6%) and the CAS (-32.3%). Because ash is not useful for bioenergy production, this data suggests that GAC could enhance bioenergy yield in hydrothermal processes. Effects of CHG on the fate of spiked hormones were investigated at 10 different operating conditions (350, 400, 450 degrees C; 60 minutes; Ru, Ni, GAC catalyst; 100, 70, and 30% biomass). These experiments showed that E2 in the spiked biomass was removed up to 99.8% with CHG at 350 degrees C/60 minutes with Ru catalyst. The cytotoxicity of the PHWW under various conditions (sample I, II, and III: 250 degrees C/30 minutes, 300 degrees C/30 minutes, and 350 degrees C/30 minutes) was investigated using a previously developed Chinese Hamster Ovary (CHO) cell assay (Hsieh AW, 1975; Wagner et al., 1998). LC50 values of three samples were calculated from the regression analysis and represents the sample concentration that induced a 50% reduction in cell density as compared to the concurrent negative controls. LC 50 and mean cytotoxicity index (CTI) values of sample I, II, and III were 0.275 and 3710.2, 0.413 and 2380.8, 0.186 and 5373.3. This analysis allowed us to define if there were significant differences in cytotoxicity among the PHWW samples, and conclusions from cytotoxicity test are: 1. Each PHWW sample induced concentration dependent cytotoxicity in mammalian cells. 2. The descending cytotoxicity potency was Sample III > Sample I > Sample II. 3. There may be an association between the temperature in the hydrothermal process because Sample I and II with the lower temperatures (250 and 300 degrees C) expressing less toxicity and sample III with a higher temperature (350 degrees C) expressing the highest level of cytotoxicity. 4. Modifications in hydrothermal processing can affect the resulting toxicity of the output product. Accomplishment 4. Integrate the process performance data into a dynamic process model describing the fate, transport, and transformation of CECs. We updated our previously developed model describing the fate and transport of bioactive CECs such as hormones and antibiotics in the manure management system using the results from previous experiments. This model was developed using the STELLA software package and will be more calibrated using the results from Accomplishments 1-3. Subsequently, it can be used to analyze a wide variety of process conditions for integrated manure management systems.

2013-67019-21355

Fate of Chemicals of Emerging Concern in Agroecosystems Amended with Animal Manure Using Novel Manure Land Management

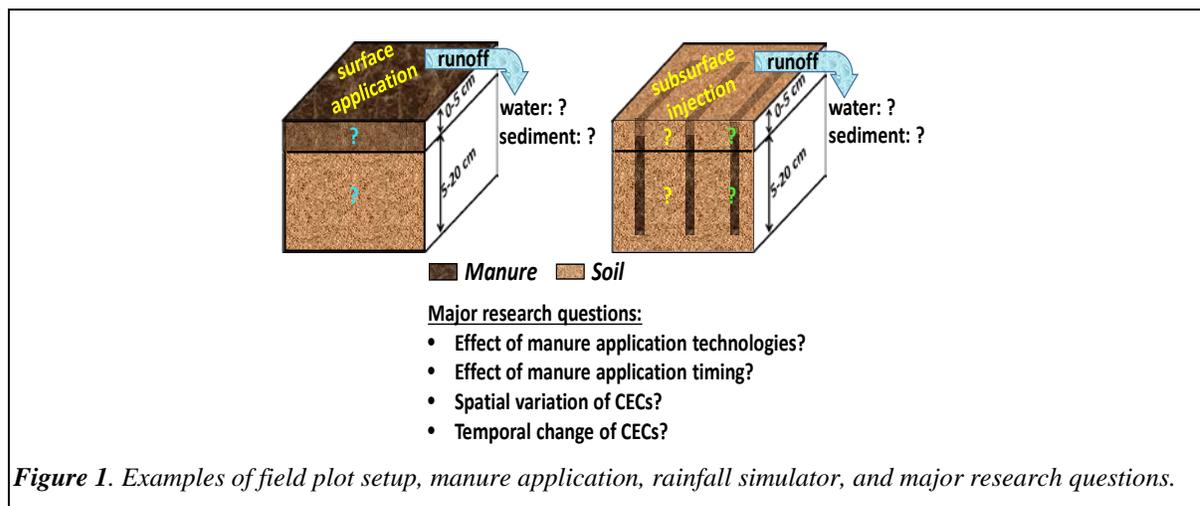
Technologies: Impact of Multi-scale Soil Processes

Kang Xia (PI) and Rory Maguire (co-PI), Department of Crop and Soil Environmental Sciences, Virginia Tech, Virginia

Katharine Knowlton (co-PI), Department of Dairy Science, Virginia Tech, Virginia

Summary: Animal manure land application to enhance soil fertility is a common animal manure management strategy worldwide. However, this practice generates route of entry for animal manure-associated chemicals of emerging concern (CECs) into the soil environment, resulting in potential negative impact on ecosystem services. To date, animal manure land management technologies are designed for reducing nutrients input to water bodies. Very little is known about the effectiveness of those technologies in preventing CECs from entering into the water bodies.

The overall goal of this project was to improve animal manure land management technologies to minimize or reduce the input of CECs to water bodies. To achieve this overall goal, combined interdisciplinary laboratory and field studies were conducted to link micro- and macro-scale soil processes affecting animal manure-borne CECs with their field-scale environmental behaviors and fate in animal manure amended soils.



Impact: As shown in Fig 1, field-scale rainfall simulation experiments were conducted on plots receiving three manure treatments (surface application, subsurface injection, and no manure control) to investigate: 1) effects of manure subsurface injection, compared to commonly used surface application, on the environmental fate of four widely used antibiotics in dairy production, including pirlimycin (PLY), tylosin (TYL), chlortetracycline (CTC), and sulfamerazine (SMZ); 2) effects of manure application timing on the environmental fate of antibiotics; and 3) the long-term transformation patterns of antibiotics in manure-applied soils. Preliminary results showed that manure subsurface injection concentrated PLY in the injection slits with limited horizontal diffusion within 15 cm from the slit, while surface application evenly distributed PLY throughout the soil surface leading to a higher runoff potential of antibiotics. The results also suggested that manure application at least 3 days before a rainfall event might significantly reduce antibiotic runoff regardless manure application methods. In addition, significant antibiotic reduction in the soil was observed within 5-10 days after the rainfall event. Mass balance distribution of the target antibiotics in the 0-5 and 5-20 cm

soil depths and runoff water and sediment suggests that manure subsurface injection concentrates antibiotics in the injection bands and, therefore, reduces their runoff potential. Thus, subsurface injection could be used as a best management practice to prevent loss of emerging contaminants in surface runoff. This study also provides evidence that manure application timing relative to rainfall event significantly affect surface runoff of antibiotics.

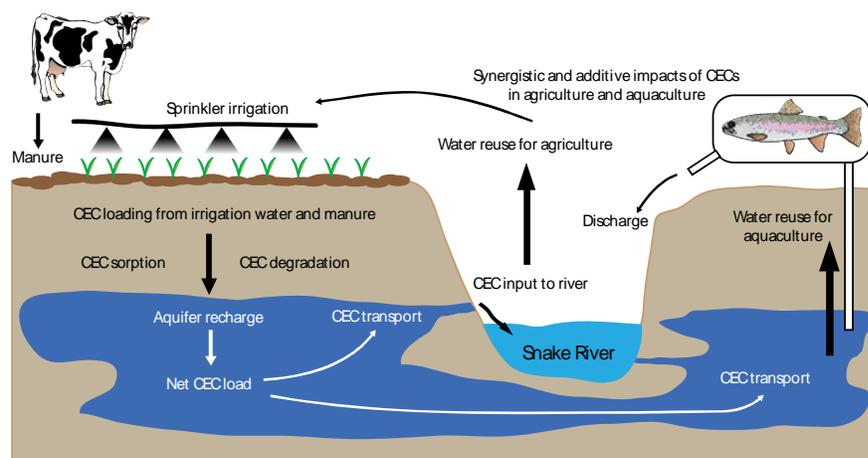
Scientific communities, farmers, policy and decision makers, general public are the stakeholders of this project. The results generated from this project will help evaluate and develop more effective new animal manure land management approaches for reducing the environmental impact of land applied manure. Animal manure land management practices preventing and minimizing the input of CECs to water bodies will be conveyed to the target stakeholder of this project via field demonstrations, extension meetings, outreach programs, scientific meetings, and journal publications.

2013-67019-21375

Chemicals of Emerging Concern in the Eastern Snake River Plain of Idaho: A Threat to Irrigated Agriculture, Dairy, and Aquaculture?

M.J. Morra, Div. of Soil & Land Resources, Univ. of Idaho, ID, J.E. Hammel, Div. of Soil & Land Resources, Univ. of Idaho, ID, D.N. Hill, Div. of Soil & Land Resources, Univ. of Idaho, ID, A.D. Moore, Div. of Soil & Land Resources, Univ. of Idaho, ID, J.J. Nagler, Dept. of Biology, Univ. of Idaho, ID, I.E Popova, Div. of Soil & Land Resources, Univ. of Idaho, ID, E.M. Top, Dept. of Biology, Univ. of Idaho, ID

Summary: The Snake River Plain of southern Idaho is a concentrated area of irrigated agriculture, dairy, and aquaculture. Due to an average rainfall of less than 300 mm, southern Idaho relies heavily on the Snake River for irrigation, aquaculture, and drinking water. In the past decade, Idaho's growth in the dairy industry has made it the 3rd largest dairy-producing state in the nation. Over 70% of dairy cattle reside within the south-centrally located Magic Valley, along with 98% of Idaho's aquaculture. Idaho supplies 70% of the nation's production of rainbow trout (*Oncorhynchus mykiss*), making this species an important economic driver and an appropriate indicator species for the environment. Dairy manure is often applied to the field as a nutrient amendment. However, this also provides a direct route for contamination from less desired compounds including antimicrobials, hormones, and metals. Irrigation water applied to crops moves quickly through the sandy soils to shallow aquifers that drain into the Snake River. Approximately 60% of total aquifer recharge is derived from irrigation with surface water. Thus, any contaminants originating from municipal or agricultural sources and transported through the soils are available in downstream waters reused for irrigation or for aquaculture. The increase in dairy facilities in the region has resulted in the land application of manure potentially containing hormones, antibiotics, and veterinary drugs. The ability of agricultural soils to attenuate transport and obviate the threat of chemicals of emerging concern (CECs) to environmental quality and downstream agricultural operations such as aquaculture is unknown. Project objectives are to quantify potentially harmful CECs, determine the endocrine-disrupting potential of manure-treated samples using fish liver bioassays, and assess the spread of antibiotic resistance genes resulting from manure amendment. Our goal is to determine the capacity of soils in the Eastern Snake River Plain of Idaho to attenuate the transport of biologically active concentrations of CECs contributed from irrigated, dairy manure-amended fields, thereby improving the sustainability of crop production, dairy operations, and aquaculture.



Impact: Our stakeholders include growers, dairy producers, aquaculture workers, the EPA, and inhabitants of the region who rely on the Snake River for water. Ideally, this knowledge will promote the sustainable field-application of dairy manure through a deeper understanding of CEC transport, transformation, and toxicity in the environment.

An extraction process to remove hormones, phytoestrogens, and veterinary pharmaceuticals from dairy manure was developed and optimized for use with High Performance Liquid Chromatography-Mass Spectrometer-Time of Flight (HPLC-MS-ToF). 17α -Estradiol and estrone were found most consistently in manure samples. Manure extractions were then used in a sensitive *in-vitro* bioassay that included hepatocytes from juvenile rainbow trout to measure an estrogenic response. Manure extractions resulted in a higher estrogenic response as compared to background soil extractions. Manure samples obtained monthly from southern Idaho dairy farms are being analyzed by HPLC-MS-ToF to quantify specific compounds and assess the associated estrogenic response.

Because manure can enrich agricultural soil with antibiotic resistance genes (ARG) and mobile genetic elements (MGE) such as plasmids, the proportion of class 1 integrons and IncP-1 plasmids in the bacterial community was assessed by quantitative PCR. Addition of manure had no significant effect on the proportion of these MGE in bacterial communities from soil leachates compared to the fertilizer treatment. Soils have been sampled at three different depths to further analyze the movement of MGE through the soil columns.

Laboratory and field experiments to assess antibiotic, hormone, and pharmaceutical transport are in progress. Undisturbed soils columns from a field site in southern Idaho were amended with dairy manure and leached for 13 weeks. Water collected from those cores was analyzed for relevant chemicals and used in hepatocyte bioassays. We observed a hormonal response that indicated the presence of endocrine disrupting compounds in water collected from both the manure-amended treatment and non-amended control columns. However, our results indicate that dairy manure is not the primary source of endocrine disrupting chemicals to agricultural soils and that manure may serve to decrease the mobility of contaminants. Chemical analysis of field lysimeter samples collected from dairy manure-amended plots and non-amended controls have shown the presence of caffeine, ibuprofen, progesterone, and tetracycline, with no difference in detections between treatment and control plots. Our ongoing investigations have not yielded data suggesting that dairy manure applications to soil at typical rates result in an observable increase in microbial antibiotic resistance or pharmaceuticals and hormone concentrations. Our data will contribute to developing best management practices designed to minimize negative environmental consequences associated with the land application of dairy manure in an irrigated environment of critical importance to three major agricultural industries.

2015-68007-23193

Managing Water for Increased Resiliency of Drained Agricultural Landscapes

PI: Jane Frankenberger, Agricultural and Biological Engineering, Purdue University

Co-PIs & key staff: Ben Reinhart, Eileen Kladvko, Laura Bowling, Bernard Engel, Linda Prokopy,

Purdue University; Matt Helmers, Lori Abendroth, Giorgio Chighladze, **Iowa State University**;

Jeff Strock, **University of Minnesota**; Dan Jaynes, **USDA-ARS**; Kelly Nelson, **University of**

Missouri; Mohamed Youssef, **NC State University** ;

Larry Brown, Brent Sohngen, **Ohio State University**; Xinhua Jia, **North Dakota State University**,

Laurent Ahiablame, **South Dakota State University**

Summary: Drained lands, which comprise at least 20% of US cropland, include some of the most productive lands in the world and can experience both water excess and water deficit within any given year. Storing drained water within the landscape could increase the sustainability of water for agriculture, particularly as intense rainfall and prolonged summer drought are expected to increase under future climate change. Our vision is to transform the process of designing and implementing agricultural drainage to include storage. To move towards this vision, we are determining economic and environmental benefits and costs of storing drainage water at individual sites by monitoring and synthesizing results with a rich network of data from existing and historic sites. Modeling extends our field results temporally to include future climate change, and spatially across the region. We are developing tools to apply the research findings in decision-making on the farm, in watersheds, and in state and national policy, through an iterative process of interaction with stakeholders. Extension and education programs extend the strategies and tools to agricultural producers, the drainage industry, watershed managers, agencies, and policy makers, and educate the next generation of engineers and scientists to design drainage systems that include storage in the landscape.

Impact: During the initial year of the project, our team of 39 researchers and educators across 9 academic institutions and agencies in the Midwest developed a database of 34 experimental drainage sites across 8 states, including **186 site-years of data**. The research sites, of which 16 are currently collecting data, encompass a variety of agronomic, hydrologic, and climate data to allow for characterization of production and water quality impacts of drainage water storage. The database encourages regional collaboration, and enhancements to the agro-ecosystem model DRAINMOD will allow for improved modeling of drainage water storage. Our outreach and education on drainage water storage in the landscape, and education modules on soil and water management concepts to grade 9-12 students and teachers, have reached more than 700 drainage stakeholders. Our website <http://transformingdrainage.org>, and broad and growing network of research, extension, and education

The project database includes data from research sites in 8 states.



provides a foundation for bringing about the long-term vision of transforming drainage to increase resiliency of drained agricultural landscapes.

