



7th

**Interagency Conference
on Research in the Watersheds**



**Enhancing Landscapes for
Sustainable Intensification
and Watershed Resiliency**

November 16-19, 2020

**Hosted by USDA-ARS and
University of Georgia
Tifton, Georgia USA**



ICRW CONFERENCE SPONSORS



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WELCOME FROM THE CONFERENCE CHAIR

Dear Colleagues,

On behalf of the Steering Committee, I welcome you to the Seventh Interagency Conference on Research in the Watersheds (ICRW7). ICRW7 is being hosted by the US Department of Agriculture-Agricultural Research Service, Southeast Watershed Research Laboratory in Tifton, Georgia. The ICRW7 is being conducted virtually due to the COVID-19 virus. The virtual platform will allow us to explore new methods of conveying our message while maintaining our history of exceptional conferences. The ICRWs are a collective effort resulting from the collaboration of Steering Committee members and the organizations they represent.

The ICRWs began in 2003 with the US Department of Agriculture-Agricultural Research Service hosted conference in Walnut Gulch, Arizona and has continued to grow and enjoy enthusiastic participation and cutting-edge scientific presentations. ICRWs have since been hosted by the US Department of Agriculture-Forest Service in 2006 and 2015, US Department of Interior-Geological Survey and CUAH-SI (Consortium of Universities for the Advancement of Hydrologic Science) in 2009, US Department of Interior-Bureau of Land Management and National Park Service in 2011, and US Environmental Protection Agency in 2018. ICRW7 carries on the tradition of engaging researchers involved in watershed research. With ICRW7 we have expanded the number of Federal Agencies participating in the Conference and grown to involve many non-federal partners.

The theme for ICRW7 is “Enhancing Landscapes for Sustainable Intensification and Watershed Resiliency”. Watersheds and coastal systems provide a wide array of economic goods and services. Balancing production goals with environmental concerns such as nutrient loading, landscape disturbance, and invasive species requires creative scientific approaches and adaptive management. The research of ICRW7 focuses on tackling these difficult issues. I look forward to the presentations, communication, and camaraderie as we all work to meet these challenges.



Thank you for your participation and best wishes for a productive and stimulating conference!

With my regards,

David D. Bosch

David D. Bosch, Conference Chair • USDA-Agricultural Research Service
Southeast Watershed Research Laboratory • Tifton, GA



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ICRW COMMITTEES

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- Jerad Bales, CUAHSI
- John Bolten, NASA
- Ainsley Brown, CUAHSI
- Brian Caruso, US FWS
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- Oliva Pisani, USDA-ARS
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- Rick Webb, USGS

Proceedings

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- John Faustini, FWS
- Charles Lane, EPA
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Program

- David Bosch, Chair, USDA-ARS
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- Scott Davis, BLM
- Oliva Pisani, USDA-ARS



PLENARY SPEAKERS



Dr. Gale A. Buchanan

Gale A. Buchanan was born in Madison County, Florida, where he spent his first 18 years on a general farm that produced crops and livestock. He received the B.S. and M.S. degrees in Agronomy from the University of Florida and the Ph.D. in Plant Physiology from Iowa State University. Dr. Buchanan, was Dean and Director of the University of Georgia College of Agricultural and Environmental Sciences from 1995 to 2004 and U.S. Department of Agriculture Undersecretary for Research, Education and Economics from 2005 to 2009. His latest book, "Feeding the World: Agricultural Research in the Twenty-First Century", details his ideas on how increased agricultural research can lead to a more efficient food production system, one that can provide food for a projected population of more than 9 billion people by 2050.



Dr. Peter Colohan

Peter Colohan is the Executive Director of the Internet of Water, a project based at Duke University's Nicholas Institute for Environmental Policy Solutions. Prior to this position, Peter had nearly a decade of Federal service with the National Oceanic and Atmospheric Administration (NOAA). At NOAA, Peter was a key advocate for the development of the National Water Model and the creation of the NOAA Water Initiative. He also served as a Federal Coordinating Lead Author for the Water Chapter of the Fourth National Climate Assessment, published in November 2018. From 2012-2014, Peter served as the Assistant Director for Environmental Information within the White House Office of Science and Technology Policy under President Barack Obama, on assignment from NOAA, where he worked closely with all Federal agencies responsible for climate, water and environmental science and technology.



Dr. Lindsey Rustad

Dr. Lindsey Rustad is a Research Ecologist for the USDA Forest Service Center for Research on Ecosystem Change in Durham, NH, co-Director of the USDA Northeastern Hub for Risk Adaptation and Mitigation to Climate Change, Team Leader for the Hubbard Brook Experimental Forest in NH. She received a B.A. in Philosophy at Cornell University in 1980, an M.S. in Forest Science at the Yale School of Forestry and Environmental Sciences in 1983, and a Ph.D in Plant Science in 1988 at the University of Maine. She is a Fellow of the Soil Science Society of America, and recently received the 2018 USDA Forest Service Northern Research Station's award for Distinguished Scientist and the 2018 USDA Forest Service Deputy Chief's award for Distinguished Science. Her areas of expertise include biogeochemistry, watershed studies, climate change impacts, advanced environmental sensor systems, and the integration of art and science.



HIGHLIGHTS

7th Interagency Conference on Research in the Watersheds Enhancing Landscapes for Sustainable Intensification and Watershed Resiliency

November 16-19, 2020 • Hosted by USDA-ARS and
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MONDAY, NOVEMBER 16TH

- Conference Workshops, 11:00 am – 6:00 pm

TUESDAY, NOVEMBER 17TH

- Plenary, **Dr. Gale Buchanan, Solving water issues through research**, 11:00 am
- **Agency and Organization Plenary: Current Research and Emerging Opportunities**, 11:55 - 2:30 PM
- Concurrent Sessions, 3:25 pm – 5:00 pm
- Interactive poster session, 5:10 - 6:00 pm

WEDNESDAY, NOVEMBER 18TH

- Plenary, **Dr. Peter Colohan, The Internet of Water: Sharing and Integrating Water Data for Sustainability**, 11:00 am
- Concurrent Sessions, 11:55 am - 5:00 pm
- Interactive poster session, 5:10 pm - 6:00 pm

THURSDAY, NOVEMBER 19TH

- Plenary, **Dr. Lindsey Rustad, Watershed Studies in the 21st Century: Integrating experiments, models and long-term observations across temporal and spatial scales**, 11:00 am
- Concurrent scientific sessions, 11:55 am - 2:00 pm
- Conclusion and “Passing the Gavel” to the USGS, hosts of the Eighth ICRW, 2:10 pm

Seventh Interagency Conference on Research in the Watersheds

AGENDA AT A GLANCE CONFERENCE ZOOM LINKS

Monday, November 16, 2020	
Workshops	
11:00 AM-2:00 PM	Morning Workshops; (1) EnviroAtlas and (2) Big Data in Watersheds: Integrating Wetlands and Floodplains in Hydrologic Modeling
2:00 PM-3:00 PM	Break
3:00-6:00 PM	Afternoon Workshop; Introduction to the Water, Energy, and Biogeochemical Model (WEBMOD)
6:00 PM	Adjourn

Tuesday, November 17, 2020	
Morning Plenary Sessions, Afternoon Concurrent Sessions, and Poster Session	
11:00-11:15 AM	Welcome and Logistics: Dr. David Bosch, USDA-ARS
11:15-11:45 AM	Plenary Speaker: Dr. Gale Buchanan, Solving water issues through research
11:45-11:55 AM	Break
11:55-1:00 PM	Agency Presentations
1:00-1:15 PM	Break
1:15-2:30 PM	Agency Presentations / Discussion
2:30-3:25 PM	Break
3:25-5:00 PM	Concurrent Sessions: <ul style="list-style-type: none"> • Bedrock Flow and Reactions: Implications for Ecohydrology and Watershed Exports (SS) • Remote Sensing of Watersheds and Riparian Systems • Watershed Modeling (A) • CEAP: Conservation Effects Assessment Project

Tuesday, November 17 continued on following page

ALL LISTED TIMES ARE IN EASTERN STANDARD TIME

Tuesday, November 17, 2020	
5:10-6:00 PM	<p>Poster Session One, three minute lightning presentations followed by open discussion</p> <ul style="list-style-type: none"> • ARS Watkinsville, GA. 1937-2012. Legacy of 75 Years of Watershed Research- Dinku M. Endale • Advancing Understanding of Total and Reactive Phosphorus Concentration and Suspended Solids Particle Size Class - Jason A. Hubbart • Improved site-specific allometric equations for Robinia pseudoacacia - Joel L. Scott • Characteristics of flow events that influence phosphorus and nitrogen loads from ranchlands of South-central Florida - A. Saha • Application of Remote Sensing Drought Indicators for Monitoring Drought and Streamflow – Vahid Rahmani • Incorporating Human Dimensions in Long-Term Agroecosystem Research Network – Alycia Bean
6:00 PM	Adjourn

Wednesday, November 18, 2020	
Morning Plenary Session, Concurrent Sessions, and Poster Session	
11:00-11:15 AM	Welcome and Logistics: Dr. David Bosch, USDA-ARS
11:15-11:45 AM	Plenary Speaker: Dr. Peter Colohan, The Internet of Water: Sharing and Integrating Water Data for Sustainability
11:45-11:55 AM	Break
11:55-2:00 PM	<p>Concurrent Sessions</p> <ul style="list-style-type: none"> • Coastal Plain Watersheds • Watershed Response to Intensifying Precipitation Extremes and Adaptation Strategies: Science and Management Challenges (SS) • Advancing Watershed Science using Machine Learning, Diverse Data, and Mechanistic Modeling (SS) • FACETS: Floridan Aquifer Collaborative Engagement for Sustainability (SS)
2:00-2:55 PM	Break

Wednesday, November 18, 2020	
2:55-5:00 PM	Concurrent Sessions <ul style="list-style-type: none"> • Water Quality and Quantity (B) • Watershed Modeling (B) • Long-Term Agroecosystem Research
5:10-6:00 PM	Poster Session Two , three minute lightning presentations followed by open discussion <ul style="list-style-type: none"> • Climate change and water resource management in the Great Plains Aquifer - R. Deepa • Evapotranspiration in a Subtropical wetland savanna using low-cost Lysimeter, Eddy Covariance and Modeling approaches - Amartya Saha • Impacts of Pasture, Hay and Row Crop Management Systems on Groundwater Quality and Quantity in the Santa Fe River Basin, Florida – Dogil Lee • Putting the Research Catchments on a Map: An Overview of Research Sites that have Shaped Knowledge in Trans-Disciplinary Research - Peter Murdoch
6:00 PM	Adjourn

Thursday, November 19, 2020	
Plenary and Concurrent Sessions, “Passing the Gavel,” Adjournment	
11:00-11:15 AM	Welcome and Logistics: Dr. David Bosch, USDA-ARS
11:15-11:45 AM	Plenary Speaker: Dr. Lindsey Rustad, Watershed Studies in the 21st Century: Integrating experiments, models and long-term observations across temporal and spatial scales
11:45-11:55 AM	Break
11:55 - 2:00 PM	Concurrent Sessions <ul style="list-style-type: none"> • Water Quality and Quantity (A) • Watershed Evapotranspiration in a Changing Environment (SS) • Integrating Science and Watershed Decision Making • Watershed Response to Change
2:10 PM – 2:30 PM	Adjournment, passing of the Gavel

ALL LISTED TIMES ARE IN EASTERN STANDARD TIME

Topical Track Color Coding

Water Quality and Quantity	Climate, Land Cover, Land Use	Models and Management	Status, Trends, Sustainability
(W)	(C)	(M)	(S)