2013-67019-21378

Persistence and Transport of Veterinary Antibiotics and Antibiotic-Resistant Bacteria in Midwestern Farming Systems

Moorman, T. B.

Summary: Antimicrobials are used in production agriculture to treat disease and promote animal growth, but the presence of antibiotics in the environment raises concern about widespread antibiotic resistance. The goal of this study, which addresses a research priority of the Renewable Energy, Natural Resources, and Environment Program, is to improve the understanding of the fate and transport of veterinary antibiotics, antibiotic-resistant bacteria and genes in soil, surface runoff, and tile-drained water to surface water in agricultural watersheds. The specific objectives are to determine the losses of antibiotics from manured fields in runoff water, tile drainage and water leaching to groundwater; determine the concurrent losses of antibiotic-resistant bacteria and antibiotic-resistance genes from manured fields in runoff water, tile drainage and water leaching to groundwater; and evaluate and improve the capabilities of the Root Zone Water Quality Model to predict losses of antibiotics. The plan to accomplish the goal includes plot- and catchment-scale experiments with different manure sources and management practices to measure the fate and transport of antibiotics, antibiotic-resistant bacteria, and antibiotic-resistant genes and supporting experiments to help parameterize the model. Outcomes include an improved understanding of how antibiotics and antibiotic-resistance bacteria and genes move in Midwestern landscapes, emphasizing the role of macropore flow and other infiltration mechanisms, and a parameterized plot/field-scale model to predict antibiotic transport to water under varying antibiotic application rates and rainfall patterns. The ability to predict fate and transport of antibiotic-resistant bacteria and antibiotic-resistance genes will aid in addressing the long term goal of protecting environmental, human, and animal health.

Impact: The issues of agricultural antibiotic use, antibiotic residues in the environment and agriculture-induced changes in abundance of antibiotic resistant genes are not separate issues, but require integrated approaches such as those described in this project. This research directly addresses the movement of antibiotics and antibiotic-resistance genes in surface runoff and tile drainage from manured fields. Field plot/catchment scale monitoring of antibiotics, antibiotic-resistance genes (ARG) and antibiotics-resistant Enterococcus will be conducted at three locations: Field 5 near Ames, IA (poultry manure); Iowa State University Northeast Research and Demonstration Farm near Nashua, IA (swine manure); and the Pioneer Farm, near Platteville, WI (beef manure). We will quantify losses of focus antibiotics (tetracycline, sulfamethazine and tylosin), related antibiotic resistance genes, and total and resistant Enterococcus in manure, surface soils and tile drainage and/or surface runoff under natural conditions over three growing seasons. Each site will have measurements that allow the direct comparison of the manure-treated area to a control (no manure). Additionally we will conduct rainfall simulation experiments on sub-areas of the selected plots in a manner designed to force surface runoff and obtain macropore flow. These controlled experiments will allow detailed measurement of ARG and antibiotic transport and the data from these studies will be used for calibration of the Root Zone Water Quality Model (RZWQM). We also propose supporting laboratory experiments to identify unknown parameters (for example, sorption and degradation rates) needed for model development and testing. Once calibration of the RZWQM is obtained we will model the field plot/catchment scale data. The experimental work will be accomplished in the first three years of the project with the fourth year devoted to modeling, data analysis, and reporting the results in scientific journals.



2013-67020-21407

Evaluation of Downstream and Ecosystem Water Quality and Quantity through Targeting Conservation Practices in Mississippi

Prem B. Parajuli, Dept. of Agricultural and Biological Engineering,
Mississippi State University, MS

Summary: The BSRW is the most heavily used aquifer in Mississippi. Because the aquifer is primarily used for irrigating crops such as corn, cotton, soybean, and rice, the water levels have been declining rapidly over the past few decades. This study evaluated climate change impacts on stream flow, crop and sediment yields from three different tillage systems (conventional, reduced 1 – close to conservation, and reduced 2 – close to no-till), in the Big Sunflower River Watershed (BSRW) in Mississippi. The Soil and Water Assessment Tool (SWAT) model was applied to the BSRW using observed stream flow and crop yields data. The model was calibrated and validated successfully for monthly stream flow, corn and soybean yields. The Long Ash-ton Research Station Weather Generator (LARS-WG) model was used to generate future climate scenarios. Model outputs showed slight differences among tillage practices for corn and soybean yields due to climate change. However, model simulated sediment yield results indicated a large difference among the tillage practices from the corn and soybean crop fields. On average, the effect of climate change and tillage practice together did not show notable changes to the future crop yields. The reduced tillage 2 practices showed the highest responses of erosion control to climate change followed by the reduced tillage 1 and conventional tillage in this study.

This study also evaluated the effects of various crop rotation practices on groundwater storage and recharge. The model performed well during the calibration and validation periods for daily streamflow and seasonal water table depth fluctuations. The crop rotation scenarios that include rice planting resulted in the lowest groundwater storage compared to the baseline crop scenario, which is due to the high irrigation rates of the rice crop. However, the rice crop rotations resulted in the highest increases of groundwater recharge rates, likely because of the response to the deficiency of ground water needed for irrigation as well as the limited water uptake by the rice crop. The crop rotations with corn and cotton resulted in the largest increases in groundwater storage, which is the result of the low irrigation rates as well as the short time period for irrigation applications. The results of this study helps watershed managers, producers, and farmers to the conservation of groundwater resources and continue maintaining their crop production.

Impact: Students, watershed stakeholders, and producers are the main stakeholders of this project. Preliminary impact of our research work includes updating watershed stakeholders on our research progress with modeling approaches and model outputs through presentation at meeting and conferences. Project objectives, activities, and preliminary project results were presented to watershed stakeholders (local, state, federal level participants) in the Mississippi Water Resources Conference in 2016. In addition, results were presented to national and international audiences through the IBE annual conference, 2016 and ASABE annual international meeting. Two referred journal articles were published in the “Agricultural Water Management” journal. Several topics related to the project (e.g. watershed characterization, climate variability, pollutant source identification, basic modeling concepts, conservation practices, water quality, use of modeling tools) were taught in the classrooms in the Fall of 2015 and Spring of 2016 semester at the Mississippi State University.

2013-51130-21523

Moving Forward on Agricultural Water Conservation in the Colorado River Basin

Reagan Waskom, Peter Leigh Taylor
Colorado Water Institute at Colorado State University

Summary: Agriculture in the Colorado River Basin (CRB) is being targeted as a major source of water to meet the anticipated future gap between supply and demand caused by urban growth, drought, and climate change. While agriculture can do its part, the technological potential for agricultural water conservation is complicated by non-technical barriers—legal, economic, and cultural. Any efforts to conserve agricultural water must be undertaken in ways that do not diminish societal benefits from agriculture: food for a growing worldwide population, ecosystem services and rural community viability. Objectives are our project are:

1. Demonstrate Already Available Technology
2. Identify Barriers to Taking Advantage of Technology
3. Strategize with Ag Producers and Water Managers to Overcome Barriers
4. Share What We Learn to Encourage Action

Impact: The impact of our work can be summarized as follows:

In the Colorado River Basin as a Whole—both Upper and Lower Basins

- Our three websites have reached ag producers, ag water managers, water policy experts and the general public throughout the entire Colorado River Basin and the West with articles and news about ag water conservation and ag water sharing strategies. Included are our summaries of more than 70 examples of ag/urban/environmental water sharing with maps and links to details.
- Our six in-depth case studies of collaboration among irrigators, municipal suppliers, federal agencies and environmental organizations detail examples of how agricultural water can be conserved for dedication to multiple uses. Included are strategies that benefit endangered fish species, allow temporary leasing of ag water for municipal use, generate water from split season irrigation agreements and delivery efficiency improvements for instream flows, and generate saved system water for Lake Mead.
- Our upcoming workshops (one in the Upper Basin and one in the Lower Basin) will convene water policy leaders and ag producers/water managers to determine specific “next steps” that can be taken to optimize agricultural water use in the Colorado River Basin. The workshops will draw on a synopsis of research and projects on alternatives to permanent fallowing, including rotational fallowing, crop changes, deficit irrigation, and irrigation efficiency improvements.
- We have conducted field trips and presented our work at conferences and for dialogue in Colorado River Basin states of California, Wyoming, Utah, and Colorado.

We have concentrated much of our work within the state of Colorado as a means of drilling deeply into specific aspects of the challenge in order to later extrapolate to the CRB. Our long term credibility and knowledge of Colorado specific issues has allowed us to improve statewide and sector wide understanding of what is and is not possible to achieve through ag water conservation. We have facilitated considerable change in how agricultural producers and those from other sectors communicate about ag water conservation, and we have opened up previously closed channels for frank dialogue about how water is used in agriculture to produce benefits to society, and how it might be able to continue to provide those benefits while optimizing the use of water in agriculture for multiple benefits. Our work within Colorado has been primarily focused on demonstrating already available technology and delving into obstacles to utilizing it through extensive work with a farmer-led irrigation efficiencies advocacy group named No Chico Brush.

2013-67019-21363

Interactions Between Antibiotic Resistance In Soil Microbial Communities And Coupled Elemental Cycles

Michael S. Strickland, Katharine F. Knowlton, Brian Badgley, John E. Barrett, Department of Biological Sciences, Virginia Tech, VA

Summary: Antibiotic usage is widespread in the livestock industry but this has recently raised concerns because of its potential to increase the prevalence of antibiotic resistance genes in the environment. While this may have direct consequences for human health and well-being, exposure to antibiotics is also likely to lead to change in the soil microbial community and the ecosystem processes that these communities regulate, such as carbon, nitrogen, and phosphorous cycling. The linkage between antibiotics, microbial communities, and elemental cycles has not been examined. We propose to examine this linkage and expect that antibiotic effects on microbial communities will be akin to a stress-response. That is, while microbial death may occur with initial exposure to antibiotics, the microbial community will begin to develop resistance, leading to increased maintenance demands and decreased microbial growth. The stress-response not only impacts the microbial community but also the elemental cycles it regulates, i.e. stress leads to both greater respiration and mobilization of nitrogen and phosphorus. This means that site fertility and sustainability may be reduced under antibiotic use.

The main goals of this project are to:

1. Investigate the influence of agricultural antibiotic inputs on microbial community composition, activity, and role in C, N, and P cycling in soils on dairy farms across the U.S.,
2. Examine the time course of effects on soil microbial communities and coupled elemental cycles after chronic antibiotic exposure that matches typical inputs under dairy cattle management regimes, and
3. Mechanistically determine the effect and interaction of types of agriculturally relevant antibiotics on soil microbial communities and ecosystem processes.

Impact: The stakeholders for this project include agricultural scientists, dairy scientists, microbial ecologists, soil scientists, and farm managers. While only just begun, our work will identify the broader scale impacts of antibiotic use on soil fertility and sustainability. Additionally, it may highlight which soils are more apt to be impacted by antibiotics.



Figure 5. Stable isotope pulse chase experiment at the Virginia Tech S.C.A.R.E. (Soil Carbon Antibiotic Resistance Experiment) site.

We have developed and implemented both short and long-term stable isotope pulse-chase experiments to directly determine the effect of antibiotic inputs on soil processes (see Figure 1 and 2).

We have examined the effect of antibiotic exposure on soil microbial biomass, physiology, and composition, and its effect on carbon cycling across 11 paired sites (reference sites and sites exposed to dairy cow manure). We found that manure-exposed sites exhibited a greater abundance of antibiotic resistant genes. Additionally, soil communities exposed to manure had mass specific respiration ~2 times that of communities exposed to lower inputs of antibiotics and this increase in mass specific respiration was positively correlated with increasing antibiotic resistant gene abundance. Yet, when exposed to subsequent doses of antibiotics, the communities sourced from manure-exposed sites were impacted less extensively than communities sourced from reference site, indicative of an ecological trade-off. Together these results suggest that soil microbial communities adapt to antibiotic inputs under manure exposure but that this incurs a cost. Such a cost has implications for ecosystem carbon cycling whereby microbial efficiency decreases leading to greater microbial respiration and potentially decreased soil carbon formation or retention. We estimate that manure-exposure and the subsequent maintenance of antibiotic resistance leads to a ~4 metric ton ha⁻¹ median increase respired C.



Figure 6. Initial processing of samples collected from the short-term stable isotope pulse chase experiment.

implications for ecosystem carbon cycling whereby microbial efficiency decreases leading to greater microbial respiration and potentially decreased soil carbon formation or retention. We estimate that manure-exposure and the subsequent maintenance of antibiotic resistance leads to a ~4 metric ton ha⁻¹ median increase respired C.

In addition to the results from the regional scale study, we have also initiated both the short- and long-term stable isotope pulse-chase experiments aimed at elucidating the effect of antibiotic additions on soil processes. The first set of short-term samples have been collected and are currently being analyzed. Thus far, results indicate that administering antibiotics to cattle can have a marked influence on how manure from those cattle influence ecosystem processes. For instance, we observed a ~6.5 metric ton ha⁻¹ difference in respired C between antibiotic treatments. Together the results of our observational scale study and our common garden experiment suggest that exposure to antibiotics may drastically alter soil microbial community structure and ecosystem function.

2013-51130-21486

Smart Phone Apps: Scientific Validation Quantification of Water Conservation

Dr. Kelly T. Morgan, Soil and Water Sciences Department, University of Florida, Florida;
 Dr. Kati Migliaccio, Agricultural and Biological Engineering Dept., University of Florida, Florida;
 Dr. George Velidis, Crop and Soil Sciences Department, University of Georgia, Georgia
 Diane Rowland, Agronomy Department, University of Florida, Florida

Summary: Fresh water supply shortages are increasingly common in the southeast (SE) US. The growing population in this region has been suggested as a key component contributing to this water stress. A recent drought (2007, two years in duration) was more severe than would historically be expected due more to rising water demands (population increase) than decrease in water availability. Another component to consider in water supply sustainability is climate change. A 2010 report indicated that water demands are expected to exceed water supply in many areas of the US which will result in greater drought risks by 2050 (Spencer and Altman 2010). In fact, much of Florida is projected to be at ‘high’ to ‘extreme’ risk of water shortage while water shortage in Alabama and Georgia is projected to range from ‘moderate’ to ‘extreme’.

Project goals:

Simple water balance models for citrus, cotton, peanut, and urban lawn were developed as part of a 2011 NIWQP grant for Florida and Georgia are being validated in replicated research plots. The goal of this project was to validate water conservation using smart phone irrigation apps under commercial production conditions on a regional basis (Florida and Georgia).

Project objectives:

1. Validate the irrigation scheduling models of the Smartphone apps for citrus, cotton, peanut, and urban lawn and quantify their water conservation and crop yield benefits.
2. Modify and finalize apps based on findings from research objectives and stakeholder feedback.
3. Conduct a survey for each app regarding the users’ perceptions and implementation.
4. Conduct in-service training events for county agents and specialists, stakeholders (local, regional, and national venues), develop and maintain a dedicated web site.

Impacts: The knowledge gained/stakeholder impacts from this project were:

Turf App

Irrigation depths applied resulted in significant water savings with the smartphone app and ET controller treatments; irrigation water savings ranged from 42% to 57% compared to the time based schedule. The turf smartphone app irrigation schedule was similar to the ET controllers with savings always significantly greater than the time-based treatment with varying similarities to the two ET controllers.

Cotton app

The Cotton app was validated results in five commercial cotton fields in southern Georgia. The Cotton App outperformed the Checkbook Method in terms of mean yield regardless of tillage treatment and did this most effectively during the two wet years. The Cotton App also outperformed the Checkbook Method in irrigation water applied and water use efficiency.

Citrus app

The Citrus App evaluation was conducted at three commercial citrus orchards in central and south Florida. Use of the citrus app consistently resulted in lower water use. The citrus app used an

average of 24% less water than the grower or current recommended irrigation schedules. Average increase in yield during the three years of the study was 18%.

Peanut app

The peanut app validation was conducted in 2015. Cumulative irrigation applied per treatment was: 5.2, for grower irrigation schedule, 0.5 for the app schedule, and 1.0 for the soil moisture sensor treatment. Therefore, irrigation treatments applied about 90%, 81% less water than the peanut grower's irrigation practices.

New concept and technologies that were developed from this work were:

Turf app

Two limitation of the app is 1) the exclusion of site-specific rainfall, and 2) the app is not directly connected to the automatic irrigation controller. So, the user must manually implement a schedule change at the controller. Thus, some notifications for bypassing irrigation events due to predicted or measured rainfall may not be implemented.

Cotton app

The Cotton App's geographical footprint is currently limited to Georgia and Florida because the app uses data from GAEMN and FAWN. Adding weather networks from other states would expand the numbers of users for this app. Another limitation to use of the Cotton App in other states is that the Kc curve currently used in the model was calibrated to environmental conditions found in southern Georgia and northern Florida.

Citrus app

Two studies determined that citrus trees affected with Greening disease (HLB) use 18% to 24% less water than trees unaffected by this disease. It was also determined that irrigation applied at daily or less frequency benefitted HLB affected trees. Thus a daily irrigation option was implemented.

2013-67019-21406

Improved Assessment of Nitrogen and Phosphorus Fate and Transport for Irrigated Agricultural Watersheds in Semi-Arid Regions

Arabi, M.

Summary: Effective management of nitrogen (N) and phosphorus (P) is essential for maintaining socioeconomic viability and healthy ecosystems in irrigated watersheds. Irrigation systems extend over vast landscapes within many of the river basins in the United States and throughout the world. These systems underpin the nation's most productive agriculture, not only contributing to the vital economic foundation of food and fiber production, but also supporting appealing rural lifestyles, and making possible scenic landscapes in otherwise inhospitable places. The reliance on irrigated agriculture for food production is only expected to increase under the changing climate with more frequent and severe droughts. For the benefits of irrigated agriculture to be enjoyed by future generations will require solutions to the large nutrient-laden flow, generated by excessive irrigation and fertilization, which makes its way back, both over and under the land surface, to stream systems. Thus, enhanced understanding and representation of the complex network of interactions between The overarching goal of the proposed project is to develop and disseminate an enhanced modeling capacity for assessing the movement, transformation, and storage of N and P species in highly managed irrigated agricultural systems, particularly in areas susceptible to severe drought events. The proposed research project will enhance and then integrate three widely-used models, SWAT, MODFLOW, and UZF-RT3, in order to address pressing needs for credible representation of N and P processes in irrigated agroecosystems under varying climatic conditions. The improvements that will be incorporated in the enhanced modeling capacity are: representation of distributed surface and subsurface flow for N and P fate and transport; representation of riparian zones; spatial variability of applied irrigation water and N and P constituents; and biogeochemical processes in the vadose zone and saturated zone such as autotrophic denitrification in the presence of shale.

Impact: What was accomplished under these goals? The SWAT-MODFLOW model is being applied to two semi-arid river basins in Colorado (Arkansas River Basin, South Platte River Basin) and one semi-arid watershed in Texas (Middle Bosque Watershed). Each model will account for hydrologic and nutrient transport processes at the watershed scale. SWAT models are compared with SWAT-MODFLOW models to determine differences in model capability. The project group has met to outline best-management practices that will be used in assessing nutrient dynamics and remediation strategies. The SWAT-MODFLOW-RT3D modeling code is being applied to the Sprague River watershed. Results (nitrate loadings in the stream network, spatially-varying groundwater nitrate concentration) compare well with measured field data. Field data (N and P in groundwater, surface water) have been collected during 3 sampling trips. For each sampling trip, water samples are collected from 22-25 groundwater observation wells and from 10 surface water sites (along the Arkansas River and in its tributaries). Results will assist in model development and model testing in the Lower Arkansas River Valley. The fourth objective is being accomplished with conference papers, workshops, establishing a website, and developing a graphical user interface (SWATMOD-Prep) for model users. The website (<http://swat.tamu.edu/software/swat-modflow/>) contains workshop material, a tutorial, the model executable, and the model source code. Everything is publically available.

2013-51130-21489

An Integrative Decision Support System for Managing Water Resources under Increased Climate Variability

Jon Bartholic¹, Stephen Gasteyer², Phanikumar Mantha³, Glenn O'Neil¹, James Duncan¹, Jeremiah Asher¹, Jason Piwarski¹, Lois Wolfson¹

¹Institute of Water Research – Michigan State University

²Department of Sociology – Michigan State University

³Department of Civil and Environmental Engineering – Michigan State University

Summary: As a growing global population increases the demand for food production, effectively managing water resources in agriculturally-dominant regions will be critical. The sustainability of those resources will be dependent on planning for and adapting to projected climate changes in the long-term.

The goal of this project was to develop and disseminate a decision support system (DSS) that reports hydrologic outputs from a diverse set of models, under multiple future climate scenarios, so that agricultural producers, and water resource policy-makers and managers can develop sustainable water strategies for their operations, communities, and ecosystems. A diverse team of modelers, web-developers, social scientists, and outreach specialists collaborated to develop a pilot version of such a system for the Kalamazoo River and Prairie River watersheds in southwest Michigan. While efforts have been made to develop better water management tools, too often this has been done without thoroughly incorporating the perspectives, perceptions, knowledge and experiences of farmers and others involved in day to day water management. This project aimed to incorporate these elements through meetings and interviews with farmers, corporate representatives, non-governmental organizations, and municipal officials about groundwater use issues in the targeted Michigan counties.

The project's objectives were:

1. Simulate hydrologic changes under multiple future climate scenarios for piloted areas of southwest Michigan.
2. Disseminate those model results through an online DSS.
3. Analyze reports by local entities on water management.
4. Conduct interviews with key local informants (farmers, municipal officials, others) about perceptions of groundwater management issues, challenges and opportunities in the target counties of our study and incorporate these findings into the DSS design.

Impact: Daily projections of four future climate models, drawn from the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset and the International Panel on Climate Change (IPCC), were fed into three hydrologic models: the Soil and Water Assessment Tool (SWAT), the Process-based Adaptive Watershed Simulator (PAWS), and the Analysis of Flows in Networks and Channels (AFINCH). These models projected changes in stream flow, groundwater recharge, evapotranspiration (ET), water table depth, and growing degree days through 2099.

Initial model results reflected trends of increasing water volume and an earlier, longer agricultural growing season. These outputs were mainly driven by a trend of increasing annual precipitation in the four climate models from CMIP3 and IPCC, despite similar increases in annual temperature. The higher water volumes generally translated in higher average annual streamflow, but some models

reported varying results with regard to the partitioning of surface precipitation between groundwater recharge and ET. In the climate scenarios which CO₂ concentrations steadily rose over time, SWAT simulated an improvement in plant water-use efficiency, which triggered a decline in ET and an increase of recharge in the latter half of the century. In contrast, PAWS projected the higher temperatures in these high-CO₂ scenarios to increase ET and keep rates of recharge relatively flat. At the time of developing the prototype DSS, only SWAT and AFINCH results were available, therefore initial users could only explore projections from those two models. The PAWS modeling was recently completed and thus a more detailed analysis of the differences in SWAT and PAWS results is underway, and will guide a subsequent refinement of the DSS.

The modeling and DSS development was informed by the engagement and surveying of key stakeholders in the region. Conservation organization officials were contacted and asked to garner what information could be culled from reports written by these organizations about groundwater management efforts in the target counties and watersheds. Extensive conversations were conducted with key informants associated with conservation efforts (including conservation organization representatives, key municipal and elected officials, and farm organization representatives). Next, meetings were held with the county farm bureau offices in the targeted counties to present the project and help identify suitable key informants. Some 40 farmers were interviewed along with municipal planners, utility operators, agribusiness officials, crop advisors, and conservation organization officials.

Analysis indicated a dramatically different orientation of farmers toward water and water management among farmers, than among many at the modeling and policy level. Farmers often possessed significant knowledge about field level hydrology that needs to be better accounted for in water management modeling and policy development. Furthermore, there was an understanding of local biodiversity and species population dynamics that needs to be built upon. At the same time, farmers talked about the challenge of water management with increased farm size, decreased diversity of cropping systems, and decreasing degrees of freedom given the dominance of corporate contracting in farming. Indeed, findings indicate that farmers are often significantly constrained by the terms of contracts with regard to applying water use conservation technologies or practices. At the community level, water use is driven not only by population growth, but also by industries that are increasingly dependent on groundwater for production, such as food process and seed corn processing.

The analysis of this data has resulted in 3 academic manuscripts:

- 1) Gasteyer, S., J. Lai. Convening Irrigators: Large Quantity Water Use Regulation in Michigan. *Regulations and Governance*.
- 2) Gasteyer, S. Irrigating Lakeland: Sociotechnical Imaginaries and Groundwater Management in Michigan. *Social Studies of Science*
- 3) Lai, J. and S. Gasteyer. The battle over creeks: water translations in Southwest Michigan. *Rural Sociology*

The findings have led to increasing conversations about how to better incorporate field level farmer knowledge into water use and water quality modeling (the subject of a recently submitted NIFA proposal. Additionally, there are now increased efforts to include not only farmers, but also agribusiness representatives in discussions about water management strategies. Additional reporting of results will be shared with stakeholders at the end of October 2016, however, this research has resulted in ongoing conversation about how to better incorporate farmer knowledge into models to improve groundwater management and use.



2012-67019-19434

Twenty-First Century Development of 21st Century Precision Agriculture for Water Quality Protection

Walter, M. T.; Stedman, R. C.; Easton, Z. M.; Faulkner, J.; Benham, B. L.

Summary: The goal of this project is develop a Decision Support System (DSS) for making day-to-day land management decisions to protect water quality. The DSS predicts runoff source areas (i.e., hydrologically sensitive areas or HSAs) in the landscape based on weather forecasts applied to a watershed model and displays the predictions on a Google(TM)-like map. Users can interact with the HSA-DSS via various mobile devices (e.g. iPad, smartphone, GPS) or desk/laptop computers. Knowing where runoff sources areas are likely to be, landowners can, for example, prioritize potentially polluting activities like manure spreading or pesticide applications to parts of their land that are NOT likely to generate storm runoff. One unique component of this project is that we will directly engage potential stakeholder-users in the development of the HSA-DSS, allowing them to provide instantaneous feedback to the developers via email or various social networking sites (e.g. Facebook, twitter, etc.). This novel development approach allows scientists and landowners to communicate directly with each other, thus ensuring that the technology developed is appropriate and operational by the intended users. Using the instant-feedback, regular meetings, and in-depth interviews, we will evaluate how readily the technology adoption diffuses to a broader sphere of users. The project will be co-located in three watersheds in the Eastern US (NY, WV, VA), representing distinctly different landscapes and social characteristics. Part of this this project's objective is to determine how well we can predict runoff source areas in these different parts of the region; this will be done through regular, multi-year soil moisture monitoring. We will also partner with on-going, independent water quality monitoring activities in the NY-watershed to determine how much impact introducing the HSA-DSS to landowners has on changes in short-term (3-yr) water quality.

Impact: What was accomplished under these goals? Objectives O1 and O2 have been achieved for the NY team using a new watershed simulation model. The VA team has a proof-of-concept for O1 based on the SWAT model. Activities to address O3 are continuous. A no-cost extension has been requested to fully address objectives O4 and O5.

2013-51130-21530

Expanding Consumer and Community Water Protection Efforts through Innovative and Integrated Mobile Technologies

Michael Dietz and David Dickson, Department of Extension, Center for Land Use Education and Research (CLEAR), University of Connecticut

Summary: The problem being addressed by this project is water pollution from stormwater runoff. Additionally, the project addresses a gap in technology by allowing citizens to have mobile access to tools to see where existing low impact development techniques are installed, as well as how to actually install a rain garden on their own.

The main goals of this project are as follows:

To encourage the use of low impact development (LID) techniques by consumers and communities through the development of nationally applicable, but locally relevant, mobile smartphone and tablet applications (apps) and a system for tracking the impact of their use. The first app will expand the Connecticut-based rain garden app to at least 15 other states around the country. The second app will allow users to access UConn's National LID Atlas, to see where various LID practices have been installed near them or add new installations to the database.

Impact: Our stakeholders are town municipal officials, landscape professionals, landscape designers, public works staff, engineers, and individual homeowners. These stakeholders are in numerous states around the country.

The first year of this project was primarily focused on collecting data from members of the national advisory team (representatives from each of the states involved), and updating the app to include sizing and plant requirements for the various states. Year two was primarily focused on the programming required to expand the rain garden app nationally. Updated iOS and Android versions of the rain garden app are now available.

Highlights of this app include:

Soils data for CA, CT, DE, FL, GA, HI, ME, MA, MD, MN, NE, NH, NJ, NY, NC, OH, OK, OR, PA, RI, SC, VT, VA, WA

Plant lists & sizing data for CT, DE, GA, HI, MA, MD, ME, MI, MN, NC, NH, NJ, NV, OH, OR, PA, RI, SC, VA, WA, VT

A keyword search of the "notes" field in the Plant Selector

Includes additional plant types (rush/sedge, ferns)

Year three has been focused on development of the mobile LID atlas app. The app was created in HTML, so it is functional on both iOS and Android operating systems. It is currently fully functional can be viewed at <http://s.uconn.edu/lidmapdev>, however it has not been publicly released as our designer is currently updating the visual components of the interface. It is expected that it will be released publicly in early September 2016.

New technologies are the primary focus of this project. The smartphone apps described above will provide a high-tech means of getting relevant information into stakeholders' hands, when and where they need it. **Since its release in 2015, the national iOS version of the rain garden app has been downloaded 5,574 times.**

To date, new knowledge gained has been through gathering information from the advisory committee. Now that the app has been distributed nationally, we will be able to collect feedback and usage data from educators promoting the apps, as well as from users of the apps.

2013-67019-21404

Coupling Solid-Aqueous-Gas Phases of Carbon and Nitrogen Across Topographic Gradients And Extreme Weather Events

Vargas, R.

Summary: Understanding how biological systems respond and feedback to a changing climate is one of the most pressing issues of our time. The USDA vision statement includes the goal to "preserve and conserve USA natural resources through restored forests, improved watersheds, and healthy private working lands." Furthermore, extreme weather events, like hurricanes and droughts, influence the full range of greenhouse gas (GHG) fluxes from soils. This is important because changes in the emissions of these GHG will impact the global warming potential of terrestrial ecosystems. Thus, in order to address global pressing issues and country level environmental/agricultural management needs, there is a need to better understand how climate variability influence key ecosystem processes in natural, managed and urban ecosystems including their feedbacks to a changing climate. We will combine in situ measurements in an ex-urban forest (protected as a State Park) and a climate change experiment under controlled scenarios (at the University of Delaware). We will measure solid, aqueous and gas phases of C and N to understand their interactions with the potential of GHG emissions from soils. We will use state-of-the-art instrumentation to continuously (hourly resolution) measure the major GHGs such as carbon dioxide, methane and nitrous oxide. The target audience will be: a) the scientific community by publishing scientific manuscripts; b) local managers by sharing results through the Extension center of the University of Delaware, and talking directly with the managers at the experimental study site (Fairhill State Park); and c) the general public through news release through UDaily (the news from the University of Delaware). The overall goal of this proposal is to understand how weather variability (especially extreme events in dry or wet years) influences the key ecosystem processes of nutrients and soil GHG fluxes in ex-urban forests. The effect of extreme events on ecosystem processes is becoming critical because during the last decade, different regions of the USA, including the Mid-Atlantic region, have experience extreme weather including droughts and hurricane. An unaccounted damage of these extreme events is that they can influence substantially the annual sums of C and N fluxes from landscapes, and therefore influencing the feedbacks of these ecosystems to local and regional climate. These unaccounted effects of extreme events are usually not considered in ecological assessments as they are "invisible effects", but could account for >\$900 ha⁻¹ due to an increase in GHG emissions from soils.