Tuesday, November 17, 2020

Plenary Session, Agency Presentations, Concurrent Sessions, and Poster Session

3:25 PM – 5:00 PM	Concurrent Sessions		
Bedrock Flow and Reactions: Implications for Ecohydrology and Watershed Exports (SS) Chairs: Bhavna Arora and Ben Gilbert	Remote Sensing of Watersheds and Riparian Systems Chair: Mike Cosh	Watershed Modeling (A) Chair: David Goodrich	CEAP: Conservation Effects Assessment Project Chair: Lisa Duriancik
5:10 PM – 6:00 PM	Poster Session One, Chair Phil Heilman		

Wednesday, November 18, 2020

Plenary Session, Concurrent Sessions, and Poster Session

11:55 AM - 2:00 PM	Concurrent Sessions		
Coastal Plain Watersheds Chair: Steve Golladay	Watershed Response to Intensifying Precipitation Extremes and Adaptation Strategies: Science and Management Challenges (SS) Chairs: Anna Jalowska and Devendra Amatya	Advancing Watershed Science using Machine Learning, Diverse Data, and Mechanistic Modeling (SS) Chair: Dipankar Dwivedi and Kimberly Ann Kaufield	FACETS: Floridan Aquifer Collaborative Engagement for Sustainability (SS) Chair: Wendy Graham
2:55 PM – 5:00 PM	Concurrent Sessions		

<p>Water Quality and Quantity (B) Chair: Doug Burns</p>	<p>Open</p>	<p>Watershed Modeling (B) Chair: Jeff Chanat</p>	<p>Long-Term Agroecosystem Research Chair: Oliva Pisani</p>
<p>5:10 – 6:00 PM</p>	<p>Poster Session Two, Chair Oliva Pisani</p>		

Thursday, November 19, 2020

Plenary Session, Concurrent Sessions, and Closing Session

<p>11:55 AM - 2:00 PM</p>	<p>Concurrent Sessions</p>		
<p>Water Quality and Quantity (A) Chair: Carl Trettin</p>	<p>Watershed Evapotranspiration in a Changing Environment (SS) Chairs: Ge Sun and Devendra Amatya</p>	<p>Integrating Science and Watershed Decision Making Chair: Rick Webb</p>	<p>Watershed Response to Change Chair: Elizabeth Keppeler</p>
<p>2:10 PM – 2:30 PM</p>	<p>Adjournment, passing of the Gavel</p>		

ALL LISTED TIMES ARE IN EASTERN STANDARD TIME



WORKSHOPS

Monday, November 16, 2020

ENVIROATLAS

Instructors: Anne Neale, Jessica Daniel, and Megan Mehaffey (EPA) 3 Hours 11 am – 2 p.m.

This half day workshop will demonstrate the U.S. EPA's web-based tool, EnviroAtlas. EnviroAtlas provides geospatial data, easy-to-use tools, GIS toolboxes, and other resources related to watershed science and ecosystem services. Participants will see live demonstrations of the EnviroAtlas Interactive Map and its analysis tools, and do a deep dive into some of the 400+ available data layers. Participants will learn how EnviroAtlas data can be used in research and different decision contexts, and get a sneak peek at upcoming additions. Attendees don't need to have a GIS background

INTRODUCTION TO THE WATER, ENERGY, AND BIOGEOCHEMICAL MODEL (WEBMOD)

Instructor: Rick Webb (USGS) 3 Hours 3– 6 p.m.

This half day workshop will demonstrate how WEBMOD simulates flows of water, major ions, stable isotopes, and temperature for a natural watershed draining the continental divide in Colorado and fields irrigated with water from the Yakima River in Washington. The course will be taught by Richard Webb, the principal developer of WEBMOD and author of the Users Manual. Participants will be provided with background theory, software and input files and learn how to run the model in batch mode and within a Graphical User Interface. WEBMOD can provide the user or water manager with robust predictions on expected changes in water quantity and quality given a variety of scenarios of changing climate, population, and land use.

BIG DATA IN WATERSHEDS: INTEGRATING WETLANDS AND FLOODPLAINS IN HYDROLOGIC MODELING

Instructors: Adnan Rajib, Qiusheng Wu, and Qianjin Zheng (Texas A&M University) 3 Hours 11 a.m. – 2 p.m.

Floodplains and wetlands have considerable effects on watershed hydrology, biogeochemical cycling, and ecology. Complex GIS formats, large data volumes, and inconsistency with the models' spatial resolution and source-code have made floodplain and wetland integration in watershed models a "Big Data" problem. In this half day workshop, we address these issues through the introduction of a coupled next-generation 100-year floodplain data layer and topographic approach for spatially explicit estimation of floodplain and wetland water storage. The workshop will include a hands-on interactive session, introducing a new semi-automatic tool which extracts the floodplain boundary and wetland water storage data for any given watershed via simple user commands in a web-based interface and seamlessly integrates the data in a user-provided hydrologic model. We will prototype this data-model integration architecture using SWAT, concurrently providing examples for other commonly used hydrologic models as well. Attendees will increase their geospatial representation/information and modeling capacity to efficiently quantify the role of floodplains and wetlands on landscape ecohydrological processes.

Full Program • November 16-19, 2020

All times are Eastern Standard Time

Monday, November 16, 2020

Workshops

- 11:00 AM – 2:00 PM Morning Workshops; EnviroAtlas and Big Data in Watersheds, Integrating Wetlands and Floodplains in Hydrologic Modeling
- 2:00 PM – 3:00 PM Break
- 3:00 - 6:00 PM Afternoon Workshops; Introduction to the Water, Energy, and Biogeochemical Model (WEBMOD)
- 6:00 PM Adjourn

Tuesday, November 17, 2020

Plenary Session, Agency Presentations, Concurrent Sessions, and Poster Session

- 11:00-11:15 AM Welcome and Logistics: Dr. David Bosch, USDA-ARS
- 11:15-11:45 AM Plenary Speaker: Dr. Gale Buchanan, Solving water issues through research
- 11:45-11:55 AM Break
- 11:55-1:00 PM Agency and Organization Plenary: Current Research and Emerging Opportunities, Randy Fowler (FS) Moderator
- 12:00 PM – 12:15 PM Jerad Bales, Consortium of Universities for the Advancement of Hydrologic Science, Inc., Executive Director
- 12:15 PM – 12:30 PM Frank H. McCormick, US Department of Agriculture, Forest Service, Acting Director, Landscape Restoration & Ecosystem Services
- 12:30 PM – 12:45 PM Teferi Tsegaye, US Department of Agriculture, Agriculture Research Service, National Program Lead for Water Availability and Watershed Management Program
- 12:45 PM – 1:00 PM Brenda Rashleigh, US Environmental Protection Agency, Assistant Center Director for Water, Office of Research and Development
- 1:00-1:15 PM Break
- 1:15-2:30 PM Agency and Organization Plenary: Current Research and Emerging Opportunities, Randy Fowler (FS) Moderator
- 1:15 PM – 1:30 PM Lori Sprague, US Department of Interior Geological Survey, Director, Earth Systems Processes Division
- 1:30 PM – 1:45 PM Scott Davis, US Department of Interior Bureau of Land Management, Senior Soil Scientist
- 1:45 PM – 2:00 PM Paul Bayer, US Department of Energy, Program Manager, Subsurface Biogeochemistry Program
- 2:00 PM – 2:30 PM Agency Panel Discussion

ALL LISTED TIMES ARE IN EASTERN STANDARD TIME

Tuesday, November 17, 2020

Plenary Session, Agency Presentations, Concurrent Sessions, and Poster Session

2:30-3:25 PM

Break

3:25-5:00 PM

Concurrent Sessions

Tuesday, November 17, 2020		Water Quality and Quantity		
3:25 PM – 5:00 PM		Bedrock Flow and Reactions: Implications for Ecohydrology and Watershed Exports (SS) Chairs: Bhavna Arora and Ben Gilbert		
Time	ID	Abstracts	Affiliation	Presenter
3:30 – 3:45 PM	W10	Groundwater Sourcing and Age Distributions in a Colorado River Headwater Stream - Rosemary W.H. Carroll ¹ , and Kenneth H. Williams ²	¹ Desert Research Institute ² LBNL	Rosemary W.H. Carroll
3:45 – 4:00 PM	W11	A Scale-Aware Modeling Framework to Quantify Subsurface Geochemical Exports and River Water Quality - Dipankar Dwivedi, Carl I Steefel, Michelle E Newcomer, Bhavna Arora, Peter S Nico, Boris Faybishenko, Baptiste Dafflon, Haruko M Wainwright, Patricia M Fox, Kenneth H Williams, and Susan Hubbard	Lawrence Berkeley National Laboratory (LBNL)	Dipankar Dwivedi
4:00 – 4:15 PM	W12	Hysteresis Patterns of Watershed Nitrogen Retention and Loss over the past 50 years in United States Hydrological Basins - Michelle E. Newcomer ¹ , Dipankar Dwivedi ¹ , John N. Christensen ¹ , Peter S. Nico ¹ , Ulrich Maier ² , Ken H. Williams ¹ , Susan S. Hubbard ¹ , and Carl I. Steefel ¹	¹ LBNL ² University of Göttingen, Germany	Michelle Newcomer
4:15 – 4:30 PM	W13	Modeling Reactive Transport, Weathering and Critical Zone Evolution at the Hillslope Scale - Harihar Rajaram ¹ , Shengbang Zhong ¹ , Ryan Haagenson ² , Robert Anderson ² , Suzanne Anderson ² , Sachin Pandey ²	¹ Johns Hopkins University ² University of Colorado, Boulder	Harihar Rajaram
4:30 – 4:45 PM	W14	Spatial distribution of pyrite oxidation under valley and ridge- Xin Gu, Andrew R. Shaughnessy, and Susan L. Brantley	Pennsylvania State University	Xin Gu
4:45 – 5:00 PM	W15	Geospatial Modeling Approach to Determine Potential Sinkholes Risk Probability and Soil Subsidence Analysis - Sudhanshu S. Panda ¹ , Jeffery Robertson ¹ , Ying Ouyang ² , and Johnny Grace III ²	¹ University of North Georgia ² USDA Forest Service	Sudhanshu S Panda

Full Program • November 16-19, 2020

Tuesday, November 17, 2020		Water Quality and Quantity		
3:25 PM – 5:00 PM		Bedrock Flow and Reactions: Implications for Ecohydrology and Watershed Exports (SS) Chairs: Bhavna Arora and Ben Gilbert		
Time	ID	Abstracts	Affiliation	Presenter
5:00 – 5:10 PM		Break		

Tuesday, November 17 2020		Climate, Land Cover, Land Use		
3:25 PM – 5:00 PM		Remote Sensing of Watersheds and Riparian Systems Chair: Mike Cosh		
Time	ID	Abstracts	Affiliation	Presenter
3:30 – 3:45 PM	C10	Soil moisture monitoring at ARS Long-Term Agroecosystem Research sites - Michael Cosh, Patrick Starks, David Bosch, Dave Goodrich, John Prueger, Mark Seyfried, Stan Livingston, and Chandra Holifield Collins	USDA-ARS	Michael Cosh
3:45 – 4:00 PM	C11	The nature of land-cover changes to aquatic buffers in the Midwestern USA: 25 years of Landsat analyses (1993-2017) - Charles Lane ¹ , Tedros M. Berhane ¹ , Samson G Mengistu ² , Jay Christensen ¹ , Heather E Golden ¹ , Shi Qiu ³ , Zhe Zhu ³ , and Qiusheng Wu ⁴	¹ US EPA ² National Research Council ³ University of Connecticut ⁴ University of Tennessee	Charles Lane
4:00 – 4:15 PM	C12	Fine-resolution mapping of surface water and wetland inundation dynamics in the Prairie Pothole Region - Qiusheng Wu ¹ , Charles R. Lane ² , Megan Lang ³ , Heather E. Golden ¹	¹ University of Tennessee ² US EPA ³ US Fish and Wildlife Service	Qiusheng Wu
4:15 – 4:30 PM	C13	Actions and plans to quantify the “Invisible Giant” – Evapotranspiration – in Florida water budgets - David M. Sumner, Nicasio Sepulveda, and W. Barclay Shoemaker	USGS	David M. Sumner
4:30 – 4:45 PM	C15	Remote-sensed Demonstration of Ecosystem Services in the Great Pee Dee Basin, South Carolina - Eric Krueger, and Melissa Strickland	The Nature Conservancy	Eric Krueger
4:45 – 5:00 PM	P11	An evaluation of ECOSTRESS products on a temperate montane humid forest - Ning Liu ^{1,2} , A. Chris Oishi ² , and Chelcy Miniati ² , Paul Bolstad ¹	¹ University of Minnesota ² USDA Forest Service	Ning Liu