Impact: Field measurements The goal for these activities will be to provide information to test H1 and H2. To test H1 we will select four hillslope transects within the 12 ha watershed at the study site during fall 2013. At each transect we will select three locations representing the bottom, middle and top of the soil catena. At each location we will install three GHG monitoring nodes (GHG-MN) to measure monthly soil moisture, soil temperature, CO₂, CH₄ and N₂O fluxes. At the same locations we will measure soil and aqueous chemistry for C and N. Soil samples will be collected from O, A and B soil horizons once a year. Soil aqueous samples will be collected using suction lysimeters. At each topographic location, lysimeters will be inserted vertically to a depth of 15 cm into the soil A horizon. A suction of 60 centibars will applied prior to the day of sample recovery. Lysimeter sampling will occur once a month irrespective of weather conditions. All water samples will be recovered within 24 hours of a precipitation event and will be filtered using 0.7 µm glass fiber filter and stored in amber glass bottles at 4°C prior to analyses. The collected water and soil samples will be analyzed for the various constituents described in the paragraphs below. In addition, we will measure monthly soil moisture, soil temperature, CO₂, CH₄ and N₂O fluxes at 50 GHG-MN randomly located across the watershed to capture spatial variability.



2014-67019-24024

Biological and Biologically Mediated Abiotic Transformation of Contaminants of Emerging Concern in Anaerobic Soils

Timothy J. Strathmann (Civil and Environmental Engineering, Colorado School of Mines, CO)

Alison M. Cupples (Civil and Environmental Engineering, Michigan State University, MI)

Summary: The growing use of municipal wastewater plant (WWTP) effluents for irrigation raises concerns because of the presence of trace contaminants of emerging concern (CEC) in these waters. Further, the land application of WWTP biosolids represents another CEC exposure pathway to agricultural systems. Both practices deserve attention because of the potential for human exposure by entering the food chain through transfers into plants. In addition, there is the potential for the development of drug-resistant bacterial populations, including pathogenic microorganisms, in soils continuously exposed to sub-therapeutic levels of antimicrobial agents. This research aims to provide a more quantitative understanding of the CEC fate-controlling processes and the active soil microbial community in CEC-impacted agricultural soils. The work will enable more accurate predictions of the fate, persistence, and biological impacts of CEC introduced to agricultural production systems.

The overall goal of this work is to develop an improved understanding of biological and abiotic processes that control the persistence and transformation of CEC derived from wastewater effluent in anaerobic soils under varying redox conditions. Activities address three major objectives: (1) assess the influence of terminal electron accepting processes (TEAPs) and redox-active soil properties on the rates and pathways for CEC transformation; (2) develop a core microbiome associated with the impacts and biodegradation of CEC; and (3) identify major CEC transformation pathways and CEC structure-reactivity in anaerobic versus aerobic soil.

Impact: Work to date demonstrates abiotic reductive transformation of selected CEC in the presence of soil constituents and biogenically reduced species that are abundant in anaerobic soil systems (e.g., ferrous iron, reduced sulfur). Work shows for the first time that emerging organophosphate flame retardants detected in WWTP effluent are subject to hydrolytic transformation catalyzed by soil minerals and mineral-adsorbed ferrous iron. The phylotypes and functional genes associated with carbamazepine (CBZ) biodegradation in soils were also identified using high throughput sequencing and a computational approach to predict functional composition of the metagenomes (phylogenetic investigation of communities by reconstruction of unobserved states, PICRUSt). CBZ biodegradation was only observed in one soil under aerobic conditions. In this soil, several phylotypes were enriched following CBZ biodegradation, including unclassified Sphingomonadaceae, Xanthomonadaceae and Rhodobacteraceae, as well as Sphingomonas, Aquicella and Microvirga. These phylotypes are considered putative CBZ degraders as they appear to be benefiting from CBZ biodegradation. These findings support the use of PICRUSt as a predictive tool for identifying soils with an enhanced CEC biodegradation capability. Future research will examine the influence of TEAP conditions on degradation of a large suite of CEC and the potential of PICRUSt to predict CEC removal rates in different agricultural soils. This research is important to stakeholders because restricting the application of WWTPs effluent and biosolids to soils with an enhanced ability for CEC biodegradation could reduce the risk of human exposure to CECs.

2013-67019-21371

Multi-Scale Investigation of Winter Runoff and Nutrient Loss Processes in Actively Managed Dairy Agroecosystems

K.G. Karthikeyan¹, Peter Vadas², Francisco Arriaga³, Melanie Stock³, Laura Good³,
Bill Jokela (Retired)⁴

Biological Systems Engineering, University of Wisconsin-Madison, WI¹

U.S. Dairy Forage Research Center, USDA-ARS, Madison, WI²

Soil Science, University of Wisconsin-Madison, WI³

U.S. Dairy Forage Research Center, USDA-ARS, Marshfield, WI⁴

Summary: Agricultural nutrient management is an important area of research and policy development due to water quality degradation by nitrogen (N) and phosphorus (P). Manure application to fields without incorporation can be a significant source of N and P loss in runoff. Winter application of dairy manure, which is commonly practiced, is risky given frequent occurrence of runoff from snowmelt and rain-on-snow events. Many states restrict winter spreading of dairy manure, but little process-oriented research of winter runoff and manure nutrient loss has been conducted to support restrictions. Our project is investigating and improving the understanding and modeling of biochemical and physical processes controlling frozen-soil and snowmelt infiltration, runoff, and nutrient loss from soil and applied manure for actively managed dairy systems. Our objectives are to: i) conduct multi-scale experiments to investigate processes controlling winter runoff and nutrient loss from soil and manure; ii) develop novel model routines for winter manure runoff that can be incorporated into process-based, field and watershed-scale models; and iii) use runoff monitoring data to evaluate new model routines.

Impact: Our results are informing policy, guidelines, and prediction tools in northern-tier U.S. states where winter manure application is practiced. Stakeholders include policy makers and extension agents helping to develop manure application guidelines and farm practices, as well as scientists involved in measuring and modeling nutrient loss in runoff from winter-spread manure. Experimental results are novel because there has been little to no process-level research of N and P loss in runoff from winter-applied dairy manure. Results are helping to develop new prediction tools that assess N and P loss from agroecosystems and evaluate if new practices and technologies can reduce that loss. We have completed several lab-scale experiments investigating nutrient release from manure to water as a function of water temperature, which helps determine the rate of nutrient release from manure during snowmelt events. We generally find that temperature does not impact manure nutrient release. Lab-scale tests on nutrient leaching from manure to melting snow water as a function of manure application rate and placement within a snow-pack have been completed as well. We generally find that manure placement does not impact overall nutrient release. As for application rate, the amount of nutrient release during snowmelt is a function of the ratio of manure mass to melting water volume. The amounts of nutrients released are consistent with amounts observed during the lab temperature experiments for liquid manure, but the nutrient release amount is less for solid manure. We hypothesize that this may be due to incomplete mixing between snowmelt water and manure solids during a gradual melt event. We have also completed lab-scale experiments investigating nutrient loss in runoff from manure placed on top of soil during snowmelt and as a function of manure placement in the snow pack. We find the amount of nutrient loss in runoff is consistent with that observed during snowmelt experiments without soil. All these lab results are being more fully processed and analyzed for publication. We have conducted an initial modeling analysis and find our current model successfully simulates P loss in runoff from winter-applied manure. Our analysis suggests snowmelt

events represent a significant time of manure P runoff and that shifting manure application out of winter periods can greatly reduce P loss. A manuscript from this analysis is currently under review.

We completed the first year (2015-2016) of the field-scale experiment, in which nutrient losses in runoff were compared between conventional versus no tillage and manure application timing treatments (unmanured controls, early December applications to frozen ground prior to snowfall, and late-January applications to snow-covered frozen ground). We aimed to apply liquid dairy manure (2-3 % solids) at a rate of 65.4 kL ha⁻¹ (7000 gal ac⁻¹) to test the maximum application rate allowed in Wisconsin. We found, however, that 37.4 kL ha⁻¹ (4000 gal ac⁻¹) was the maximum rate that could be applied without generating immediate runoff from manure, indicating the maximum hydraulic loading of medium-textured soils with 5% slope may be overestimated. Therefore, the application rate was decreased to 37.4 kL ha⁻¹. During the 2015-2016 monitoring season, nine runoff events occurred between 11/30/15 – 3/30/16, five of which occurred on frozen soil. Generally, the use of conventional tillage decreased runoff and nutrient losses. Plots with no-tillage produced runoff in all nine events; in each of these events, an average of 78% of the no-till plots generated runoff. Plots with conventional tillage produced runoff in two of the nine events, with an average of 15% of the plots generating runoff per event. The reduction in runoff from the conventionally-tilled plots – regardless of their manure timing treatment – is attributed to the surface depressional storage created by the tillage operation, which provided additional time for the meltwater to infiltrate the soil. We generally found that the manure timing treatments did not produce significantly different volumes of runoff from the unmanured controls.

Runoff samples were analyzed for total solids (TS), volatile solids (VS), total Kjeldahl N (TKN), total N (TN), total Kjeldahl P (TKP), dissolved reactive P (DRP), electrical conductivity (EC), and pH. In general, nutrient concentrations were significantly different between conventional tillage and no-tillage. Applying manure to unfrozen soil in December produced significantly greater VS, TKN, TN, and TKP concentrations in the first event post-application, but treatment effects were not significantly different in subsequent runoff events. Manure applications to frozen soil (January application) generally had significantly greater TKN, TN, TKP, DRP, and EC in the following three runoff events. Nutrient data have been processed with a series of t-Tests; a Generalized Linear Mixed Model (Proc GLIMMIX) analysis of the data is in progress.

The analysis of the mechanistic data from the coupled water-energy balance, which was measured to quantify snowmelt dynamics in response to tillage and manure applications, is also in progress. Supplementary data that will be incorporated into the winter water-energy balance include soil water characteristic curves, saturated hydraulic conductivity, particle size analysis, EC of snow samples, and albedo estimation from digital imagery. Our preliminary analysis generally indicates that the hydraulic loading capacity of soil near saturation or frozen soil conditions may be over-estimated by current standards. The use of conventional tillage might significantly reduce wintertime runoff by providing surface depressional storage for snowmelt. Manure applied earlier versus later in the freezing season (i.e., December vs January) reduces cumulative nutrient losses, likely because the soil infiltration potential is reduced as soil frost formation increases during the winter season.

Oral Session III
(Salon III)

2013-67019-21394

Grazing Management Effect on Micro- and Macro- Scale Fate of C and N in Rangelands

Martha Mamo¹, Jeff Bradshaw¹, Richard Ferguson¹, Kent Eskridge¹, Kenneth Evans¹, John Guretzky¹, Walter Schacht¹, Jerry Volesky¹, Patrick Wagner¹, Anita Wingeyer², Haishun Yang¹

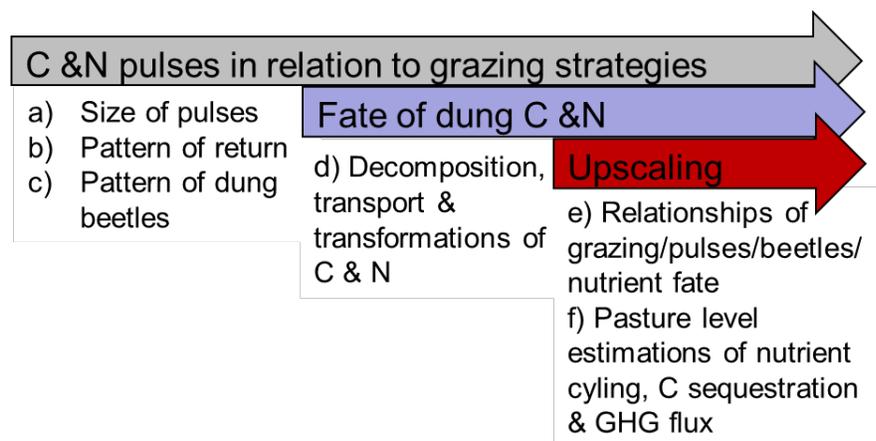
¹University of Nebraska-Lincoln

²Instituto Nacional de Tecnologia Agropecuaria -EEA Paraná- Argentina

Summary: This project is a multidisciplinary research approach to evaluate physical and biological processes affecting the transport, transformation, losses and storage of nitrogen (N) and C pulses induced by grazing. While there are several components to this project (see figure below), we report here the effects of dung beetle activity on the fluxes of GHG (CO₂, CH₄, N₂O), dung decomposition, and soil nutrient changes from dung pats that were exposed and unexposed to dung beetles in the semi-arid meadows of the Sandhills region of Nebraska. While higher fluxes of CO₂ and N₂O, and lower fluxes of CH₄ due to dung pat exposure to dung beetles were observed, these effects were not consistently significant in all seasonal experiments. Dung pat exposure to dung beetles increased the rates of mass loss in field moist dung pats, as well as rates of moisture loss. While higher concentrations of nutrients from dung pats in soil were observed, dung beetles had a minimal impact on the soil nutrient concentrations below decomposing dung pats. This study suggests that dung beetle within subirrigated meadows of the semi-arid Sandhills may not be significant in increasing GHG emission.

Impact: Our Stakeholders include: Scientific community, ranchers, extension educators, undergraduate and graduate students

The knowledge of how the spatial and temporal pattern of nutrient return in rangeland ecosystems can influence nutrient cycling at the landscape scale will benefit the livestock industry but also society through contribution to the long-term mitigation of GHG. The project is utilizing aerial platform technology for spatial and temporal analyses of nutrient pulse distribution in low stocking and high stocking density pastures. The project personnel collected over 4000 dung beetles across three ranches with 22 dung beetle species; and there were 20 new county records between Rock and Brown counties in Nebraska.



The components of the integrated multidisciplinary project in rangeland ecosystem

2013-67019-21384

Denitrification within Saturated Riparian Buffers Re-Designed To Remove Nitrate from Artificial Subsurface Drainage

Thomas Isenhart, Natural Resource Ecology and Management, Iowa State University; Kirsten Hofmockel, Ecology, Evolution, and Organismal Biology, Iowa State University; Dan Jaynes, USDA-ARS-NLAE; Tim Parkin, USDA-ARS-NLAE

Summary: This project is quantifying nitrate (NO_3) removal from artificial subsurface (tile) drainage from cropland that has been diverted as shallow groundwater within riparian buffers (*saturated buffer*). The overarching goal of this project is to advance our understanding of the mechanisms by which saturated buffers remove NO_3 . Our overall hypothesis is that NO_3 is removed within saturated riparian buffers by denitrification and that the process goes primarily to the end member of di-nitrogen (N_2) gas with little nitrous oxide (N_2O) production – a powerful greenhouse gas. Specific objectives are to: 1) quantify NO_3 loss within saturated buffers established under a range of conditions; 2) determine the mechanisms by which NO_3 is processed within saturated buffers; and 3) inform the development of criteria under which saturated buffers are being implemented as a conservation practice. The project evaluates the physical, biogeochemical (including microbial), and coupled processes affecting the flow, fate and transport of NO_3 within tile-drained croplands.



Impact: Over ten field-years of observations have demonstrated the significant potential of saturated buffers to remove nitrate from agricultural subsurface drainage. This research has documented total nitrate removed, nitrate removal as a fraction of nitrate delivered to the tile outlet, and the cost of nitrate removal per kg of nitrate-N removed. The project has also identified site characteristics known to limit the performance of installed saturated buffers.

Potential denitrification within the saturated buffers is assessed using the acetylene inhibition method. Denitrification rates were found to vary greatly, with ongoing research assessing potential limiting factors. Greenhouse gas fluxes are measured from the soil surface and dissolved gas concentrations measured from seepage water moving through the buffer. Nitrous oxide emissions from saturated riparian buffers were found to be greater than unsaturated riparian buffers. Dissolved nitrous oxide concentrations were greatest closest to the distribution tile and negligible at the stream edge. These data suggest greater rates of incomplete denitrification in saturated buffers compared to unsaturated riparian buffers.

Saturated buffers are being rapidly adopted as a practice to reduce nitrate loss from subsurface drainage. This research has been translated into the USDA-NRCS Conservation Practice Standard Code 604 – Saturated Buffers.

2013-67020-21352

Seed Grant to Determine Molecular Speciation of Phosphorus in Soils from a Long-Term Dairy Manure Amendment Trial in Idaho

Daniel Strawn, University of Idaho, Moscow, Idaho

Summary: Growth in the dairy industry in Idaho has created a surplus of manure that may be a useful source of fertilizer for crops. The purpose of this project was to determine the effects of manure amendments on phosphorus (P) speciation in the calcareous soils of southern Idaho. Sequential extraction, nuclear magnetic resonance (^{31}P -NMR) spectroscopy, microbe analysis, and x-ray absorbance near-edge spectroscopy (XANES) analysis were used to analyze changes in the soil caused from manure amendments over a three-year period.

Adsorption experiment were also conducted to examine the impact of manure on P adsorption to calcite, which is a major sink for P in soils. Speciation in the adsorption experiments was analyzed using P L-edge and K-edge X-ray absorption spectroscopy.

Impact: Speciation analysis of the manure amended soils shows that P in the soils primarily existed as Ca-P minerals (54-74%), along with adsorbed phosphorus (25-35%) and organic phosphorus compounds (which were primarily monoesters and diesters).

Results from the P adsorption on calcite experiments showed that percent P adsorbed dropped significantly in the presence of manure. XANES analysis also found distinct differences in the P minerals formed in the presence of manure, suggesting manure affects P solubility and mineralization.

In this project we explored the limits of determination of P speciation in soils, and used the results to understand how manure amendments change P speciation in calcareous soils. Understanding the speciation of P in soils will lead to better soil and manure management to limit off-site nutrient transport.

Results from this work are being used on a long-term dairy manure amendment study. The goal of the study is to provide guidance to dairy manure waste handlers for how best to use the manure as a soil amendment to promote crop growth, but limit off-site leaching of nutrients to surface and ground waters. Results from this study for the initial three years of the project have been provided to the scientific team overseeing the long-term study. As the long-term study continues, future research will utilize results from this study to understand how P speciation and P availability change.

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Processes Controlling the Source, Movement, and Release of Soil Phosphorus in Midwestern Streams from Pasture and Crop Land

Richard Schultz, Natural Resource Ecology and Management, Iowa State University; Thomas Isenhardt, Natural Resource Ecology and Management, Iowa State University; John Kovar, USDA-ARS-NLAE; James Russell, Animal Science, Iowa State University; Keith Schilling, IIHR, University of Iowa; Michael Thompson, Agronomy, Iowa State University; Mark Tomer, USDA-ARS-NLAE

Summary: This research identifies and quantifies key processes controlling the release and transport of phosphorus in Midwestern streams. The central hypothesis of the research is that P flux to receiving waters can be reduced by site-specific management of soils and sediments with the greatest risks of P release in a watershed. Specific objectives of the research are to (1) quantify annual flux of sediment-bound P from channel erosion; (2) quantify annual flux of soluble P; (3) determine how adsorption/desorption and precipitation/dissolution processes regulate P mobility; and (4) estimate the net contributions of channel, groundwater, and overland flow sources of P loads. This research is being conducted in the Walnut Creek Watershed, an intensively managed agricultural watershed in central Iowa; it utilizes an existing monitoring network and leverages long-term datasets.



Impact: Repeated measurements of channel cross-sectional area, erosive channel length, lateral streambank recession, and streambed sediment storage have occurred between 1998 and 2016. Channel cross-sectional measurements suggest the majority of channel length has continued to degrade and widen over the entire period, with a mean annual degradation of $2.5 \text{ m}^3 \text{ m}^{-1}$. Lateral streambank recession rate has fluctuated within a range of -0.64 (i.e., deposition) to 34.2 cm yr^{-1} . Relating site-specific stream bank recession measurements, stream discharge, and time-lapse photography is assisting to identify the dominant erosional processes (e.g., hydraulic, slumping, subaerial) associated with individual stream bank stratigraphic members.

Additional studies are focused on the distribution and transformations of solid-phase P in the sediments, P sink/source status of the sediments under varying physicochemical conditions, potential P release from the sediments to the stream water at varying redox potentials. Under all physicochemical treatments, it was more likely that the in-stream deposits would act as sources than would bank sediments or the floodplain soils. Among the four bank sediments of Walnut Creek, the younger sediments with more organic matter had greater labile and slowly cycling P associated with Fe, reflecting a greater potential to contribute to elevated levels of P in the stream water. Research results are being used to inform the science and technology-based frameworks to assess and reduce nutrients to Iowa waters and the Gulf of Mexico.

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Soil Health and Water Quality Impacts of Growing Energy Beets for Advanced Biofuel Production in North-Central United States

Zhulu Lin¹, Jasper Teboh², Michael Ostlie², Blaine Schatz², David Ripplinger³, Jill Motschenbacher⁴

¹*Agricultural & Biosystems Engineering Department, North Dakota State University, Fargo, ND*

²*Carrington Research & Extension Center, North Dakota State University, Fargo, ND*

³*Agribusiness & Applied Economics Department, North Dakota State University, Fargo, ND*

⁴*School of Natural Resource Sciences, North Dakota State University, Fargo, ND*

Summary: Non-food grade energy beet is being bred solely for biofuel feedstock in the US. Energy beet can reportedly be grown on moderately salt-affected marginal land, thus providing economic benefits to producers. Energy beet also plays a role in nutrient cycling in soil profile affecting subsequent crops in rotation. As a non-mycophytic plant, energy beet may reduce microbial population and activities in the soils following beet production, which has led to the so-called corn-following-sugar beet syndrome. Some also report that soil compaction due to high traffic during harvesting can lead to enhanced soil erosion. Therefore, our project will assess the impacts on soil health, crop performance and downstream water quality when growing energy beet for biofuel production at a large scale. Specifically, we will

- (1) Conduct field experiments to assess the impact of growing energy beet on soil physical and biological properties and the performance of subsequent crops in rotation;
- (2) Improve and apply the Decision Support System for Agrotechnology Transfer (DSSAT) and the Root Zone Water Quality Model (RZWQM2) model to simulate crop yield, water flow, and fate and transport of nitrogen in energy beet fields;
- (3) Develop an integrated biophysical, economic and GIS-based transportation model to examine the supply of beet-bioethanol from five potential sites in North Dakota; and
- (4) Apply Soil and Water Assessment Tool (SWAT) to simulate the downstream water quality impact caused by energy beet biofuel production at the watershed scale.

Impact: Three four-year rotations, beet-corn-soybean-wheat (R1), soybean-corn-soybean-wheat (R2), and beet-corn-beet-wheat (R3), were arranged in a randomized complete block design with four replicates to study the effect of energy beet on corn production in rotation (Fig. 1). We observed widespread purple corn leaves in the plots preceded by energy beets, a symptom caused by P deficiency in early corn development. Although crop yields were not significantly different, the average plant height and starch content in the plots preceded by energy beets were significantly shorter or lower than those preceded by soybeans. Interestingly, the effect on protein content in corns was reversed. That is, the protein content was significantly higher following energy beet than soybeans.



Figure 1. Field study experimental design. Note: soil water quality samples collected at the plots with underlined numbers.

In terms of crop-soil interaction modeling, we have modified Crop and Environment REsource Synthesis (CERES) Beet model and incorporated it into DSSAT, which was in turn linked to RZWQM. Both models were calibrated and validated against the field data collected at our experimental plots (Fig. 1) in 2014 and 2015. Parameter estimation and sensitivity analysis were conducted using PEST software. We are in collaboration with the model developers to include the Beet module into the next official releases of DSSAT and RZWQM. We have already received inquiries about the Beet module in DSSAT and RZWQM after our paper was presented at the ASABE conference.

We have completed land use change simulation surrounding five potential beet bioethanol plant sites in North Dakota using a GIS-based biophysical-economic transportation model developed by our economists. Our study finds that beet bioethanol could provide net benefits to farmers and ethanol producers in the region, under current market conditions, but only if the bioethanol plant site is carefully selected.

2013-67019-21359

Biogeochemical Iron Cycling in Subalpine Wetlands with Different Hydraulic Connectivity: Impact on Fate and Transport of Organic C and N

Thomas Borch, Eugene Kelly and Ellen Daugherty, Department of Soil and Crop Sciences, Colorado State University, Colorado

Charles Rhoades, USDA Forest Service, Colorado

Céline Pallud, Jeanne Barreyre, Kathrin Schilling and Linden Schneider, Department of Environmental Science, Policy, and Management, University of California, Berkeley

Summary: The goal of the proposed research project is to develop a mechanistic and kinetic understanding of how contrasting hydrologic conditions within distinct wetland types influence iron (Fe)-mediated mobilization and retention of organic carbon (OC) and organic nitrogen (ON). Specific objectives are to: 1) Characterize the molecular structure of OC and ON and flux of water that passes through wetlands with short and long hydrologic residence time using advanced techniques, 2) Elucidate the impact of wetland hydrology, redox conditions, and soil temperature on the fate of OC and ON associated with Fe mineral phases, 3) Investigate the effects of different hydrological, electron acceptor, and climatic conditions on biological Fe(III)-reduction kinetics and dissolved organic carbon (DOC) oxidation kinetics within intact soil cores and on the consequent fate of OC and ON using a novel kinetic approach, and 4) Identify the influence of advective vs. diffusive flow on the mobilization and retention of OC and ON in synthetic soil aggregates and in more complex intact soil cores. The selected sites represent two important wetland types with contrasting hydrologic regimes spanning broad ranges of soil moisture conditions in watersheds representative of extensive source areas for mid-latitude water supplies. This will give us the opportunity to assess the "underlying mechanisms" determining Fe, nitrogen (N), and carbon (C) availability in wetlands while adding fundamental knowledge about soil, temperature, and hydrological processes affecting cycling of OC and ON in forests of the Colorado Rockies that serve as the headwaters for the water supplies of 7 US states for agriculture, municipal, and industrial use.

Impact: Our stakeholders include primarily water managers, agricultural land managers, and carbon modelers since our studies indicate that changes in soil moisture or temperature are likely to impact organic carbon structure, reactivity, concentration, mineralization, and mobility. For instance, the type and concentration of toxic disinfection byproducts is directly related to the chemical nature of DOC entering drinking water treatment facilities. Additionally, changes in Fe biogeochemical cycling will influence the size and turnover rate of soil C pools, which could negatively impact C storage.

In order to investigate sorptive fractionation of DOC on Fe-oxide surfaces, we conducted column-based sorption experiments with ferrihydrite-coated sand and various types and fractions of DOC at 7, 25, and 45°C. We found that humic acids sorbed quickly to the Fe-oxide surface, but overall, fulvic acids sorbed in greater quantities. Based on the known chemical differences between these two classifications of DOC, these results suggest that aromatic compounds may have a strong preference for the Fe-oxide surface, while acidic or small molecules may sorb in larger quantities, perhaps due to electrostatic attraction or steric restrictions. Preliminary high resolution Fourier transform ion cyclotron resonance (FT-ICR) mass spectrometry analyses indicate that tannin-like compounds may preferentially sorb to the Fe-oxide surface. Generally, DOC sorption increased with increasing temperature, although response varied among DOC types.

To better understand the role of DOC in Fe(II) preservation, we used X-Ray absorption spectroscopy to analyze Fe(II)-DOC complexes. Our results revealed that interactions between Fe(II) and the citrate-like groups in DOC molecules comprise the majority of Fe(II)-DOC interactions (for those DOC types studied). Previous studies have shown that complexation with citrate does not promote redox stabilization of Fe(II), so this research implies that another mechanism, perhaps consistent redox cycling or strong complexation with a small portion of DOC functional groups, such as bipyridine-like groups, may be responsible for long-term preservation of reduced Fe in oxic circumneutral waters.

In order to investigate the effects of temperature on biological Fe(III) reduction kinetics, we performed flow-through reactor experiments supplying soluble Fe(III)-EDTA to intact soil cores over a range of temperature of 6-18°C. We showed that the potential for Fe(III) reduction and Fe(III) reduction kinetics in subalpine wetland soils varied with wetland type, soil depth, and with *in situ* moisture conditions. The highest potential for Fe(III) reduction was observed for the highest temperature, the constantly reducing soils, and the more C-rich, shallower soil depths. The highest affinity for Fe(III) (lower K_m) was observed at ~12°C, which corresponds to the mean annual soil temperature. Such findings suggest there is a local adaptation of microbial kinetics to temperature and that soil warming could lead to decreasing water quality in subalpine wetlands, as a result of increased Fe(III) reduction mediated DOC release.

In order to study the effects of temperature and *in situ* hydrological conditions on Fe(III) reduction and on the consequent fate of DOC, we performed flow-through reactor experiments over a range of temperature of 6-18°C on intact soil cores sampled at different wetland types and depths. We used Fe(II) export rates as a proxy for Fe(III) reduction, and found that the Fe(II) export rates in the contrasting wetlands were affected differently by temperature, with higher temperatures stimulating Fe(II) export in the long hydrologic residence time-wetland, but slowing Fe(II) export in the short hydrologic residence time-wetland. Contrastingly, DOC export rates were not correlated to Fe(II) export rates and showed no significant difference across wetland types, sites, and depths.

In order to investigate the effects of sulfate, an alternative terminal electron acceptor for anaerobic respiration, on Fe(III) reduction and the consequent fate of DOC, we performed the same experiments as in the previous section, with various concentrations of sulfate added in the inflow solution. We compared soils from different wetland types and depths at a constant temperature of 12°C, simulating the mean annual soil temperature. Even if sulfate is not present at our field sites, we observed a potential for sulfate reduction at all sites and depths. We found that sulfate reduction rates increased almost linearly with input sulfate concentrations, and did not follow Michaelis-Menten kinetics, which we attributed to an adaptation of microbial communities, which increased in abundance with each increase in sulfate concentration. Interestingly, we also observed that sulfate reduction and Fe(II) production concurrently occurred. Furthermore, the presence of sulfate leads to an increase by 2 to 3 orders of magnitude in Fe(II) export rates, which suggests the abiotic reduction of Fe(III)-oxides by biogenic sulfide, highlighting the highly coupled nature of the S and Fe cycles. In addition, sulfate reduction activity did not affect DOC export rates.