Tuesday, November 17 2020		Climate, Land Cover, Land Use		
3:25 PM – 5:00 PM		Remote Sensing of Watersheds and Riparian Systems		
		Chair: Mike Cosh		
Time	ID	Abstracts	Affiliation	Presenter
5:00 – 5:10 PM		Break		

Tuesday, November 17 2020		Models and Management		
3:25 PM – 5:00 PM		Watershed Modeling (A)		
		Chair: David Goodrich		
Time	ID	Abstracts	Affiliation	Presenter
3:30 – 3:45 PM	M11	Two-dimensional continuous simulation of watershed processes using a time-area hydrology model, HYSTAR - Young Gu Her	University of Florida	Young Gu Her
3:45 – 4:00 PM	M13	Coupled terrestrial and aquatic carbon modeling towards improved watershed sustainability assessment - Xuesong Zhang	Pacific Northwest National Laboratory and University of Maryland	Xuesong Zhang
4:00 – 4:15 PM	M14	Effect of wetland and depression water storage on continental-scale hydrologic dynamics - Adnan Rajib ¹ , Heather Golden ² , Charles Lane ² , and Qiusheng Wu ³	¹ Texas A&M University ² US EPA ³ University of Tennessee	Adnan Rajib
4:15 – 4:30 PM	M16	Modeling Interactions of Riverine Flow and Riparian Vegetation for Quantifying Recruitment and Survival of Native Vegetation in California - Zhonglong Zhang	Portland State University	Zhonglong Zhang
4:30 - 4:45 PM	P16	Wetness Index based on Landscape position and Topography (WILT): Modifying the TWI to incorporate landscape position relative to water bodies - Menberu B. Meles, Seth E. Younger, C. Rhett Jackson, Enhao Du, and Damion Drover	USDA-ARS	Menberu B. Meles
4:45 - 5:00 PM		OPEN		
5:00- 5:10 PM		Break		

Tuesday November 17, 2020		Status, Trends, Sustainability		
3:25 PM – 5:00 PM		CEAP: Conservation Effects Assessment Project		
		Chair: Lisa Duriancik		
Time	ID	Abstracts	Affiliation	Presenter
3:30 – 3:45 PM	S16	Overview of the Impacts of CEAP for the First 15 Years - D.N. Moriasi ¹ , L.F. Duriancik ² ; E.J. Sadler ¹ , T. Tsegaye ¹ , J.L. Steiner ¹ , M.A. Locke ¹ , T.C. Strickland ¹ , and D.L. Osmond ³	¹ USDA ARS ² USDA NRCS ³ North Carolina State University	Daniel Moriasi
3:45 – 4:00 PM	S18	Comparisons of radar, bubbler, and float water levels in the Goodwater Creek Experimental Watershed - Claire Baffaut, Ken A. Sudduth, and E. John Sadler	USDA ARS	Claire Baffaut
4:00 – 4:15 PM	S19	Agricultural Producers' Willingness To Accept Payments For Improving Water Resources In The Florida Aquifer - Unmesh Koirala ¹ , Damian C. Adams ¹ , and Jose R. Soto ²	¹ University of Florida ² University of Arizona	Damian C. Adams
4:15 – 4:30 PM	S20	Ecological Effects of Agriculturally-Sourced Colored Dissolved Organic Matter in Two Mississippi Watersheds - Richard E. Lizotte, Jr., and Martin A. Locke	USDA ARS	Richard E. Lizotte, Jr.
4:30 – 4:45 PM	S21	A Novel Transient Tracer for Assessing Watershed Lag Time and Agricultural Nitrogen Fate - G.W. McCarty, C.J. Hapeman, C.P. Rice, G.E. Moglen, R.E. Plummer, P.M. Downey	USDA ARS	Gregory McCarty
4:45 – 5:00 PM	P31	Advancing Conservation Effects Assessment in Watersheds: Delivering Outcomes for the Farm Bill - Lisa F. Duriancik	USDA NRCS	Lisa Duriancik
5:00-5:10 PM		Break		

Tuesday, November 17, 2020

5:10 – 6:00 PM • Poster Session One, Chair Phil Heilman

ID	Title	Affiliation	Presenter
P4	ARS Watkinsville, GA. 1937-2012. Legacy of 75 Years of Watershed Research - Dinku M. Endale ¹ , Harry H. Schomberg ¹ , and Jean L. Steiner ²	¹ USDA-ARS ² Kansas State University	Dinku Endale
P5	Advancing Understanding of Total and Reactive Phosphorus Concentration and Suspended Solids Particle Size Class - Jason A. Hubbart, and Elliott Kellner	West Virginia University	Jason Hubbart
P6	Improved site-specific allometric equations for Robinia pseudoacacia - Joel L. Scott ¹ , Jessie I. Motes ² , Sarah L. Ottinger ² , Nina Wurzbarger ² , Chelcy F. Miniat ¹ , and Katherine Elliott ¹	¹ USDA Forest Service ² University of Georgia	Joel Scott
P21	Characteristics of flow events that influence phosphorus and nitrogen loads from ranchlands of South-central Florida - E Boughton ¹ , S Shukla ² , P Bohlen ³ , E Keel ¹ , A. Saha ¹ , A. West ¹ , S Hollingsed ¹ , J Maki ¹ , R Mesmer ¹ , M Clark ¹ , and H Swain ¹	¹ Archbold Biological Station ² University of Florida ³ University of Central Florida	Amartya Saha
P22	Application of Remote Sensing Drought Indicators for Monitoring Drought and Streamflow - Vahid Rahmani, and Devon Banded	Kansas State University	Vahid Rahmani
P23	Incorporating Human Dimensions in Long-Term Agroecosystem Research Network - Alycia Bean, Alisa Coffin, J.D. Wulfhorst, Claire Friedrichsen, Gwendwr Meredith, and Zach Hurst	USDA-ARS	Alycia Bean

Wednesday, November 18, 2020

Morning Plenary Session, Concurrent Sessions, and Poster Session

11:00-11:15 AM	Welcome and Logistics: Dr. David Bosch, USDA-ARS
11:15-11:45 AM	Plenary Speaker: Dr. Peter Colohan, The Internet of Water: Sharing and Integrating Water Data for Sustainability
11:45-11:55 PM	Break
11:55-2:00 PM	Concurrent Sessions

Wednesday November 18, 2020		Water Quality and Quantity		
11:55 AM – 2:00 PM		Coastal Plain Watersheds		
		Chair: Steve Golladay		
Time	ID	Abstracts	Affiliation	Presenter
12:00-12:15 PM	P ₁	Little River Experimental Watershed History - David D. Bosch, Joseph M. Sheridan, Frank M. Davis, Tim C. Strickland, Dinku M. Endale, Alisa W. Coffin, and Oliva Pisani	USDA-ARS	David D. Bosch
12:15 – 12:30 PM	W16	Peak Flow Characterization for the Little River Experimental Watershed - David D. Bosch ¹ , Katrin Bieger ² , Jeff G. Arnold ¹ , and Peter M. Allen ³	¹ USDA-ARS ² Texas A&M ³ Baylor University	David D. Bosch
12:30 - 12:45 PM	W18	A methodology for developing a compound flooding model using long term data collection and basic stochastic hydrology - Nolan Williams, and Joshua Robinson	Robinson Design Engineers	Nolan Williams
12:45 – 1:00 PM	W21	Adaptive management for aquatic species recovery in the Apalachicola-Chattahoochee-Flint river basin - Elise Irwin ¹ , Kristie Coffman ² , Maureen Walsh ³ , Sean Blomquist ³ , Heather Bulger ⁴ , Sarah Miller ⁴	¹ USGS ² Alabama Cooperative Fish and Wildlife Research Unit ³ USFWS ⁴ USACE	Elise Irwin
1:00 – 1:15 PM	W32	Strengthening resiliency in coastal watersheds by protecting ecosystem services: A web-based GIS map viewer decision support system - Anne Kuhn, Jane Copeland, Marisa Mazzotta, Emily Trentacoste, and Bill Jenkins	US EPA	Anne Kuhn

Wednesday November 18, 2020		Water Quality and Quantity		
11:55 AM – 2:00 PM		Coastal Plain Watersheds Chair: Steve Golladay		
Time	ID	Abstracts	Affiliation	Presenter
1:15 – 1:30 PM	W23	Longleaf pine forest restoration increases isolated wetland hydroperiod in the Gulf Coastal Plain of southeastern US - Steve Golladay, Brian Clayton, Steven Brantley, Chelsea Smith, Jill Qi, and David Hicks	Jones Center at Ichauway	Steve Golladay
1:30 - 1:45 PM		OPEN		
1:45 - 2:00 PM		OPEN		
2:00 - 2:55 PM		Break		

Wednesday November 18, 2020		Climate, LandCover, Land Use		
11:55 AM – 2:00 PM		Watershed Response to Intensifying Precipitation Extremes and Adaptation Strategies: Science and Management Challenges (SS) Chairs: Anna Jalowska and Devendra Amatya		
Time	ID	Abstracts	Affiliation	Presenter
12:00 – 12:15 PM	C21	Changes in the Future Extreme Precipitation Using Dynamically Downscaled Simulations From 2025 to 2100 for three forested and three urban stations in Southeastern U.S. Watersheds - Anna M. Jalowska, Devendra M. Amatya, Tanya L. Spero, Geneva M. E. Gray, Jared H. Bowden	US EPA	Anna M. Jalowska
12:15 – 12:30 PM	C18	Watershed Management and Hazard Mitigation Planning: Collaborative Benefits in a Changing Climate - Mahtaab Bagherzadeh, and Perry Thomas	Kentucky Division of Water	Mahtaab Bagherzadeh
12:30 – 12:45 PM	C19	Spatial downscaling of precipitation data using advanced machine learning at the watershed scale - Utkarsh Mital ¹ , Dipankar Dwivedi ¹ , James B. Brown ¹ , Carl I. Steefel ¹ , Scott L. Painter ²	¹ Lawrence Berkeley National Laboratory ² Oak Ridge National Laboratory	Utkarsh Mital

Wednesday November 18, 2020		Climate, LandCover, Land Use		
11:55 AM – 2:00 PM		Watershed Response to Intensifying Precipitation Extremes and Adaptation Strategies: Science and Management Challenges (SS)		
		Chairs: Anna Jalowska and Devendra Amatya		
Time	ID	Abstracts	Affiliation	Presenter
12:45 – 1:00 PM	C20	Extreme Events Simulated by Dynamical Downscaling - Tanya L. Spero ¹ , Jared H. Bowden ² , Anna M. Jalowska ¹ , Meghan S. Mallard ¹ , and Geneva M. Gray ²	¹ US EPA ² NC State University	Tanya L. Spero
1:00 – 1:15 PM		OPEN		
1:15 – 1:30 PM	C22	USA Continental Scale Intensification of Sub-daily Precipitation Intensities from ARS Experimental Watersheds - Eleonora Demaria, David Goodrich, David Bosch, Patrick Starks, John Sadler, Anthony Buda, Steven van Vector, and Douglas Smith	USDA-ARS	David Goodrich
1:30 – 1:45 PM	C23	A Comparison of Dynamical and Statistical Downscaled Climate Change Projections to Inform Future Precipitation Intensity-Duration-Frequency Curves - Jared H. Bowden ¹ , Anna Jalowska ¹ , Geneva M. Gray ² , Tanya L. Spero ¹ , Adam Terando ³ , Ryan Emanuel ² , Jaime Collazo ^{2,3}	¹ US EPA ² North Carolina State University ³ USGS	Jared H. Bowden
1:45 – 2:00 PM	C24	Effects of species conversion on hydrology and nutrient cycling in the central Appalachians - Benjamin Rau, Charlene Kelly, and Mary Beth Adams	USDA Forest Service, Northern Research Station, West Virginia University.	Benjamin Rau
2:00 – 2:55 PM		Break		

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Wednesday November 18, 2020		Models and Management		
11:55 AM - 2:00 PM		Advancing Watershed Science using Machine Learning, Diverse Data, and Mechanistic Modeling (SS) Chair: Dipankar Dwivedi and Kimberly Ann Kaufeld		
Time	ID	Abstracts	Affiliation	Presenter
12:00 – 12:15 PM	M24	AI to Advance Watershed Co-Design: Toward Seamless Interactions between Diverse, Multi-Scale Watershed Data, Models and Hardware - Susan S. Hubbard, Deb Agarwal, Bhava Arora, Baptiste Dafflon, Dipankar Dwivedi, Nicola Falco, Juliane Mueller, Carl Steefel, Sebastian Uhlemann, Charu Varadharajan, Haruko Wainwright	Lawrence Berkeley National Laboratory	Haruko Wainwright
12:15 – 12:30 PM	M20	Quantifying the Influence of Matrix Diffusion in Fractured Bedrock on Solute Retention and Transport at the Hillslope Scale - Harihar Rajaram	Johns Hopkins University	Harihar Rajaram
12:30 – 12:45 PM	M21	Watersheds as natural spatial units for aggregating geospatial data for a global river bank erosion model - Jon Schwenk, Joel Rowland, and Kimberly Kaufeld	Los Alamos National Laboratory (LANL)	Jon Schwenk
12:45 – 1:00 PM	M22	Simulating Hydrology's Role in Fire Behavior - Adam Atchley ¹ , Alexandra Jonko ¹ , Elchin Jafarov ¹ , Rod Linn ¹ , Louise Loudermilk ² , Elizabeth Kleynhans ³ , Sean Michaletz ³ , Kevin Hiers ⁴ , and Brett Williams ⁵	¹ LANL ² US Forest Service ³ University of British Columbia ⁴ Tall Timbers ⁵ US Air Force	Adam Atchley
1:00 – 1:15 PM	M23	Wavelet and entropy approaches for improved characterization of geochemical hot moments - Bhavna Arora, Jiancong Chen, Dipankar Dwivedi, Haruko Wainwright, Carl Steefel, Kenneth Williams, and Susan Hubbard	Lawrence Berkeley National Laboratory	Bhavna Arora
1:15 – 1:30 PM	M25	Multi-criteria, time-dependent sensitivity analysis considering hydrologic signatures, model performance metrics, and forcing uncertainty - Menberu B. Meles, Dave C. Goodrich, Carl Unkrich, Shea Burns, and Hoshin Gupta	USDA ARS	Menberu B. Meles
1:30 – 1:45 PM	M26	Machine Learning Tools for Predicting Freshwater Fish Populations - Douglas Patton, Mike Cyterski, Deron Smith, Kurt Wolfe, Brenda Rashleigh, John M Johnston, and Rajbir Parmar	US EPA	Douglas Patton

Wednesday November 18, 2020		Models and Management		
11:55 AM - 2:00 PM		<p align="center">Advancing Watershed Science using Machine Learning, Diverse Data, and Mechanistic Modeling (SS)</p> <p align="center">Chair: Dipankar Dwivedi and Kimberly Ann Kaufield</p>		
Time	ID	Abstracts	Affiliation	Presenter
1:45 – 2:00 PM	M19	What Role Does Hydrological Science Play in the Age of Machine Learning? - Grey Nearing	University of Alabama	Grey Nearing
2:00 - 2:55 PM		Break		

Wednesday November 18, 2020		Status, Trends, Sustainability		
11:55 AM - 2:00 PM		<p align="center">FACETS: Floridan Aquifer Collaborative Engagement for Sustainability (SS)</p> <p align="center">Chair: Wendy Graham</p>		
Time	ID	Abstracts S10-S15	Affiliation	Presenter
12:00 – 12:15 PM	S10	Stakeholder-Driven Modeling in Support of Groundwater Sustainability: the Floridan Aquifer Collaborative Engagement for Sustainability - W. Graham ¹ , D. Kaplan ¹ , D. Adams ¹ , K. Athearn ¹ , T. Borisova ¹ , W.L. Bartels ¹ , M. Monroe ¹ , L. Staal ¹ , M. Dukes ¹ , C. Barrett ¹ , K. Rowles ² , M. Masters ² , A. Smith ³ , P. Dwevidi ³ , C. Furman ³ , G. Vellidis ³ , W. Porter ³ , and P. Srivastava ⁴ (FACETS) Project	¹ University of Florida ² Albany State University ³ University of Georgia ⁴ Auburn University	Wendy Graham
12:15 – 12:30 PM	S11	Predicting Precision Nitrogen Side-dress Applications for Maize with a Simulation Model - Toffanin A., Vellidis G.	University of Georgia	Ariana Toffanin
12:30 – 12:45 PM	S12	Economics of Best Management Practices to Improve Water Quality and Quantity in the Upper Floridan Aquifer - A. Smith ¹ , G. Hancock ¹ , U Koirala ² , R. Karki ³ , K. Athearn ² , and Y. Liu ¹	¹ University of Georgia ² University of Florida ³ Auburn University	Amanda Smith

Wednesday November 18, 2020		Status, Trends, Sustainability		
11:55 AM - 2:00 PM		FACETS: Floridan Aquifer Collaborative Engagement for Sustainability (SS) Chair: Wendy Graham		
Time	ID	Abstracts S10-S15	Affiliation	Presenter
12:45 – 1:00 PM	S13	Scrutinizing Significance of Trees in Watershed Modeling - Henrique Haas ¹ , Latif Kalin ¹ , Puneet Srivastava ¹ , Nathan G. F. Reaver ² , David A. Kaplan ²	¹ Auburn University ² University of Florida	Henrique Haas
1:00 – 1:15 PM	P30	Impact of land use change and different management practices on nitrate loading to groundwater in Santa Fe River Basin - Sagarika Rath, Wendy Graham, and David Kaplan	University of Florida	Sagarika Rath
1:30 – 1:45 PM	S14	The importance of process representation for simulating coupled surface-groundwater flow: a comparison of SWAT, SWAT-MODFLOW and DisCo - Rob de Rooij ¹ , Patricia Spellman ² , Sagarika Rath ¹ , Nathan Reaver ¹ , Wendy Graham ¹ , and David Kaplan ¹	¹ University of Florida ² University of South Florida	Rob de Rooij
1:45 - 2:00 PM	S15	The integration of Social Learning and Facilitation methods to enhance stakeholder engagement for the FACETS project - Furman, C. ¹ , Bartels, W. ¹ , Rowles, K. ¹ , and Masters, M. ²	¹ University of Georgia ² Albany State University	Carrie A. Furman
2:00 - 2:55 PM		Break		

Wednesday November 18, 2020		Water Quality and Quantity		
2:55 - 5:00 PM		Water Quality and Quantity (B) Chair: Doug Burns		
Time	ID	Abstracts	Affiliation	Presenter
3:00 – 3:15 PM	W24	An Investigation of Phosphorus Concentration Trends in Waters of the U.S. - James N. Carleton, Steve LeDuc, Meridith Fry, Sylvia Lee, and Britta Bierwagen	US EPA	James N. Carleton
3:15 – 3:30 PM	W26	Sub-Watershed Trace Element Regimes in Surface Waters of an Appalachian Mixed-Land-Use Watershed - Elliott Kellner, and Jason A. Hubbart	West Virginia University	Elliott Kellner

Wednesday November 18, 2020		Water Quality and Quantity		
2:55 - 5:00 PM		Water Quality and Quantity (B)		
		Chair: Doug Burns		
Time	ID	Abstracts	Affiliation	Presenter
3:30 – 3:45 PM	W27	Relationship of water quality in a tidal freshwater stream to inputs from terrestrial watersheds - C.C. Trettin ¹ , D.A. Amaty ¹ , C. Allan ² , T. Callahan ³	¹ USDA Forest Service ² University of North Carolina ³ College of Charleston	Carl Trettin
3:45 – 4:00 PM	W28	Economic Analysis of Modern Irrigation Scheduling Strategies on Cotton Production under Different Tillage Systems in South Georgia - Anukul Bhattarai, Yangxuan Liu, Vasileios Liakos, George Vellidis, and Amanda Smith	University of Georgia	Anukul Bhattarai
4:00 – 4:15 PM	W30	How does high input maize production affect water quality? - Dimitrios Pavlou ¹ , Anna Orfanou ¹ , Miguel L. Cabrera ¹ , Glendon Harris ¹ , Gerrit Hoogenboom ² , R. Dewey Lee ¹ , Reagan L. Noland ³ , Wesley M Porter ¹ , David E. Radcliffe ¹ and George Vellidis ¹	¹ University of Georgia ² University of Florida ³ Texas A&M University	Dimitrios Pavlou
4:15 – 4:30 PM	P2	In-field hydrologic properties affected by sugarcane row spacing in south Louisiana - Paul White	USDA -ARS	Paul White
4:30 – 4:45 PM	P8	Feasibility and implications of two approaches for estimating recharge from hydrologic events at the Panola Mountain Research Watershed, Georgia - Brent T. Aulenbach and Jeffery W. Riley	USGS	Brent T. Aulenbach
4:45 – 5:00 PM	W33	Forty Years of Data: Challenges and opportunities afforded by long-term data sets - Kenton Sena ¹ , Tanja Williamson ² , Christopher Barton ¹	¹ University of Kentucky ² U.S. Geological Survey	Kenton Sena
5:00 - 5:10 PM		Break		

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Wednesday November 18, 2020		Models and Management		
2:55 PM – 5:00 PM		Watershed Modeling (B)		
		Chair: Jeff Chanat		
Time	ID	Abstracts	Affiliation	Presenter
3:00 – 3:15 PM	M27	South Georgia Groundwater Contamination Susceptibility Determination through an Automated Geospatial Model using Combined Modeling Approach of DRASTIC and MODFLOW6 - Sudhanshu S Panda ¹ , Ying Oyang ² , and Johnny Grace III ²	¹ University of North Georgia ² USDA Forest Service	Sudhanshu S Panda
3:15 – 3:30 PM	M29	Trends in Deuterium Excess Coupled with Trends in Groundwater Levels Observed at Shingobee and Williams Lake, Minnesota Reveal Local Evaporative Processes - Paul Schuster, Richard Webb, Don Rosenberry, and Dallas Hudson	USGS	Richard Webb
3:30 – 3:45 PM	M30	Non-Point Source Pollution Modelling under conservation practices in The Upper Choctawhatchee Watershed Using Soil and Water Assessment Tool (SWAT) - Yashar Makhtoumi ¹ , Lucy Ngatia ² , Johnny M. Grace III ³ , Aavudai Anandhi ² , and Gang Chen ¹	¹ FAMU-FSU ² Florida A&M University ³ USDA Forest Service	Yashar Makhtoumi
3:45 – 4:00 PM		OPEN		
4:00 – 4:15 PM	M33	Pinpointing decadal-scale “hot spots” of legacy nitrogen storage in the Chesapeake Bay watershed using differential spatially referenced regression - Jeffrey G. Chanat	USGS	Jeffrey G. Chanat
4:15 – 4:30 PM	P15	Simulating Hydrology of Current Conditions and Post-Longleaf Pine Restoration on a Coastal Forest Watershed, SC- M. D. Hamidi ¹ , D. M Amatya ² , C. C. Trettin ² , and Z. Dai ³	¹ Durham University, Durham, U.K ² USDA Forest Service ³ Michigan Technological University	D. M Amatya
4:30 – 4:45 PM	P32	Development of Regional Streamflow Duration Assessment Methods (SDAMs) for the United States - Julia Kelso ^{1,2} , Raphael Mazar ² , Ken Fritz ¹ , Rachel Harrington ¹ , Tracie-Lynn Nadeau ¹ , and Brian Topping ¹	¹ Oak Ridge Institute for Science and Education ² US EPA ³ Southern Coastal California Water Research Project	Julia Kelso