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Nitrogen Transformations in Aquaponic Systems

Samir K. Khanal, Molecular Biosciences and Bioengineering, University of Hawaii at Manoa, HI

Summary: In aquaponic systems, nitrogen-containing organic compounds in fish feed are transformed into different forms of organic nitrogen (e.g., fish muscle tissue, plant tissue, etc.) and inorganic nitrogen (e.g., ammonia, nitrite, nitrate, nitrogen gas, etc.). Nitrogen plays an important role in vegetable and fish production in aquaponic systems. Thus, an understanding of the nitrogen transformations, in correlation with operational parameters (e.g., hydraulic loading rate (HLR), dissolved oxygen (DO), pH and sludge draining frequency from a biofilter), is essential to improve the nitrogen use efficiency (NUE) and to maintain a good water quality for aquaculture. In this research, pak choi, romaine lettuce, chive, tomato (plants) and tilapia (fish) were selected in a floating-raft aquaponic system. The aquaculture system was connected to hydroponic system via a 2-stage biofilter. We examined the effects of HLR, DO, pH, and sludge draining frequency on nitrogen transformations in aquaponic systems by integrating nitrogen mass balance with the natural abundance nitrogen isotopic mass balance. Nitrogen transformations and NUE were investigated at four different HLRs (HLR of 1.0 - 2.5 m/d), two different DO levels in fish tanks (low DO and high DO), three pH levels (5.0-6.8), and two sludge draining frequencies (weekly sludge draining and monthly sludge draining). Results showed that nitrite oxidation efficiency and ammonia oxidation efficiency started to drop at HLR of 0.25 m/d and 0.1 m/d, respectively. However, there was no effect on nitrogen transformations when the systems were operated at HLRs of 0.5 m/d or higher. Nitrogen loss via denitrification at low DO, resulted in low NUE and low plant yield in aquaponic systems. Moreover, ammonia oxidation by microorganisms in the biofilter was inhibited at pH of 5.0, leading to accumulation of ammonium. pH below 6.0 did not completely inhibit ammonia oxidation, but the oxidation rate started to decrease. To maintain productive NUE for those plant species in floating-raft aquaponic systems, we recommend HLR of 1.5 m/d, pH of 6.8-7.0 and DO of 6 mg/L (at the inlet of biofilter). NUE of plants in aquaponic systems can be improved by reducing feed-to-plant ratio when nitrate accumulation occurs, or it can be improved by reducing anoxic zone in biofilter, such as operating with weekly draining of sludge.

Impact: Our results, including publications and recommendations presented in the summary, will be practical guidelines for aquaponic farmers to maintain good water quality for fish and plant growth, and to improve NUE in aquaponic systems. Based on our isotopic and mass balance results, we identified biochemical pathways of nitrogen transformations in aquaponic systems. Thus, researchers could use our findings to improve the design and operation of aquaponic technologies. Our technique using natural abundance isotopic mass balance can be applied in other aquaponic studies (e.g. carbon cycle, media-filled aquaponics, full-scale aquaponics, new feed types, etc.). Also, our floating-raft aquaponic systems at the University of Hawaii has been a showcase for public, graduate/undergraduate/high school students, local farmers and researchers. The knowledge has been transferred to broader audience via presentations at local symposiums. We are in the final stage of submitting two journal papers based on this research.

2013-67019-21361

Colloid Mobilization and Biogeochemical Cycling of Organic Carbon, Nitrogen and Phosphorous in Wetlands

Vasilas, B. L.

Summary: Wetlands, because of their ability to remove nutrients and pollutants before they enter downstream waters, are a valuable component of integrated approaches to manage impairing water resources at the urban-agricultural interface. The biogeochemical processes that control the retention, transformation, and transport of nitrogen (N), phosphorous (P), dissolved organic matter (DOM) and how these processes are affected by colloid mobilization need to be systematically evaluated. Our hypothesis is that iron reduction-oxidation events in redox-dynamic wetlands can cause wide shifts in concentrations of colloids and dissolved materials. The goal of the proposed project is to provide a comprehensive investigation on the mechanisms and processes that control the fate and transport of nutrients (N and P) and DOM in wetland environments characterized by hydrologic and redox flux. The objectives will be accomplished through extensive ground water and surface water sampling at three selected freshwater wetland sites (where we have long-term monitoring data) which represent a range in hydroperiod and hydrodynamics, and complimentary laboratory experiments. Water samples will be taken at wetland inlets and outlets and analyzed for concentration and forms of N, P, Fe, OM, and mobile colloids. Batch and column experiments will be run to elucidate the mechanisms of colloid mobilization and the role of mobile colloids in the fate and transport of N, P, and OM. Laboratory and field studies will be integrated: field observations will be used to determine the critical parameters to be examined in laboratory experiments and laboratory results will provide mechanistic interpretation of field data.

Impact: The objectives will be accomplished through extensive field sampling at selected wetland sites (where we have long-term monitoring data) and complimentary laboratory experiments. The selected field sites represent a range in hydroperiod and hydrodynamics, and therefore a range in redox conditions. We will measure the concentrations and identify the forms of N, P, Fe, OM, and mobile colloids in the inlet and outlet of wetlands. We will conduct batch and column experiments to elucidate the mechanisms of colloid mobilization and the role of mobile colloids in the fate and transport of N, P, and OM. The laboratory and field studies will be closely integrated: field observations will be used to determine the critical parameters to be closely examined in laboratory experiments and laboratory results will provide mechanistic interpretation of field data. Interpretation of the data generated by laboratory analyses of water samples (N, P, colloids, DOM) require characterization of soil conditions (e.g., saturation, Eh) and hydrologic conditions (rising, falling, or static water table) at time of sample collection. These characterizations will be based on data collected from direct measurement of soil Eh (Pt electrodes), identification of reducing conditions (IRIS tubes), and monitoring well and piezometer measurements. To allow for extrapolation of results (application to similar wetlands) we will determine if the samples were collected during a year with a "representative" hydroperiod.

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Integrating Soil Carbon Stabilization Concepts and Nitrogen Cycling

Castellano, M. J.

Summary: Nitrogen fertilizer represents the largest input of energy to corn-based cropping systems. However, nitrogen fertilizer is used with poor efficiency (typically <50%). Much of the unused nitrogen fertilizer is lost to air and water resources, representing an economic loss to farmers that can diminish air and water quality. Improvements in our understanding of nitrogen fertilizer use efficiency can ultimately lead to decreases energy use, money savings and improved environmental quality. Recent evidence suggests that the amount of soil organic matter can affect nitrogen fertilizer use efficiency. Using isotopically labeled nitrogen fertilizer, this project will determine how soil organic matter affects the retention and loss of nitrogen fertilizer. Ultimately, this project will provide information that can lead to improvements in nitrogen fertilizer use efficiency.

Impact: What was accomplished under these goals? Nitrogen is a critical nutrient for crop production, but is easily lost from agricultural systems where it becomes a pollutant of air and water resources. Managing the nitrogen cycle has been identified by the National Research Council as a global research priority for the 21st century. We have sought to improve our understanding of the processes that balance nitrogen fertilizer retention and loss in agricultural systems. In particular, we hypothesize sufficient nitrogen fertilizer inputs and soil fertility is critical to maximize nitrogen retention within crop production systems. We conducted a nitrogen fertilizer use efficiency experiment across long-term nitrogen fertilizer gradients in two corn production systems. These experiments add different amounts of nitrogen fertilizer to corn in order to determine the economic optimum nitrogen fertilizer application rate. We found that although agronomic optimum nitrogen fertilizer input was critical to maintain soil health, historical long-term underapplication or overapplication of nitrogen fertilizer did not negatively impact corn yield when nitrogen fertilizer input was returned to the optimum amount of nitrogen. In other words, corn yield was remarkably resilient to historical mismanagement of nitrogen fertilizer. Obj. 1. Determine how physico-chemical C storage mechanisms, C storage capacity, and C storage kinetics interact to affect inorganic N retention and N mineralization. We added isotopically labeled nitrogen fertilizer to soils spanning a range of soil health. The range in soil health was created by historic nitrogen fertilizer input. Poor soil health was associated with low or zero nitrogen fertilizer input whereas good soil health was associated with optimum or excessive nitrogen fertilizer input (see publication from previous progress report). We are currently measuring how these differences in soil health affected the retention of nitrogen fertilizer inputs when they were adjusted to the optimum rate after more than 15 years of insufficient or excessive inputs. Obj. 2. Determine whether C storage capacity, C storage kinetics, and the quality of organic matter inputs (plant chemistry, C/N) interact to affect soil organic matter storage in stable pools. Using the isotopically labeled nitrogen fertilizer experiment, we are tracking the fate of nitrogen fertilizer in soil, crops and air + water. We are presently analyzing data from this experiment that were collected during the 2015 growing season. Initial results demonstrate historical nitrogen fertilizer rate impacted the retention of inorganic nitrogen in the soil. Obj. 3. Determine how the potential effects of C storage capacity and C storage kinetics affect fertilizer nitrogen use efficiency. Using the isotopically labeled nitrogen fertilizer experiment, we are tracking the fate of nitrogen fertilizer in soil, crops and air + water. We are presently analyzing data from this experiment that were collected during the 2015 growing season.

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Regional-Scale Assessment of N₂O Emissions within the US Corn Belt: The Impact of Precipitation and Agricultural Drainage on Indirect Emissions

Tim Griffis¹; Xuhui Lee²; John Baker^{1,3}; Joel Nelson^{1,4}; Rod Venterea^{1,3}; and Mark Seeley¹;
¹Department of Soil, Water, and Climate, University of Minnesota; ²School of Forestry and
Environmental Studies, Yale University; ³United States Department of Agriculture-Agricultural
Research Service; ⁴Soil and Landscape Analysis Laboratory, University of Minnesota

Summary: The N₂O budget remains poorly constrained at the regional scale due to a lack of observational data and constraints on key processes represented in bottom-up emission inventories and models. Atmospheric measurements within the US Corn Belt indicate that regional N₂O emissions far exceed bottom-up estimates. It is hypothesized that episodic hot spots (indirect emissions) associated with shallow water pathways (drainage tiles, ditches, and riparian zones) that have a strong hydrologic connection with agricultural ecosystems can help explain this disparity.

The goals are to: 1) quantify the distribution of drainage networks and N₂O emission hot spots; 2) evaluate indirect emissions on the regional N₂O budget using tall tower observations and a novel inverse modeling approach; and 3) forecast how changing precipitation patterns in the Upper Midwest may impact regional N₂O emissions.

Impact: Our stakeholders include the broader scientific community and atmospheric science specialists who are concerned with atmospheric composition, radiative forcing, and climate prediction. Our stakeholders also include agencies such as MPCA and land managers and farmers who aim to reduce the greenhouse gas impact of agricultural activities.

First, using a novel, non-steady-state flow-through chamber system, N₂O fluxes were measured across a stream order gradient within the US Corn Belt. The results show that N₂O emissions scale with the Strahler stream order. This information was used to estimate riverine emissions at the local and regional scales and demonstrates that previous bottom-up inventories based on the IPCC default values have significantly underestimated these indirect emissions. This work was published in the *Proceedings of the National Academy of Sciences of the United States of America*. Second, we have implemented an inverse regional/continental scale analysis using the STILT and Weather Research and Forecasting model. The results indicate that we can partition regional N₂O emissions into their direct and indirect components. This information is critical for assessing the implementation of mitigation strategies. This work has been published in *Global Biogeochemical Cycles*. Third, we have assessed the regional-scale controls on dissolved N₂O in the Upper Mississippi River using a novel equilibration technique and forecasted how future changes in nitrate concentration will impact N₂O emissions from rivers. This work has been published in *Geophysical Research Letters*. Our stakeholders will benefit from these unique data and model products as it will help to guide N₂O emission management strategies and future policy decisions.

Application of PO₄ Isotopes to Detect Sources and Cycling of Phosphorus in East Creek, a Chesapeake Bay Watershed

Deb P Jaisi, Department of Plant and Soil Sciences, University of Delaware, Newark, DE 19716

Summary: Nutrient contamination of surface waters has long been a major water-quality problem around the world. Phosphorus (P) released from agriculture is the largest non-point source of P pollution in the Chesapeake Bay. Despite this fact, understanding of sources and reaction mechanisms controlling cycling of P within ecosystems and export remains limited because of the lack of inherent tracers for analyzing P sources. To overcome this limitation, this research proposed to utilize stable oxygen isotope ratios of phosphate as a tracer to systematically analyze different P sources, mixing, and recycling in the East Creek watershed and export to the Chesapeake Bay. The major goals of this research were to i) identify the mobility of P released from different land sources particularly from agriculture as well as downstream process of retention and remobilization of P deposited in river sediments, ii) identify P flux at the sediment-water interface and corresponding source/sink depth under site relevant physico-chemical and biogeochemical conditions, and iii) develop a watershed wide source based P mass-balance model to estimate internal P cycling and export to the Chesapeake Bay.

Impacts: Among the potential upland sources of P in the East Creek watershed, agricultural fields contribute a significant proportion of dissolved and particulate P (PP) pool. Soils under different land cover, such as forest and wetland did not seem to significantly contribute as a PP source. Interestingly, streambanks were the most likely source (or alternatively, sink) of PP in the water column. Legacy P from streambank reserves could have a lasting impact on P loading to the bay, and further research is needed to understand what hydrological and biogeochemical conditions promote P release from these source sites. While physical remobilization of sediments is not expected, remineralization of P_o as well P release via reductive dissolution of Fe minerals or ion exchange in sulfate rich, high salinity regions likely act as constant P source to the water column. Thus, agricultural fields, streambanks, and sediments are all important P sources to the water column, although relative contribution as well as mechanisms of P release to the creek from each source is expected to differ among source, space, and time.

Transport of P through East Creek, as is true for similar tidal rivers or estuarine environments, is influenced by tides, salinity (and solution chemistry), and temperature. These factors control deposition and remineralization/remobilization, sorption and desorption, and biological uptake and release. Quantitative understanding of these factors through a source vector approach is undergoing and expected to contribute scientifically through mechanistic insights on processes and practical applications through translating these findings that could be helpful to devise or revise management practices to reduce or limit P loading to the bay.

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Toward Sustainable Nitrogen and Carbon Cycling on Diversified Horticulture Farms Serving Community Food Systems

Krista L. Jacobsen, Department of Horticulture, University of Kentucky
Ole Wendroth, Department of Plant and Soil Sciences, University of Kentucky*
John Schramski, College of Engineering, University of Georgia
**presenting author*

Summary: On a national level, community food systems are gaining increasing political cache and economic viability. As a part of this movement, smaller scale, diversified horticulture-based farms are experiencing renewed profitability and visibility. However little is known about key soil processes influencing the environmental sustainability of farms serving local markets. Specifically, these operations operate along a gradient of intensification, spanning extremely low-external input systems to year-round, tillage and input-intensive systems. The objective of this study is (i) to compare the nitrogen dynamics and key loss pathways in five farming systems, including four organic systems, representing a gradient of intensification (characterized by quantity of inputs, and the frequency of tillage and fallow periods) and (ii) to identify the sensitivity of measurement of the parameters to describe the key plant growth and soil processes. In addition to C and N dynamics, we are also seeking to better understand the net effects of intensification on whole system C balances using field-based measures as well as life cycle analytical approaches. We have parsed this work into two field experiments, with complementary modeling activities. For the purposes of the 2016 Project Director's meeting and project highlights, we will focus on empirical and modeling activities in one of these studies.

The goal of the first experiment is to quantify N and C cycling, loss rates, and trace gas fluxes from a three-year crop rotation within three of the study systems (a low external input organic system, an organic high tunnel, and a conventional vegetable production system). Throughout this study (field work ending in September 2016), we are evaluating labile C and N pools at the 0-15, 15-30 and 30-50 cm depths. Carbon turnover and losses are being evaluated through soil measures including: total soil C, labile soil C via particulate organic matter or permanganate oxidizable carbon, and gas fluxes of carbon dioxide and methane. Nitrogen turnover and losses are being evaluated through monthly samples of soil and resin-bound mineral N (ammonium and nitrate), ion exchange resin lysimeters, and gas fluxes of ammonia and nitrous oxide. Sites are instrumented with solid-state electrical resistance soil moisture sensors and tensiometers at the 15, 30, 45, and 60 cm depths, measured weekly. Initial analysis of trace gas fluxes measured during the main growing seasons indicates higher N₂O and CO₂ fluxes in the Extensive Organic system. The Organic High Tunnel system had intermediate CO₂ flux levels and the lowest N₂O fluxes of the three systems. The Conventional system had the lowest CO₂ flux levels, with intermediate N₂O fluxes. Fluxes peaked in all systems in June with declining rates through late summer and fall. Data from this study will also be used in modeling N dynamics and losses using the LEANCH-M and RZWQM models.

The goal of the second experiment is to characterize soil C and N processes in a model crop in the five study systems in a model crop in each of the three growing seasons in the study region: spring planted table beet (*Beta vulgaris*), summer planted green pepper (*Capsicum annuum*), and fall planted collard green (*Brassica oleracea var. medullosa*). Each model crop will be tracked for one year in each system, beginning with the crop and through succeeding crop and/or cover crops characteristic of the production system. Life cycle analyses, using carbon as a surrogate for energy, will allow for

comparison between input: output for each crop and system. This field work will be completed in Spring 2017.

Impact: The stakeholders in this work are the farmers and associated research and Extension community working in sustainable agriculture-oriented horticulture-based systems. The results of this study will improve our understanding of how intensification in organic farming systems affects N availability and losses to the environment. The complementary energy-returned-on-energy-invested analysis will contextualize these results within the broader input: output for several whole farming systems, and key model crops in the five study systems. These complementary approaches allow us to understand specific drivers and variabilities on these processes, as well as discuss them in the context of the overall sustainability of these farming systems as measured by energetic efficiencies.



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Hydrological-Microbial Interactions Controlling Landscape Phosphorus Mobility

John M. Regan, Civil and Environmental Engineering, the Pennsylvania State University, PA

M. Todd Walter, Biological and Environmental Engineering, Cornell University, NY

Hunter J. Carrick, Biology, Central Michigan University, MI

Anthony R. Buda, USDA-ARS-Pasture Systems and Watershed Management Research Unit, PA

Summary: Nonpoint source inputs of phosphorus (P) have contributed significantly to the eutrophication of lakes and streams within receiving watersheds. While the hydrologic processes involved in these discharges are reasonably well understood, less is known about the role microbial mechanisms play in regulating P transport. The goal of this project is to improve the scientific understanding of how the interactions between hydrology and microbial processes affect P mobility and retention in the landscape; our study focused specifically on P mobilization-retention by microbial activities unique to key landscape components prone to different hydrological conditions, ranging from perennially-saturated (e.g., in streams) to rarely saturated (e.g., steep upland areas). The experimental objectives are to determine the relative roles of the following microbially-mitigated P release-retention processes in agricultural watersheds, through coupled field-scale and laboratory mesocosm studies (Fig. 1):

1. iron reduction-oxidation
2. polyphosphate (polyP) retention-release
3. dissolution of P via decomposition of organic matter

The long-term objective of this research is to develop better land- and water-management strategies that capitalize on improved hydro-microbiological insights for reducing nonpoint source nutrient enrichment of freshwater bodies.

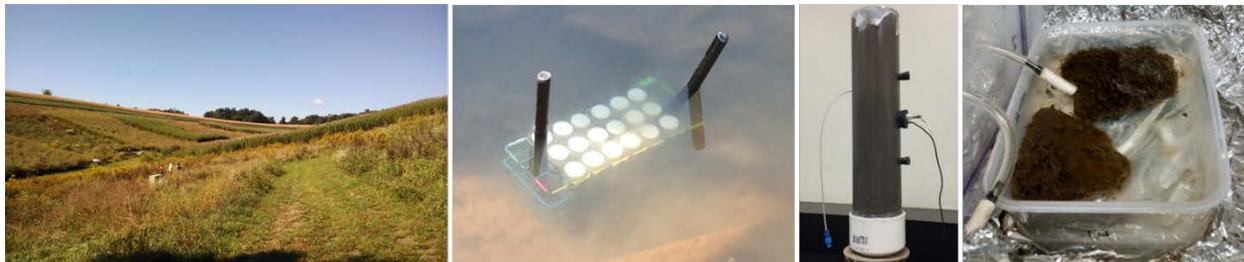


Fig. 1. Field- and bench-scale studies of microbial processes in soil and benthic biofilms potentially involved in P mobilization and retention.

Impact: Our focus has been to improve the collective understanding of how P is transferred from terrestrial to aquatic environments, with specific focus on identifying the microbial mechanisms that produce biogeochemical hot-spots and hot-moments for P. This new knowledge can be used to develop new P management strategies. Field-scale studies showed that resident stream biofilms exhibited a high capacity to store new supplies of P from simulated watershed loading events. While P retention significantly increased at higher P loads, the biofilms did not achieve P saturation during week-long loading events. We identified unique components of the biofilm microbial assemblage that accounted for the majority of this P storage as polyP (i.e., bacteria and eukaryotic diatoms). The polyP-containing bacterial populations were separated and phylogenetically identified, and found to be quite distinct from polyP-accumulating populations frequently enriched in wastewater treatment plants.

Laboratory mesocosms studies of benthic biofilms, which were subjected to alternating aerobic and anaerobic conditions to mimic the diel conditions induced in phototroph-dominated biofilms, showed the microbially catalyzed release of phosphate from the biofilms to the overlying bulk water under anaerobic conditions and the removal of phosphate from solution during aerobic conditions (Fig. 2). In our studies of agricultural soils, measurements of P fractions across a gradient of soil wetness index (SWI) indicated a negative correlation between biologically available P and SWI at one of our monitored sites but no correlation at the other site, suggesting a connection between SWI and P availability but the potential for additional contributing factors. We have just begun soil column experiments, with sterilized controls as well as columns lacking iron oxides, to differentiate the relative contributions of biologically influenced iron redox chemistry and polyP-accumulating microbes to P release and retention during periods of saturation and draining. Collectively, this information will be used to enhance our understanding of microbial participation in P transport, which will allow the inclusion of these reactions in models and the development of strategies to favorably promote or inhibit their contribution.

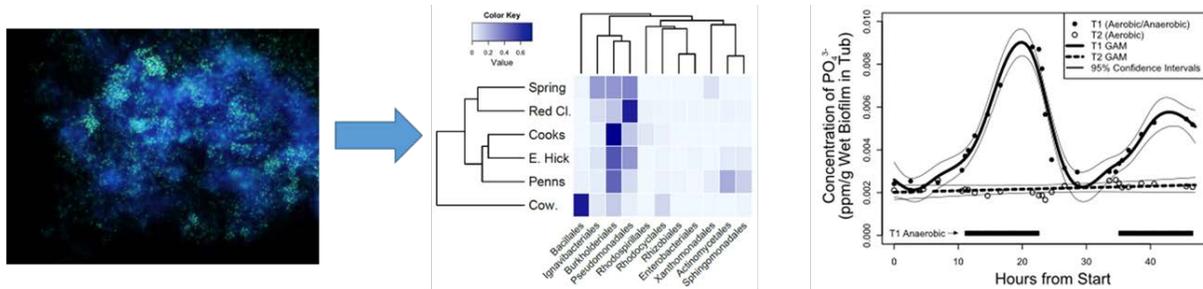
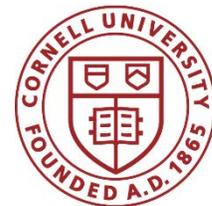


Fig 2. Integration of field and laboratory studies of benthic biofilms to understand populations involved in polyP formation and hydrolysis and the resultant impact on dissolved P concentrations.



2014-67019-21553

Impacts of Nitrogen Deposition on Microbial Community Carbon Dynamics in Forest Soils

Spencer Debenport¹, Christine Goodale², Dan Buckley¹

¹School of Integrative Plant Sciences

²Department of Ecology and Evolutionary Biology
Cornell University, New York

Summary: Human activities have more than doubled the input of fixed forms of nitrogen into the biosphere, driving major increases in the decomposition of nitrogen onto forests. Models of soil ecosystem response to environmental change do not currently account for the impact of nitrogen enrichment on soil systems. Long term additions of nitrogen often inhibit organic matter decomposition in forest soils, leading to decreases in soil respiration and increases in soil carbon stocks. Currently, the effect of nitrogen deposition on microbial community structure and its role in soil organic matter dynamics remains poorly characterized. The overall goal of this project is to evaluate the impact of elevated nitrogen deposition on the dynamics of soil carbon metabolism by soil microbial communities in forest ecosystems. We seek to test the hypothesis that changes in microbial community structure and function occur in response to nitrogen enrichment, and that these changes are the primary mechanism by which nitrogen enrichment inhibits soil organic matter degradation in forest soils.

Impact: A long-term trail consisting of treatments that received either N, N+S, S, or no addition was initiated in 2011 across multiple primary and secondary forest stands in NY State. This design evaluates the impact of N inputs while using S additions to control for the effects of acidification. Soil chemical characteristics were influenced by treatment, with plots that received S showing significant reductions in pH and plots that received N showing significant increases in litter N content. A general reduction in litter decomposition rate was observed in response to both N and S additions. Microbial community composition of both forest soil and leaf litter was characterized in all treatments through amplicon sequencing of bacterial 16S rRNA genes and fungal internal transcribed spacer (ITS) regions. Site and stand age had significant impacts on microbial community composition and variation due to treatment and time were subordinate to these effects. We are currently exploring how treatment effects interact with stand age to identify the ecological traits that drive variation in microbial community structure and function across forest stands.

2013-67019-21369

Biologically Based Fertilizer Recommendations to Meet Yield Expectations and Preserve Water Quality

Franzluebbers, Alan; USDA – Agricultural Research Service, Raleigh NC

Crozier, Carl; North Carolina State University, Plymouth NC

Haney, Rick; USDA – Agricultural Research Service, Temple TX

Kaye, Jason; Pennsylvania State University, University Park PA

Kemanian, Armen; Pennsylvania State University, University Park PA

Mirsky, Steven; USDA – Agricultural Research Service, Beltsville MD

Schomberg, Harry; USDA – Agricultural Research Service, Beltsville MD

Thomason, Wade; Virginia Tech University, Blacksburg VT

White, Charlie; Pennsylvania State University, University Park PA

Summary: Corn is one of the most demanding crops for N and therefore often requires a high rate of N fertilizer to achieve high productivity. Animal manure application complicates fertilizer recommendations due to manure composition, timing and method of application, and frequency and rate of application that can control nutrient release and availability to crops. Producers need a soil test to determine how much inorganic N fertilizer is needed when considering native sources and animal manures.

Goals – Develop a biologically based tool to improve N management in high N demanding cereal crops. We hypothesize that a biologically based soil N test will (1) increase N fertilizer recommendations in specific soil conditions with low N-supplying capacity to improve productivity and (2) decrease N fertilizer recommendations in specific soil conditions with high N-supplying capacity to alleviate economic loss and environmental threats.

Impact: Research in this proposal is helping to build a solid foundation of knowledge in fundamental (i.e. process of soil N mineralization) and applied agricultural sciences (i.e. improved N fertilizer recommendations from a biological soil testing tool) that will be vital for helping to solve the persistent water quality issues throughout the estuary regions of the Eastern Seaboard. Field research was started in the 2014 summer growing season, developed further in the 2015 growing season, and continues with field experiments in 2016. Many of these experiments are on-farm, allowing producers direct opportunities to learn about how their soil and crop management approaches are affecting soil biological activity. A graduate student has been analyzing soil properties from 50 site-years comprised of typically three depths (0-10, 10-20, and 20-30 cm) and four replications (i.e. 759 samples). Soil samples were tested for N supplying capacity in greenhouse growth trials with sorghum-sudangrass for 8 weeks. Collaborators in Virginia, Maryland, and Pennsylvania are also conducting field trials to assess N availability and the ability of the flush of CO₂ following rewetting of dried soil to predict N availability. Additional stakeholders have been assembled through collaboration with Virginia Department of Conservation and Recreation and the American Farmland Trust. Leveraging has occurred through additional on-farm tests with no-tillage wheat producers and livestock producers managing tall fescue pastures. Highly positive results have been discovered and we are excited to share widely once research has been completed.

2011-51130-31128

Measuring Success of Targeted BMP Implementation, and Getting Smarter About Ephemeral Gully Sediment and Nutrient Sources and BMPs

Aleksey Y. Sheshukov, Biological & Agricultural Engineering, Kansas State University

Tim Keane, Landscape Architecture and Regional Planning, Kansas State University

Nathan Nelson, Agronomy, Kansas State University

Ron Graber, Daniel Devlin, KCARE, Kansas State University

Summary: Sediment (soil) is a major threat to thousands of flood-control and water-supply reservoirs in the Great Plains of the U.S., and understanding about where (sources) and when (timing and delivery rates) the soil is coming from is crucial. In some cases, major sources, such as ephemeral gullies in crop fields and stream bank and channel erosion, are not understood and are being ignored in sediment control efforts. This project focused on using field research and computer modeling to learn more about ephemeral gully erosion, and measure the effectiveness of several methods to reduce soil and nutrient losses from ephemeral gullies. We developed methods to locate gullies and estimate their length using topographic index and soil erosion models that were applied in Little Arc watershed in central Kansas. About 20% cropland fields had ephemeral gullies present, while only 10% fields showed medium to high sheet and rill erosion rates (>2 Mg/ac/year). Structural BMPs, such as terraces, diversions, and grass waterways, significantly contributed to a reduction of gully fields, and affected the modeling results. Three farm fields (two no-till, one conventional tillage) were surveyed several times a year for three years. A set of BMP strategies was selected to battle gully progression, and it included objectives of reducing surface runoff into gully channel, depositing sediment in the channel, and protecting channel bed and banks with vegetation. Subsurface soil moisture redistribution was found to play a significant role in channel erosion and a critical shear stress model that accounted for soil hydraulic gradient was introduced and tested on few fields in the studied area. The research studies also determined that total phosphorous loss from fields with ephemeral gullies can be reduced by 47 to 92% strictly by elimination of ephemeral gully erosion, however dissolved P can increase due to P stratification in the soil.

We developed a new Certificate Program WaFER (Watershed and Fluvial Ecosystem Resources) at Kansas State University to educate college students about land and stream sediment sources and processes to help train future leaders and technical source-people. The program was approved by colleges and in the final stage of getting started. Four graduate students were trained in Biological and Agricultural Engineering, Agronomy, and Landscape Architecture, who successfully graduated. The project results were disseminated with WRAPS stakeholder leadership teams, during several field days, at various conferences, and in research publications. We organized a workshop on JET erosion test at KSU with 25 participants from five universities. New knowledge will also help researchers and stakeholders in other watersheds in Kansas and the U.S. identify and address similar problems. We collaborated with Iowa State University and Oklahoma State University on modeling and measuring soil erosion on farm fields.

Impact: The results obtained in this project showed that sediment and nutrient export from a watershed can be reduced by implementation of best management practices (BMP) in the targeted fields. Impacts of sediment sources from ephemeral gully erosion cannot be overlooked as they produce soil loss as high as 40%. Four students were supported and graduated from KSU with MS and PhD degrees. This project initiated activities with the City of Wichita Stormwater Advisory Board on water-quality BMP trade-off program that was approved in 2016 and is in the implementation stage. A website erosion.ksu.edu was created to educate stakeholders and share our findings.