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Wednesday November 18, 2020		Models and Management		
2:55 PM – 5:00 PM		Watershed Modeling (B)		
		Chair: Jeff Chanut		
Time	ID	Abstracts	Affiliation	Presenter
4:45 – 5:00 PM	P18	Agricultural Greenhouse Gas Emissions in Response to Climate Change: A Basin Scale Modeling Approach - "Mahnaz Dil Afroz ¹ , Aavudai Anandhi ² , and Gang Chen ¹	¹ FAMU-FSU ² Florida Agricultural & Mechanical University	Mahnaz Dil Afroz
5:00 – 5:10		Break		

Wednesday November 18, 2020		Status, Trends, Sustainability		
2:55 PM – 5:00 PM		Long-Term Agroecosystem Research		
		Chair: Oliva Pisani		
Time	ID	Abstracts	Affiliation	Presenter
3:00 – 3:15 PM	S22	Cropping patterns over two decades in the Little River Experimental Watershed, Georgia, USA – A.W. Coffin, D.D. Bosch, T.C. Strickland, D.M. Endale, O. Pisani, and R. Lowrance	USDA ARS	Alisa Coffin
3:15 – 3:30 PM	S23	Characterizing transport of natural and anthropogenic constituents in a long-term agricultural watershed in the northeastern US – T. Veith ¹ , H. Preisendanz ² , and K. Elkin ¹	¹ USDA ARS ² Pennsylvania State University	Dr. Heather Preisendanz
3:30 – 3:45 PM	S24	Dissolved organic matter in agricultural watersheds: Spatial and temporal variability across the LTAR network – O. Pisani ¹ , J.A. Biederman ¹ , D.D. Bosch ¹ , E. Boughton ² , R. Boughton ² , E. Brooks ³ , R.B. Bryant ¹ , A.R. Buda ¹ , A.W. Coffin ¹ , K. Cole ¹ , D.M. Endale ¹ , D.C. Goodrich ¹ , C.J. Hapeman ¹ , M.A. Kautz ¹ , K.W. King ¹ , R.N. Lerch ¹ , R.E. Lizotte ¹ , G.W. McCarty ¹ , T.B. Moorman ¹ , D. Moriasi ¹ , E. Murray ¹ , R. Plummer ¹ , V. Sclater ² , M. Seyfried ¹ , T.C. Strickland ¹ , A. Verser ¹ , P.M. White ¹ , and H.F. Wilson ⁴	¹ USDA ARS ² Archbold Biological Station ³ University of Idaho ⁴ Agriculture and Agri-Food Canada	Oliva Pisani
3:45 – 4:00 PM	S25	Southern Plains LTAR Agroecosystem Research – P.J. Starks, D.N. Moriasi, and Ann-Marie Fortuna	USDA ARS	Patrick Starks
4:00 – 4:15 PM	S26	Use of a simulation model for increasing agroecosystems sustainability – A. Orfanou ¹ , D. Pavlou ¹ , K.J. Boote ² , M.L. Cabrera ¹ , G. Harris ¹ , R.D. Lee ¹ , R.L. Noiland ³ , G. Vellidis ¹ and W.M. Porter ¹	¹ University of Georgia ² University of Florida ³ Texas A&M University	Anna Orfanou

Wednesday November 18, 2020		Status, Trends, Sustainability		
2:55 PM – 5:00 PM		Long-Term Agroecosystem Research		
		Chair: Oliva Pisani		
Time	ID	Abstracts	Affiliation	Presenter
4:15 – 4:30 PM	S27	Using remote sensing and deep learning to test regional boundaries of the Gulf Atlantic Coastal Plain Long-Term Agroecosystem Research network site – A. Stone, A. Coffin, M. Madden, L. Seymour, M. Holder, and J. Powell	University of Georgia	Joseph Powell
4:30 – 4:45 PM	S28	Expanding LTAR Capabilities with Water Parcel Tracking – J.M. Baker ¹ , R. Felton ¹ , T.J. Griffis ² , G.W. Feyereisen ¹ , and S.A. Porter ³	¹ USDA ARS ² University of Minnesota ³ Environmental Working Group, Minneapolis, MN	John Baker
4:45 – 5:00 PM	S29	The role of bioavailable phosphorus loading on Lake Erie harmful algal blooms – L. Johnson, T. Guo, N. Manning, and D. Baker	Heidelberg University	Laura Johnson
5:00 - 5:10 PM		Break		

Wednesday, November 18, 2020			
5:10PM –6:00 PM • Poster Session Two, Chair Oliva Pisani			
ID	Abstracts	Affiliation	Presenter
P24	Water Footprint of Agricultural Crops: A Meta-analysis on Current Understanding and Future Perspectives - R. Deepa, and A. Anandhi	Florida Agricultural & Mechanical University	R. Deepa
P25	Evapotranspiration in a Subtropical wetland savanna using low-cost Lysimeter, Eddy Covariance and Modeling approaches - Amartya Saha, Nicholas McMillan, Haoyu Li, Xukai Zhang, Phoebe Judge, Elizabeth Boughton	Agroecology Research Center, Archbold Biological Station, Buck Island Ranch, Lake Placid, Florida, USA	Amartya Saha
P29	Impacts Of Pasture, Hay And Row Crop Management Systems On Groundwater Quality And Quantity In The Santa Fe River Basin, Florida - Dogil Lee, Sagarika Rath, and Wendy D. Graham	University of Florida	Dogil Lee

Wednesday, November 18, 2020

5:10PM –6:00 PM • Poster Session Two, Chair Oliva Pisani

ID	Abstracts	Affiliation	Presenter
P33	Putting the Research Catchments on a Map: An Overview of Research Sites that have Shaped Knowledge in Trans-Disciplinary Research - Steven Sebestyen ¹ , James Shanley ² , Jonathan Duncan ³ , Theresa Blume ⁴ , Peter S. Murdoch ² , and Richard Webb ²	¹ USDA Forest Service ² USGS ³ Pennsylvania State University ⁴ GFZ German Research Center for Geosciences	Pete Murdoch

Thursday, November 19, 2020

Plenary and Concurrent Sessions, "Passing the Gavel" Adjournment

11:00-11:15 AM	Welcome and Logistics: Dr. David Bosch, USDA-ARS
11:15-11:45 AM	Plenary Speaker: Dr. Lindsey Rustad, Watershed Studies in the 21st Century: Integrating experiments, models and long-term observations across temporal and spatial scales
11:45-11:55 AM	Break
11:55-2:00 PM	Concurrent Sessions

Thursday, November 19, 2020

Water Quality and Quantity

11:55– 2:00 PM

Water Quality and Quantity (A)

Chair: Carl Trettin

Time	ID	Abstracts	Affiliation	Presenter
12:00 – 12:15 PM	W1	Converting naturally regenerated mixed pine-hardwood to loblolly pine plantation forests reduces streamflow the Piedmont of North Carolina- Johnny Boggs, Ge Sun, and Steven McNulty	USDA Forest Service	Johnny Boggs
12:15 – 12:30 PM	W2	Utilizing modeling to better understand habitat impacts - Chelsea Smith, Steven Brantley, Jill Qi and Stephen Golladay	The Jones Center at Ichauway	Chelsea Smith

Thursday, November 19, 2020		Water Quality and Quantity		
11:55– 2:00 PM		Water Quality and Quantity (A)		
		Chair: Carl Trettin		
Time	ID	Abstracts	Affiliation	Presenter
12:30 – 12:45 PM	W3	Benefits of State and Private Forest Lands for Water Supply in the Southern United States - Ning Liu ^{1,3} , G. Rebecca Dobbs ^{2,3} , Peter Caldwell ³ , Chelcy Ford Miniati ³ , Paul V. Bolstad ¹ , Stacy Nelson ² , and Ge Sun ³	¹ University of Minnesota; ² North Carolina State University ³ USDA Forest Service	Ning Liu
12:45 – 1:00 PM	W4	Caveat to using the Large Woody Debris Index to assess degrading streams ¹ - Rebecca Fanning ¹ , and Joshua Robinson ²	¹ College of Charleston ² Robinson Design Engineers	Rebecca Fanning
1:00 – 1:15 PM	W5	Determining functional lift in restored Coastal Plain headwater streams in Little Pine Knot Watershed in Western Georgia - Stacey Sloan Blersch ¹ , Kirsten Walsh ¹ , Sara Gottlieb ²	¹ Columbus State University ² The Nature Conservancy, GA	Stacey Sloan Blersch
1:15 – 1:30 PM	W6	Agricultural intensification and erosion control through land and water management practices in the watershed villages of Mali - Birhanu Zemadim Birhanu, Kalifa Traore, Karamoko Sanogo, Ramadjita Tabo, Gundula Fischer, and Anthony Michael Whitbread	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Birhanu Zemadim Birhanu
1:30 – 1:45 PM	W7	A synthesis of ecosystem management strategies for forests in the face of chronic nitrogen deposition - Christopher M. Clark ¹ , Jennifer Richkus ² , Phillip W. Jones ² , Jennifer Phelan ² , Douglas A. Burns ³ , and Wim de Vries ⁴ , Enzai Du ⁵ , Mark E. Fenn ⁶ , Laurence Jones ⁷ , and Shaun A. Watmough ⁸	¹ U.S. Environmental Protection Agency ² RTI International ³ U.S. Geological Survey ⁴ Wageningen University and Research ⁵ Beijing Normal University, Beijing ⁶ USDA Forest Service ⁷ Centre for Ecology & Hydrology ⁸ Trent University	Douglas Burns

Thursday, November 19, 2020		Water Quality and Quantity		
11:55– 2:00 PM		Water Quality and Quantity (A) Chair: Carl Trettin		
Time	ID	Abstracts	Affiliation	Presenter
1:45 – 2:00 PM	W9	Riparian land cover and hydrology influence stream dissolved organic matter composition in an agricultural watershed - Oliva Pisani, David D. Bosch, Alisa W. Coffin, Dinku M. Endale, Dan Liebert, and Timothy C. Strickland	USDA-ARS	Oliva Pisani
2:00 – 2:10 PM		Break		
Thursday, November 19, 2020		Climate, Land Cover, Land Use		
11:55 – 2:00 PM		Watershed Evapotranspiration in a Changing Environment (SS) Chairs: Ge Sun and Devendra Amatya		
Time	ID	Abstracts	Affiliation	Presenter
12:00 – 12:15 PM	C1	A Multi-approach Assessment of Evapotranspiration and Water Budget of a Southeastern US Atlantic Coastal Plain Forest - Devendra M Amatya ¹ and Milan Fischer ²	¹ USDA Forest Service ² Global Change Research Institute CAS, Czech Republic	Devendra M Amatya
12:15 – 12:30 PM	C2	Do riparian forests alter water uptake in response to flash droughts? Case study from Panola Mountain Research Watershed - Jeffrey W. Riley ¹ , Luke A. Pangle ² , Brent T. Aulenbach ¹ , and Michael A. Forster ³	¹ USGS South Atlantic Water Science Center ² Georgia State University ³ School of Agriculture and Food Science, The University of Queensland	Jeffrey Riley
12:30 – 12:45 PM	C3	Spatially explicit evapotranspiration for improved characterization of basin water budget dynamics at multiple spatiotemporal scales - Gabriel Senay	USGS Earth Resources Observation and Science Center	Gabriel Senay
12:45 – 1:00 PM	C4	Effects of forest understory removal and prescribed fire on watershed water yield and evapotranspiration in the southern Appalachian Mountains, USA - Caldwell, P.V. ¹ , Elliott, K.J. ¹ , Miniati, C.F. ¹ Liu, N. ¹ , Knoepp, J.D. ¹ , Oishi, A.C. ¹ , and Bolstad, P.B. ²	¹ USDA Forest Service Coweeta Hydrologic Laboratory ² University of Minnesota	P.V. Caldwell

Thursday, November 19, 2020		Climate, Land Cover, Land Use		
11:55 – 2:00 PM		Watershed Evapotranspiration in a Changing Environment (SS)		
		Chairs: Ge Sun and Devendra Amatya		
Time	ID	Abstracts	Affiliation	Presenter
1:00 – 1:15 PM	C6	Using ET estimated from remotely sensed data to investigate drought-induced tree mortality in a temperate forest in the Central US - Yun Yang ^{1,2} , Martha Anderson ¹ , Feng Gao ¹ , Christopher Hain ³ , Jeffrey Wood ⁴ , Lianhong Gu ⁵	¹ Hydrology and Remote Sensing Lab, USDA-ARS, Beltsville, MD ² ESSIC, University of Maryland, College Park, MD ³ NASA Marshall Flight Center, Nashville, AL ⁴ University of Missouri, MO ⁵ Oak Ridge National Lab, Oak Ridge, TN	Yun Yang
1:15 – 1:30 PM	C8	Evapotranspiration: the Unsung Hero for Ecosystem Services - Ge Sun	USDA Forest Service Asheville, NC, USA	Ge Sun
1:30 – 1:45 PM	C25	Evaluating high water table hydrology and eddy covariance measurements of evapotranspiration at a newly instrumented watershed in coastal South Carolina - Thomas M. Williams, Thomas L. O'Halloran, Bo S. Song, Jeremy D. Forsythe, and Brian J. Williams	Clemson University	Thomas L. O'Halloran
1:45 – 2:00 PM	C26	Stand-level transpiration increases after eastern redcedar encroachment into the Cross-timbers - Patricia R. Torquato ^{1, 2*} , Rodney E. Will ¹ , Bo Zhang ¹ and Chris B. Zou ¹	¹ Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078, USA; ² School of Ecosystem and Forest Science, The University of Melbourne, Burnley, Victoria 3121, Australia	Patricia R. Torquato
2:00 – 2:10 PM		Break		

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Thursday, November 19, 2020		Models and Management		
11:55 PM – 2:00 PM		Integrating Science and Watershed Decision Making		
		Chair: Rick Webb		
Time	ID	Abstracts	Affiliation	Presenter
12:00 – 12:15 PM	M1	Assessment and Decision Support for Natural Asset Management in Connecticut Coastal Watersheds to Meet Combined Water Quality and Biointegrity Goals - Paul E. Stacey	Footprints In The Water LLC	Paul E. Stacey
12:15 – 12:30 PM	M3	Real-time coastal salinity index for monitoring coastal drought and ecological response to changing salinity values along the Gulf of Mexico and the Eastern Atlantic Coast - Matthew Petkewich ¹ , Kirsten Lackstrom ² , and Bryan McCloskey ¹	¹ USGS ² Carolinas Integrated Sciences and Assessments	Matthew Petkewich
12:30 – 12:45 PM	M4	A systems approach to nitrogen remediation in a coastal watershed - Laura Erban, Tim Gleason, and Kate Mulvaney	US EPA	Laura Erban
12:45 – 1:00 PM	M5	Water Prediction Tools for Informing Climate Adaption Strategies as a Focus of Community Engagement - Fred L. Ogden	NOAA	Fred L. Ogden
1:00 – 1:15 PM	M8	Science Needs of Arizona's Watersheds - Philip Heilman ¹ , Tahnee Robertson ² , Karen Simms ³ , and Gerardo Armendariz ¹	¹ USDA-ARS SWRC ² Southwest Decision Resources ³ Pima County	Philip Heilman
1:15 – 1:30 PM	M9	Watershed Functional Zone; Multi-type multi-scale integration for understanding watershed functioning - Haruko M Wainwright ¹ , Nicola Falco ¹ , Baptiste Dafflon ¹ , Sebastian Uhlemann ¹ , Michelle E Newcomer ¹ , Maya Franklin ¹ , Burke J Minsley ² , Jeffery Deems ³ , Kenneth Hurst Williams ¹ , Susan Hubbard ¹	¹ Lawrence Berkeley National Laboratory ² USGS ³ University of Colorado, Boulder	Nicola Falco
1:30 – 1:45 PM	M10	Next-generation monitoring and research for resilient ecosystems and natural resources - Peter S. Murdoch, Joel Blomquest, John Brakebill, Chris Konrad, and Brian Pellerin	USGS	Peter Murdoch
1:45 – 2:00 PM	P12	From Forests to Faucets: A drinking water utility's approach to protecting its source through watershed management - Raven Lawson and Benjamin D. Thesing	Central Arkansas Water	Benjamin Thesing

Thursday, November 19, 2020		Models and Management		
11:55 PM – 2:00 PM		Integrating Science and Watershed Decision Making Chair: Rick Webb		
Time	ID	Abstracts	Affiliation	Presenter
2:00 - 2:10 PM		Break		

Thursday, November 19, 2020		Status, Trends, Sustainability		
11:55 AM - 2:00 PM		Watershed Response to Change Chair: Elizabeth Keppeler		
Time	ID	Abstracts	Affiliation	Presenter
12:00 – 12:15 PM	S1	Changing Climate Variance: Implications for the United States Eastern Deciduous Forest - Jason A. Hubbart	¹ West Virginia University ² Davis College	Jason Hubbart
12:15 – 12:30 PM	S2	Combined effect of non stationary stressors in Choctawhatchee Watershed - Yashar Makhtoumi ¹ , Lucy Ngatia ² , Johnny M. Grace III ³ , Aavudai Anandhi ² , and Gang Chen ¹	¹ FAMU-FSU College of Engineering ² Florida A&M University ³ USDA Forest Service	Yashar Makhtoumi
12:30 – 12:45 PM	S3	Long-term low flow responses to evolving timber harvest techniques in the Pacific Northwest - Elizabeth Keppeler ¹ , Ashley Coble ² , Joe Wagenbrenner ¹ , Holly Barnard ³ , Timothy Link ⁴ , and Brooke Penaluna ¹	¹ USDA Forest Service ² National Council for Air and Stream Improvement ³ University of Colorado, Boulder, CO ⁴ University of Idaho, Moscow, ID	Elizabeth Keppeler
12:45 – 1:00 PM	S7	Field-Based Assessment Of An Urbanized Montane Headwater Catchment: The Impact Of Watershed-Wide Green Stormwater Infrastructure Retrofits - Joshua Robinson, and Philip Ellis	Robinson Design Engineers	Joshua Robinson

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Thursday, November 19, 2020		Status, Trends, Sustainability		
11:55 AM - 2:00 PM		Watershed Response to Change		
		Chair: Elizabeth Keppeler		
Time	ID	Abstracts	Affiliation	Presenter
1:00 – 1:15 PM	S8	Lessons Learned from Stream Restoration Partnerships in North Carolina: A State Forestry Agency’s Perspective - Alan Coats, Tom Gerow, Jr., A.J. Lang, and Bill Swartley	N.C. Forest Service	Tom Gerow, Jr.
1:15 – 1:30 PM	S9	Analyzing long-term effect of gully erosion on land degradation in Upper Blue Nile basin, Ethiopia - Mesenbet Yibeltal ^{1,2} , Atsushi Tsunekawa ³ , Nigussie Haregeweyn ¹ , Enyew Adgo ² , Derege Tsegaye Meshesha ² , Dagnachew Aklog ¹ , Tsugiyuki Masunaga ³ , Mitsuru Tsubo ¹ , Paolo Billi ¹ , Matthias Vanmaercke ^{1,4} , Kindiye Ebabu ^{1,2} , Mekete Dessie ² , Dagnenet Sultan ² , Mulatu Liyew ^{1,2}	¹ Tottori University, Tottori, Japan ² Bahir Dar University, Bahir Dar, Ethiopia ³ Shimane University, Shimane, Japan ⁴ Université de Liège, Belgium	Mesenbet Yibeltal
1:30 – 1:45 PM	P17	Ecosystem water service of tropical island under the changing climate regimes and the altered land cover/use - Qiong Gao and Mei Yu	University of Puerto Rico	Mei Yu
1:45 – 2:00 PM		OPEN		
2:00 – 2:10 PM		Break		

Thursday, November 19, 2020

Adjournment, passing of the Gavel

2:10 - 2:30 PM Adjournment, passing of the Gavel



7th

Interagency Conference
on Research in the Watersheds

Enhancing Landscapes for
Sustainable Intensification
and Watershed Resiliency

Abstracts



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

Converting naturally regenerated mixed pine-hardwood to loblolly pine plantation forests reduces streamflow the Piedmont of North Carolina

JOHNNY BOGGS, GE SUN, AND STEVEN MCNULTY
USDA FOREST SERVICE

There were almost no pine plantations in the southern United States in the 1950s. Now there are over 39 million acres of planted pine with most of that expansion occurring over the last twenty-five years to meet the rising demand for wood. Land management practices that include species conversion can have consequences to surface water availability by altering total forest transpiration. In 2010, two mixed-pine hardwood watersheds located in two different North Carolina Piedmont basins (i.e., Carolina Slate Belt, (CSB) and Triassic Basin, (TB)) were clearcut. In 2010, loblolly pine (*Pinus taeda*) was planted in the CSB watershed and shortleaf pine (*Pinus echinata*) was planted in the TB. Plot-level basal area measurements and continuous streamflow were monitored in each watershed to quantify how streamflow changed following the conversion from mixed-pine hardwood to pine. The CSB soils are thick, well-drained, and tend to function in a similar capacity across seasons. Conversely, the TB soils are thin, with a confining clay layer 30cm below ground surface, and are more prone to stormflow generation than CSB particularly in nongrowing seasons. We found that annual water yield increased by 260% in the CSB and 250% in the TB one year after the clearcut. However, yield decreased in subsequent years due to a rapid growth of the planted pines. By 2019, annual water yield was 6% less in the CSB than if the hardwood trees had not been cut. Despite the different soils, changes in basal and species are a more powerful regulator of annual hydrology in these ecosystems. This study is ongoing and the growth of the young pine trees will continue to be linked to streamflow measurements. Data from this project will help public and private landowners decide how to most effectively sustain forest and water resources together with silvicultural activities across the Piedmont region. Study results also have important implications to evaluate the role of vegetation in regulating storm runoff in the rapidly urbanizing Piedmont region in the southern U.S.