2012-67020-30234

Practical Benefits of Biochar Amendment to Agricultural Systems: Linking Soil and Microbial Processes to Economic Feasibility and Sustainability

Crow, S. E.; Deenik, J.; Yanagida, J.; Penton, C. R.; Tiedje, J.; Simpson, M.

Summary: There is universal interest in assessing the potential for biochar to be incorporated into sustainable production systems; however, we still lack critical pieces that could determine the economic and environmental feasibility of the system. In Hawaii, interconnectedness exists among urban, agricultural, and natural areas and the Hawaiian Islands are a natural model for regional sustainable living. Local sources of biosolid waste and industrial-scale carbonization together with farmers who, for both economic and environmental reasons, are willing to implement viable sustainable practices mean that our results could have immediate adoption. The overarching objective of this project is to apply a multidisciplinary approach to develop a mechanistic understanding of soil and microbial processes underlying improvement in the agricultural production systems of a bioenergy feedstock (Napier grass, var. Bana) and food crops (rotation of cowpea and sweet corn) as a result of amendment with sewage sludge-derived biochar. Overall, we anticipate that soil amendment with biochar produced from waste materials such as processed sewage waste will increase the viability of sustainable agriculture as a result of improvements in soil condition through increased carbon sequestration and water retention, mitigation of climate change through decreased efflux of greenhouse gases, and decreased waste inputs to landfills. Our long-term goal is to improve resource management through more sustainable agricultural practices; by addressing the process-level origins of improvements in our production systems, results can be more broadly applied to other agricultural regions.

Impact: What was accomplished under these goals? The field trial ended in December 2015 and a multidisciplinary approach was taken to assess the sustainability of biochar use in Hawaiian agriculture by integrating economic, social, and environmental variables present in the system. System boundaries were, in effect, drawn around the hypothetical farm enterprise, ensuring the real-world applicability of project results and conclusions. Field trials of biochar soil amendment were carried out on O'ahu in two crops and two soils. The system-specific physical dynamics of C and N cycling (hereafter referred to as the C and N budget) were measured in two areas: 1) flux of gaseous CO₂, CH₄, and N₂O from soil (GHG flux); and 2) changes in soil C and N stocks. In support of these biophysical measurements, further C and N budget analysis was carried out in the following three areas: 1) C sequestration from biochar amendment; 2) biofuel potential of crop biomass; and 3) on-farm GHG emissions from fossil fuel consumption. Quantification of net global warming potential (GWP) was based on relevant C and N budget components--namely, cumulative GHG emissions, C sequestration achieved through biochar amendment, and biofuel potential of crop biomass--plus the fossil-derived GHG emissions created by on-farm management practices. Concurrently, economic analysis of the agronomic system was performed to calculate costs of production (inputs) and revenues from crop yields (outputs). Then, to quantify the social and environmental costs of GWP in economic terms, economic valuation of the net GWP of the system was performed. Finally, valuation of inputs, yields, and GWP were combined into a full-cost accounting benefit cost analysis (BCA). Manipulating components of the BCA in several important ways tested scenarios. A scenario of simulated crop yields was considered along with actual yields obtained from field trials. Irrespective of the biochar used in field experiments, two contrasting scenarios of biochar procurement were considered. Three price scenarios were considered for valuation of GWP. Lastly, sensitivity analysis was performed to

quantify the correlation between variables and the corresponding NPV from BCA. The temperature response of soils is an area that is the subject of much research. In general, the more labile a substance, the less sensitive it is to changes in temperature whereas more stable substrates will degrade at a faster rate as temperatures increase. Soil is a heterogeneous substrate and biochar amended soil is even more complex, so the soil temperature sensitivity with biochar additions is largely unexplored. It is also important to consider how the microbial community changes with soil, cropping system and temperature increases. Changes in soil properties like pH can shift microbial communities, a shift to a no-tillage system can increase the abundance of bacteria and mycorrhizae which can increase stable soil C content, and temperature increases can increase the abundance of pathways for C-degradation and denitrification. The influence of temperature on soil respiration and N₂O may also have threshold effects where certain temperatures increases have a larger impact than others. Additionally, soil microbial communities are also influenced by the presence of biochar, adding another level of complexity. To elucidate some of these variables, a study examined the CO₂ and N₂O flux of two tropical soils with contrasting crop management systems over an eight point temperature range. The objectives of the incubation study were three-fold. Objective 1: Characterize changes in soil properties for two agronomic soils and two cropping systems from initial post-amendment to year 1 as well as changes in the biochar over 1 year in the soil environment. Objective 2: Determine how CO₂ and N₂O fluxes changed over increasing temperatures in contrasting tropical agriculture soils with different crop and tillage management with and without biochar. Objective 3: Determine how soil respiration and N₂O flux for the Mollisol napiergrass soils with and without biochar treatment will respond to an input of a labile substance (glucose) at both 23 and 31°C. In addition, the total microbial abundance was assessed using quantitative bacteria 16S rRNA as well as nosZ genes to assess the abundance of bacteria able to reduce N₂O on both the post 60 day incubation soils and in glucose amended soils to simulate microbial response to additional plant inputs. In summary, during this reporting period the central two-year field trial wrapped up and the primary benefit-cost analysis, microbial community analysis, and incubation experiment were all completed. Multiple students were awarded degrees and defended theses and results from the various project components were disseminated widely to an international scientific audience as well as to local Hawaii-based stakeholders.

2012-67019-30227

Peptide/Protein Stabilization and C and N Sequestration in Soils: Contributions of Mineralogy in Native and Agro-managed Soils

Williams, M. A.; Xia, K.

Summary: Soil organic N dynamics have received increasing attention due to their critical role in controlling plant productivity and affecting soil organic matter stabilization. Peptides/proteins, constituting 30-60% of the soil organic matter pool and as a regulator of overall N availability, are a critical pool of both rapidly cycling and bioavailable organic matter and a potentially important form of stabilized organic C and N. However, the details of their stabilization and turnover remain largely unknown. Our preliminary synchrotron-based studies demonstrated that peptide/protein-N is the dominant organic N species associated with soil minerals. Furthermore, our investigation has shown that mineral-associated peptide/protein accrual with time is sensitive to agricultural practices. Agricultural practices are known to reduce total soil organic C and N, but it is not known how key soil organic N species, such as peptides/proteins, respond to agricultural disturbance across a wide range of soils. Using micro-scale molecular techniques to describe "macro" ecosystem-scale processes, the main goal of this proposal is to determine the fundamental determinants of organic matter stabilization, accrual, and N turnover across ecosystems that depend on organism (plant and microbial) and mineral-peptide/protein interactions. This goal will be accomplished through the study of the large soil protein/peptide pool. Understanding the mechanisms of molecular stabilization and turnover of soil organic matter are paramount to the sustainable management of agricultural and unmanaged ecosystems. The proposed research directly addresses the goals of Processes and Transformation in Soil, Water, and Air of the NIFA-AFRI Foundational Program #4 (Renewable Energy, Natural Resources, and Environment).

Impact: What was accomplished under these goals? Proteinaceous amino acids were shown to change during soil and ecosystem development and to be related to both plant and microbial inputs and decomposition products. Soil mineralogy, which changes during ecosystem development also helped to explain changes in proteinaceous soil organic matter. The research has directly addressed the program priority area through the study of fundamental biogeochemical processes that control the transformation and storage of nitrogen and carbon and include the involvement of microbial communities in both relatively native and managed ecosystems. By understanding how soil organic matter forms, we are one step closer to managing organic matter accrual, in new ways, using mechanistic molecular knowledge.

2012-67019-23408

Impact of Agricultural Stream Restoration on Riparian Hydrology and Biogeochemistry

McMillan, S.

Summary: The primary objective of this research is to understand and predict the impact of river restoration in agroecosystems on surface water-groundwater (SW-GW) interactions and biogeochemical processes in the near-stream zone (hyporheic and riparian zones). Restoration approaches that aim to improve water quality by enhancing retention time and promoting reducing conditions may increase nitrogen removal via denitrification, but be achieved at the expense of phosphorus desorption and emission of greenhouse gases (GHG) (N₂O, CO₂, CH₄). Through this project, we will test the hypotheses that (1) restored streams will have elevated water tables and prolonged, more extensive areas of reducing conditions compared to unrestored, (2) instream channel complexity will lead to higher denitrification rates, higher phosphorus concentrations in pore water via desorption, and increases in N₂O and CH₄ fluxes in restored compared to unrestored reaches, and (3) restoration approaches closely aligned with reference channel geomorphology will have greater SW-GW interactions and biogeochemical transformations. Well/piezometer transects will be established at representative cross sections in the streambed and riparian areas in restored, unrestored and reference reaches to allow for calculation of water and solute fluxes. Water levels in the near-stream zone will be measured in real-time; solute and GHG fluxes will be measured on a biweekly to monthly basis. Results from this research will potentially transform the way we assess the success of stream restoration projects and will help design better stream restoration strategies that include hyporheic and riparian zone function as one of the design criteria driving future restoration projects in agroecosystems.

Impact: What was accomplished under these goals? As indicated in previous years' report, all the sites were instrumented in year 1, and seasonal and storm monitoring conducted seasonally until summer 2015. Briefly, we conducted seasonal and post storm sampling for the four sites we instrumented in year 1, namely: (1) a straightened channel with no riparian buffer, (2) a meandering, but incised stream reach with an narrow (10m) forested riparian buffer and (3) a restored reach (completed in 2012) with a regraded riparian zone that was newly planted with a mix of herbaceous grasses and small deciduous trees and (4) an unimpacted, meandering channel with complex instream geomorphology, well developed floodplain and mature deciduous trees in the riparian zone. Seasonal data are still being analyzed as seasonal sampling continues. However, some storms and artificial precipitation data have been published or submitted for publication to a journal. Below are the references and the abstract of the articles published thus far: Vidon, P, Marchese, S., Welsh M., S, McMillan. 2015. Short-term spatial and temporal variability in greenhouse gas fluxes in riparian zones. Environmental Monitoring and Assessment. DOI: 10.1007/s10661-015-4717-x. ABSTRACT: Recent research indicates that riparian zones have the potential to contribute significant amounts of greenhouse gases (GHG: N₂O, CO₂, CH₄) to the atmosphere. Yet, the short-term spatial and temporal variability in GHG emission in these systems is poorly understood. Using two transects of three static chambers at two North Carolina agricultural riparian zones (one restored, one unrestored), we show that estimates of the average GHG flux at the site scale can vary by one order of magnitude depending on whether the mean or the median is used as a measure of central tendency. Because the median tends to mute the effect of outlier points (hot spots and hot moments), we propose that both must be reported or that other more advanced spatial averaging techniques (e.g., kriging, area weighted average) should be used to estimate GHG fluxes at the site scale. Results also indicate that short-term temporal variability in GHG fluxes (a few days) under seemingly constant temperature and hydrological

conditions can be as large as spatial variability at the site scale, suggesting that the scientific community should rethink sampling protocols for GHG at the soil-atmosphere interface to include repeated measures over short periods of time at select chambers to estimate GHG emissions in the field. Although recent advances in technology provide tools to address these challenges, their cost is often too high for widespread implementation. Until technology improves, sampling design strategies will need to be carefully considered to balance cost, time, and spatial and temporal representativeness of measurements. Vidon, P, Marchese, S, Welsh M., McMillan S. Impact of precipitation intensity and riparian geomorphic characteristics on greenhouse gas emissions at the soil-atmosphere interface in a water limited riparian zone. *Water, Air and Soil Pollution* (in review). ABSTRACT: As greenhouse gas (GHG: N₂O, CO₂, CH₄) concentrations continue to increase in the earth's atmosphere, there is a need to further quantify the contribution of natural systems to atmospheric GHG concentrations. Within this context, characterizing GHG contributions of riparian zones following storms events is especially important. This study documents soil GHG effluxes in a North Carolina riparian zone in the days following both a natural 2.5 cm precipitation event, and that same event associated with the addition of 8.7 cm artificial rainwater in select static chambers. No significant differences in CO₂, CH₄, and N₂O fluxes in response to increased moisture were observed between a depression, a sand bar, and an upland forested area. However, in this water-limited riparian zone, less negative CH₄ fluxes (i.e. methane oxidation decreased) and higher CO₂ fluxes (i.e. aerobic respiration increased) were observed following precipitation. A short-term burst in N₂O emission was observed in the hours after precipitation occurred, but elevated N₂O emissions did not persist long enough to turn the site from the N₂O sink to a N₂O source in the 3 days following the beginning of the experiment. Our results are in contrast with riparian GHG studies in wetter environments, and illustrate the importance of water limitation in regulating riparian soil response to precipitation with respect to GHG emissions. More studies should be conducted in water-limited environments (e.g. US southeast / southwest) before management strategies commonly applied in wetter environments (e.g. US Northeast / Midwest) are applied in these regions. Several other manuscripts are in various stages of preparation.

Grant Reporting Suggestions

A requirement for NIFA grantees is to report on an annual basis the progress and accomplishments of their project. Once the project has come to an end it is also a requirement to submit a final termination report. This report should cover the entire period of the award.

NIFA relies on you, the grantee, to generate and report the outcomes and impacts of your project from NIFA investments in research, education and extension. Better quality information from NIFA awardees will mean higher quality outcomes and impacts reports that will lead to better program management and to tracking the success of the grant programs.

When writing your final termination reports please keep in mind the following points. If some of the points don't fit within the REEport reporting system, additional material can be sent to the National Program Leader.

- Outputs are things you do, such as: activities, events, services, products, people reached. Outputs help link what you do with the project impact. Outcomes /Impacts answer the question “What happened as a result of my project”? It creates a change in knowledge, actions or conditions.
- Outcomes/Impacts sometimes are seen in a long-term and not during the period of the grant. We encourage the submissions of these outcomes. They can be directly sent via e-mail to the National Program Leader. This information may include but not limited to: published manuscripts, presentations, developed workshops, press releases, news releases, significant findings, newly developed technology, people benefited from the project and other communications that are critical for the success of our program.
- What benefit has come from your work? Provide answers to this question in terms that will be meaningful to congressional leaders, community leaders, taxpayers, farmers, and other researchers. Because you, as an agricultural scientist, are accustomed to communicating in technical terms about details of your work, this will require stepping back to consider a broader perspective. You will likely need to translate results of your study from scientific terms to lay terms – things that everyday people can relate to. For example, when deciding what impact to report, you might consider changes in: **Economics, Community, Environment, Agricultural practices, Scientific knowledge**
- If you have knowledge of publications that were cited as a result of your projects, please include this information as well.
- If your project didn't go as expected, we would like to know the circumstances that created change or failure. If you had to do it over again, what would you have done differently in your project during the funding period?
- What were the major challenges you or your organization faced during the grant period?

Appropriate Acknowledgment of Your Award

The Agriculture and Food Research Initiative (AFRI) plays an essential role in fulfilling the mission of the National Institute of Food and Agriculture. Proper acknowledgment of your USDA-NIFA-AFRI funding in published manuscripts, presentations, press releases, and other communications is critical for the success of our agency's programs. This includes proper acknowledgment of the program and agency, as well as that of the Department and grant number.

We expect you to use the following language to acknowledge NIFA support, as appropriate:

“This project was supported by Agriculture and Food Research Initiative Competitive Grant no. XXX-XXXXX-XXXXX from the USDA National Institute of Food and Agriculture.”

We also expect that you will use our agency's official identifier in all of your slide and poster presentations resulting from your AFRI award.

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