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

Utilizing modeling to better understand habitat impacts

CHELSEA SMITH, STEVEN BRANTLEY, JILL QI AND STEPHEN GOLLADAY
THE JONES CENTER AT ICHAUWAY

Over the past two decades the southeastern United States has experienced multiple severe to exceptional droughts that have been further compounded by human water demand through population growth, agricultural needs and other land-use changes. Water consumption by irrigated row crops and forest evapotranspiration (ET) are the largest water users within the Apalachicola-Chattahoochee-Flint (ACF) basin. Recent models have examined how reducing agricultural irrigation and converting fire-suppressed mixed pine/hardwood forests to longleaf pine affects streamflow within a sub-basin of the ACF (Ichawaynochaway Creek). While increases in flow are positive steps in alleviating ecological stress, understanding how flow relates to imperiled habitats during dry periods is crucial. Using survey techniques, specific elevation profiles of four shoals were generated to equate changes in flow to changes in habitat inundation at each shoal near a long term USGS gage used in the above models. These data allow us to examine how small changes in flow might affect available habitat both for small organisms such as macroinvertebrates as well as fish. We focused on the dry (25th percentile) and extremely dry (5th percentile) ranked mean monthly flows where the largest relative changes in flow were seen. Inundation percentage was similar among varying reductions in agriculture from 30% to 70% with a mean increase of 4.72% habitat. Inundation change was significantly higher when a combination of 30% agricultural reduction and longleaf pine restoration were combined with a mean increase 17% in the extremely dry months. Examining water depth capable of fish movement (>14 cm), similar patterns were seen with an average agricultural increase of 4.89% and agriculture plus pine combination at 23.85%. There was no significant difference in inundation during months at the 25th percentile as shoal habitat was above 80% available at these flow levels before simulations. Understanding how increases in the amount of water available in a watershed with changing land-use correlates to improvements in habitat is critical to finding watershed management solutions that serve both ecological needs and human water demands.



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

Benefits of State and Private Forest Lands for Water Supply in the Southern United States

NING LIU, UNIVERSITY OF MINNESOTA AND USDA FOREST SERVICE

G. REBECCA DOBBS, NORTH CAROLINA STATE UNIVERSITY

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PETER CALDWELL, USDA FOREST SERVICE

CHELCEY FORD MINIAT, USDA FOREST SERVICE

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STACY NELSON, NORTH CAROLINA STATE UNIVERSITY

GE SUN, USDA FOREST SERVICE

Forests provide the most stable and highest quality waters among all land uses. The southeastern U.S. is heavily forested and most of the forests are owned and managed by state and private entities, thus it is critical to understand the role of forested lands in providing water across the region, the fastest growing in the nation. Here we quantified surface water supply originating on State and Private Forest (SPF) lands in the 13 southern states at the 12-digit Hydrologic Unit Code watershed scale, using the Water Supply Stress Index (WaSSI) hydrologic model. Water originating on seven forest ownership types was tracked through the river network and linked to a database of surface drinking water intakes to estimate the population served by water from SPF lands across the southeast. We found that SPF lands in the 13 southern states comprised 44.2% of the total land area and contributed 44.3% of the 836 billion m³ yr⁻¹ total available water supply in the region. Of the 7,582 surface water intakes in the study area, 6,897 (91%) received some portion of their water from SPF lands, while 4,526 intakes (66%) received more than 20% of the water from SPF lands. Approximately 55 million people in the southeast, and 1.8 million people outside the 13 southern states, derived some portion of their water supply from SPF lands. These results highlight the importance of southern State and private forests in providing drinking water to downstream communities.



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

Caveat to using the Large Woody Debris Index to assess degrading streams

REBECCA FANNING, COLLEGE OF CHARLESTON & JOSHUA ROBINSON OF
ROBINSON DESIGN ENGINEERS

The legacy effects of deforestation, row-crop cultivation, beaver extirpation, and removal of instream structural components such as river rock and log jams have permanently altered the fluvial geomorphology of watersheds across the Southeastern Piedmont region of the US. Contemporary research on log pieces and log jams as structural interventions capable of reversing stream incision has considerably influenced stream restoration methods in other parts of the United States. In the arid Southwest, for example, Beaver Dam Analogs (BDAs) and Post Assisted Log Structures (PALS) sometimes combined with beaver reintroductions have significantly improved the hydrological and ecological integrity of restored streams. Many of these methods draw from designs adapted in the early 1900's by the Forest Service and Soil Erosion Service. While these practices have enjoyed a renaissance in the western US, their application to the unique environmental legacies of the southeast are underrepresented in the literature and in practice. Hand-built wooden structures offer tremendous potential to reverse stream incision in the Southeast, where legacy erosion perpetuates a state of Riparian Hydrologic Drought.

We employed the Large Woody Debris Index (LWDI) to assess naturally occurring logs and log jams in South Carolina streams to compare a degraded 1200-acre tributary system of Minkum Creek in Gaffney to a recovering reference watershed within Kings Mountain National Military Park. Logistic regression of reference condition stream channel dimensions was used to establish impairment ratios that estimate the degree of channel incision and widening within the Minkum Creek stream network. We found that streams with 'functioning' LWDI scores suffered significantly higher depth impairment ratios than streams with 'not functioning' LWDI scores ($p = .0522$). Moreover, 'functioning' streams had statistically significant channel top-width impairment ratios compared to both 'not functioning' ($p = 0.0644$) and 'functioning at risk' ($p = 0.0546$) categories of stream reaches. Our findings suggest that 'functioning' LWDI scores indicate a stream reach is evolving on a trajectory from incising to widening. Thus, the functional categories of the LWDI are misleading and should not be employed as success criteria for stream restoration activities utilizing engineered log jams to reverse degradational processes in streams.



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

Determining functional lift in restored Coastal Plain headwater streams in Little Pine Knot Watershed in Western Georgia

STACEY SLOAN BLERSCH CSU EARTH AND SPACE SCIENCES,
KIRSTEN WALSH, CSU EARTH AND SPACE SCIENCES,
SARA GOTTLIEB, TNC IN GEORGIA

Over 30,000 dams currently exist in Georgia, many of which no longer serve their intended purpose, resulting in a significant loss of ecosystem services, including carbon sequestration, erosion regulation, and water purification. In August 2019, Columbus State University (CSU) began partnering with The Nature Conservancy (TNC) in Georgia to evaluate baseline conditions on two second order tributaries of Upatoi Creek near Ft. Benning, Georgia – Little Pine Knot Creek and Juniper Creek. Two earthen dams are scheduled for removal and by January 2020 in order to restore stream connectivity, reduce downstream sedimentation, and improve aquatic habitat at these locations. Functional assessment results from Summer and Fall 2019 will be presented based on continuous measurements of whole ecosystem metabolism using HOBO Dissolved Oxygen Data logger and HOBO temperature and light sensors. Hydrogeomorphic classifications of each creek and reference sites will also be discussed, providing a baseline for evaluating shifts in plant species composition over time.

Lower costs of monitoring equipment and ease of deployment makes ecosystem metabolism a viable metric to evaluate watershed management strategies long-term, as well as meet permitting requirements to show functional lift. While functional lift pre- and post-restoration were the intended purposes of this study, these methods can also be used to potential evaluate land-based management activities, such as the impacts of burning on carbon cycling through these headwater streams as a result of scheduled burns of longleaf pine forest ecosystems.



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

Agricultural intensification and erosion control through land and water management practices in the watershed villages of Mali

BIRHANU ZEMADIM BIRHANU, KALIFA TRAORE, KARAMOKO SANOGO, RAMADJITA TABO, GUNDULA FISCHER, AND ANTHONY MICHAEL WHITBREAD

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS (ICRISAT)

Land and water management practices have been widely implemented in rural Mali since the 1980s to improve agricultural productivity and erosion control. One of the most common land and water management practice applied in the central and southern parts of rural Mali is contour bunding (CB). In this study the impact of CB technique was evaluated based on defined sets of sustainable agricultural intensification domains. Field experimentation involved implementation of contour lines with farm ridges, agronomic trails, and runoff and erosion measurements. Agronomic data was collected on sorghum, maize, groundnut and millet for three consecutive years (2015 to 2017). Runoff and erosion data were collected and soil nutrients analysis were conducted at the Institut d'Economie Rurale (IER) in Mali. Data on social, economic and human well-being was obtained from individual farmer surveys. CB involves the layout of contour lines with land leveling devices to identify points of equal elevation and construction of contour lines with draught animals and human labor. Majority of the labor input to construct and maintain the CB comes from adult men who are head of the household (58%) and youth male (33%). Results indicated that with the application of CB yield of crops was statistically higher with the highest increase in grain yield and biomass obtained for maize and millet ($p < 0.01$). CB application was useful in retaining soil water and reduced erosion rate. In treatment fields, 162 mm of rainfall per year was saved as soil moisture and on average 13,090 ton per hectare of soil was lost from farm fields without CB and CB implementation significantly reduced the soil loss by 163% ($p < 0.01$). The improvements in crop yield and biomass, and the retention of soil nutrients positively changed household livelihood conditions. Majority of farmers (78%) witnessed better income from the sale of crops grown on CB plots and made them to be food secure



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

A synthesis of ecosystem management strategies for forests in the face of chronic nitrogen deposition

CHRISTOPHER M. CLARK, U.S. ENVIRONMENTAL PROTECTION AGENCY;
JENNIFER RICHKUS, RTI INTERNATIONAL;
PHILLIP W. JONES, RTI INTERNATIONAL;
JENNIFER PHELAN, RTI INTERNATIONAL;
DOUGLAS A. BURNS, U.S. GEOLOGICAL SURVEY;
WIM DE VRIES, WAGENINGEN UNIVERSITY AND RESEARCH;
ENZAI DU, BEIJING NORMAL UNIVERSITY, BEIJING;
MARK E. FENN, USDA FOREST SERVICE;
LAURENCE JONES, CENTRE FOR ECOLOGY & HYDROLOGY;
SHAUN A. WATMOUGH, TRENT UNIVERSITY

High levels of atmospheric nitrogen (N) deposition may have deleterious effects on terrestrial and aquatic ecosystems. If N deposition exceeds the uptake capacity of forested ecosystems, enhanced N loads to fresh waters may result and contribute to problems such as estuarine eutrophication. Although N deposition has declined in much of North America and Europe since the 1990s, these decreases may be insufficient to induce recovery from decades of elevated deposition, suggesting that management interventions may be necessary to promote recovery and to achieve reduced N loads from forested ecosystems. Here, we review the effectiveness of four remediation approaches (prescribed burning, thinning, liming, carbon addition) on three indicators of recovery from N deposition (decreased soil N availability, increased soil alkalinity, increased plant diversity), focusing on literature from the U.S. We reviewed papers indexed in the Web of Science since 1996 using specific key words, extracted data on the responses to treatment along with ancillary data, and conducted a meta-analysis using a three-level variance model structure. We found 69 publications (and 2158 responses) that focused on one of these remediation treatments in the context of N deposition, but only 29 publications (and 408 responses) reported results appropriate for meta-analysis. We found that carbon addition was the only treatment that decreased N availability (effect size: -1.80 to -1.84 across metrics), while liming, thinning, and prescribed burning all tended to increase N availability (effect sizes: +0.4 to +1.2). Only liming had a significant positive effect on soil alkalinity (+10.5% to +82.2% across metrics). Only prescribed burning and thinning affected plant diversity, but with opposing and often statistically marginal effects across metrics (i.e., increased richness, decreased Shannon or Simpson diversity). Thus, it appears that no single treatment is effective in promoting recovery from N deposition, and combinations of treatments should be explored. These conclusions are based on the limited published data available, underscoring the need for more studies in forested areas and more consistent reporting suitable for meta-analyses across studies



WATER QUALITY AND QUANTITY (A), CARL TRETTIN MODERATOR

Riparian land cover and hydrology influence stream dissolved organic matter composition in an agricultural watershed

OLIVA PISANI, DAVID D. BOSCH, ALISA W. COFFIN, DINKU M. ENDALE, DAN LIEBERT, TIMOTHY C. STRICKLAND

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Dissolved organic matter (DOM) represents an essential component of the carbon cycle and controls biogeochemical and ecological processes in aquatic systems. The composition and reactivity of DOM are determined by the spatial distribution of its sources and its residence time in a watershed. While the effects of agricultural land cover on DOM quality have been reported across spatial scales, little is known about how this relationship can change over time. Furthermore, the influence of riparian land cover on stream DOM composition has received little attention. To this end, a multi-year (2016-2018) DOM characterization study was conducted using bi-weekly water samples collected from seven sub-watersheds nested within the Little River Experimental Watershed (LREW) near Tifton, Georgia, USA. DOM optical properties were determined to assess compositional variations using UV-Vis and excitation-emission matrix (EEM) fluorescence spectroscopy coupled with parallel factor (PARAFAC) analysis. PARAFAC analysis indicated that DOM in the LREW was dominated by three humic-like fluorescing components of terrestrial, microbial, and anthropogenic origin and a protein-like component. DOM composition was influenced by land cover, and shifted towards recently produced, low molecular weight DOM with low aromaticity as the percentage of agricultural land within riparian wetlands increased. The optical properties of DOM were dominated by recently produced, microbial-derived material during low discharge and low baseflow periods. The results of this two-year study indicate that the replacement of forested riparian buffers with agricultural land can result in altered DOM composition which may affect carbon cycling and downstream water quality in agricultural watersheds.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

A Multi-approach Assessment of Evapotranspiration and Water Budget of a Southeastern US Atlantic Coastal Plain Forest

DEVENDRA M AMATYA, USDA FOREST SERVICE, CENTER FOR FOREST WATERSHED RESEARCH, CORDESVILLE, SC AND MILAN FISCHER, GLOBAL CHANGE RESEARCH INSTITUTE CAS, CZECH REPUBLIC

We conducted a multi-approach analysis to estimate evapotranspiration (ET) and its components of an Atlantic Coastal Plain forest, U.S.A. We used daily measurements of soil moisture (SM) and water table (WT), daily weather data to compute potential ET (PET) by two methods: Penman-Monteith (P-M) and Priestley-Taylor (P-T), and site-specific soil field capacity (FC) to quantify actual ET (AET) during the 2014-2016 period. Canopy interception (I) loss was quantified using established relationship with rainfall (R). Daily transpiration (T) was estimated with only a limited sap-flux measurements (224) to compare with daily AET. The ET was $= I + AET$. Monthly streamflow (O), calculated as a residual in water budget (rainfall (R) - I - AET (by P-M and P-T methods)), and change in soil air volume (ΔS), assuming negligible deep seepage, was compared with the measured data. The monthly AET was also obtained as residual in water budget ($R - I - O - \Delta S$) using SM and WT depth each, with drainable porosity for calculating ΔS .

The mean monthly AET (MMAET) was 91% ($\pm 11.8\%$) of the P-M PET. Results showed R_2 and mean monthly difference in residual streamflow and the observed data were 0.97 and -2.2 mm for the P-M AET and 0.94 and 6.2 mm, respectively, for the P-T method, indicating a slightly better performance of the former. Sap flux measurements showed T loss as 67.7% of P-M PET AET ($R_2 = 0.65$; $p < 0.00001$) and 57.6% of ET. The MMAET of 83.7 mm using the SM based ΔS was similar to 83.8 mm using the change in WT depth (slope = 0.98; $R_2 = 0.88$). Our analysis shows that the SM measurements together with the FC and P-M based PET can be used to reasonably quantify the monthly AET on these wetland forests and the WT-based ΔS may be a proxy in absence of SM. While these field methods are being tested to quantify AET complemented by MIKE SHE hydrologic modeling in an adjacent paired watershed with various treatments being undertaken for evaluating longleaf pine restoration effects on water yield, some of the limitations and uncertainties will be discussed.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Do riparian forests alter water uptake in response to flash droughts? Case study from Panola Mountain Research Watershed

JEFFREY W. RILEY, USGS SOUTH ATLANTIC WATER SCIENCE CENTER;

LUKE A. PANGLE, GEORGIA STATE UNIVERSITY;

BRENT T. AULENBACH, USGS SOUTH ATLANTIC WATER SCIENCE CENTER; MICHAEL A.

FORSTER, SCHOOL OF AGRICULTURE AND FOOD SCIENCE,

THE UNIVERSITY OF QUEENSLAND

The term flash drought describes abnormally dry conditions that manifest over a relatively short period of time due to a combination of reduced precipitation, high temperatures, and increased solar radiation due to low cloud cover that increases evapotranspiration, resulting in reduced soil moisture and potential for vegetative stress. However, the negative impacts to vegetation may be mitigated in landscapes with shallow water tables. In this study, we evaluate the buffering role that groundwater may serve in reducing impacts from drought by sustaining water utilization of riparian trees.

This study was conducted at the Panola Mountain Research Watershed during a flash drought that occurred over the southeastern US in late summer/fall 2019. Between August 6th and September 24th, the drought monitor degraded 3 classes, from no drought to D2 (severe drought). To evaluate possible impacts from the rapid drying, we examined sap flow data from 20 riparian trees to evaluate changes in water use that may indicate tree stress. Further, we used diurnal water table fluctuations (DWTF) in nine wells to assess the magnitude of water drawn from the saturated zone to support transpiration (TG).

Sap flow at all trees remained consistent throughout the period, responding to vapor pressure deficit and solar radiation but not showing a trend with increasing drought severity. In contrast, water-table fluctuations indicated that a greater quantity of water was sourced from the saturated zone at some wells. This pattern was not consistent across the riparian zone, likely owing to specific combinations of water table depth, rooting depth, and physiological adaptations. Comparing TG derived from DWTFs between September 2018 and September 2019, we observed greater TG at most wells in 2019, suggesting that as soil moisture is depleted, riparian vegetation extracts a greater volume of water from the saturated zone when possible. In riparian zones, and other areas with shallow water tables, groundwater likely sustains water utilization until drought becomes prolonged and the water table declines below the rooting depth. While riparian trees can benefit from shallow groundwater, this water uptake pattern can influence baseflow from low-order watersheds during flash droughts, potentially reducing streamflow for downstream uses.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Spatially explicit evapotranspiration for improved characterization of basin water budget dynamics at multiple spatiotemporal scales

GABRIEL SENAY U.S. GEOLOGICAL SURVEY EARTH RESOURCES
OBSERVATION AND SCIENCE CENTER

The accurate estimation of evapotranspiration (ET) is vital in characterizing watershed water budget dynamics for understanding rainfall-runoff processes, water use and availability, and impact of drought on the ecosystem. With the availability of historical remote sensing data and gridded weather datasets, several ET algorithms have been developed that could produce ET maps at multiple spatiotemporal scales. The Operational Simplified Surface Energy Balance (SSEBop) is one such method that is being applied for generating seasonal and annual ET at 100 m (Landsat) and 1km (MODIS: Moderation Resolution Imaging Spectroradiometer) spatial resolution in diverse ecosystems around the world. Owing to differences in satellite spatiotemporal domains, Landsat and MODIS-based ET can bring complementary data and information for watershed science. For example, Landsat-scale ET provides higher spatial information for smaller watersheds where field scale hydrologic and water resources assessments are desired. On the other hand, MODIS-scale ET is adequate for basin-scale studies where aggregate summary by broad land cover types and landforms is needed. Furthermore, historical assessment of ET is now possible using Landsat which goes back to the early 1970s and 1980s for examining long-term trend analysis. The applications of both Landsat and MODIS-based ET will be presented for crop water use mapping, drought monitoring, and basin-scale water budget studies in diverse ecosystems around the world at multiple spatiotemporal scales.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Effects of forest understory removal and prescribed fire on watershed water yield and evapotranspiration in the southern Appalachian Mountains, USA

CALDWELL, P.V.; ELLIOTT, K.J.; MINIAT, C.F.; LIU, N.; KNOEPP, J.D.; OISHI, A.C. USDA FOREST SERVICE COWEETA HYDROLOGIC

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Climate change, disturbances, and forest management in the southern Appalachian mountain region have induced changes in canopy species composition and expansion of subcanopy shrubs (i.e., *Rhododendron maximum* L. and *Kalmia latifolia* L.). As a result, these forests are less resilient to drought and have reduced productivity, timber quality, water yield, and understory biodiversity. Forest managers need innovative management practices aimed at enhancing resilience and the provisioning of ecosystem services including a clean, reliable water supply. We evaluated the effect of one such management strategy on water yield and evapotranspiration using the paired watershed experimental design at the USDA Forest Service Coweeta Hydrologic Laboratory in the southern Appalachian Mountains. The riparian rhododendron understory was cut and slashed, and stumps were herbicided across the 37.8 ha treatment watershed in winter 2018, and a low severity prescribed fire was conducted in spring 2019. Thirty-three years of pretreatment water yield and precipitation measurements in the treatment and adjacent 41.3 ha reference watersheds provided an excellent calibration ($R^2 > 0.99$), allowing us to quantify the effects of the rhododendron removal only in the first year and rhododendron removal plus prescribed fire in the second year after treatment. Rhododendron removal resulted in a significant water yield increase of 6.2 cm (3.0%) over what would have been expected had the treatment not occurred. Evapotranspiration (precipitation minus water yield) also decreased by 6.2 cm, a 5.8% change. Second year results including the effect of the prescribed fire using data collected through March 2020 are forthcoming and will be available at the time of presentation of our work. These results suggest that rhododendron removal followed by prescribed fire will likely decrease evapotranspiration and increase water yield, enhancing water supplies in the region. Future work will quantify the effect of the treatment on forest species composition and other ecosystem services including ecosystem productivity and biodiversity.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Using ET estimated from remotely sensed data to investigate drought-induced tree mortality in a temperate forest in the Central US

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Drought can have large impacts on forested ecosystems. Short-term drought can make forests more susceptible to insect attack, infection and wildfire, while long-term severe drought can directly cause catastrophic hydraulic disconnection that induces tree mortality. Evapotranspiration (ET) is a key parameter that links the hydrological and ecological processes and is an effective indicator of vegetation health. Mapping ET using satellite remote sensing data has been widely applied to study the spatial dynamics of water use at regional scales for decades. Surface energy balance methods, based on remotely sensed land surface temperature retrieved from thermal infrared imaging systems, are commonly used to map ET. In this study, we applied the ALEXI/DisALEXI (Atmosphere-Land Exchange Inverse model and associated flux disaggregation algorithm) energy balance modeling system over a drought-sensitive temperate forest in the Central US. to estimate 30 m daily ET from 2010 to 2014, including an extreme drought event that occurred in 2012. ET retrievals from multi-scale satellite sensors including Landsat and MODIS (Moderate Resolution Imaging Spectroradiometer) were fused to daily 30 m ET using STARFM (Spatial Temporal Adaptive Reflectance Fusion Model). This study area contains an AmeriFlux site (US-MOz), and has a good record of tree mortality data, especially after the 2012 drought. The model results were evaluated at the flux tower site and showed good agreement with observed fluxes. The actual-to-reference ET ratio (fRET) was also estimated and used as a vegetation stress indicator to investigate the relationship between evaporative stress and drought-induced tree mortality. We found a significant correlation ($R^2 = 0.52$) between tree mortality data in 2013 and fRET difference between pre-drought year (2010) and drought year (2011, 2012), which suggests a high correlation between drought-induced tree mortality and pre-drought forest health condition at the US-MOz site. This study demonstrated the capability of using remotely sensed ET metrics at high spatiotemporal resolution for monitoring forest water use and drought-induced tree mortality.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Evapotranspiration: the Unsung Hero for Ecosystem Services

GE SUN, EASTERN FOREST ENVIRONMENTAL THREAT ASSESSMENT CENTER, USDA FOREST SERVICE SOUTHERN RESEARCH STATION

The connections between ecosystem functions and services (water supply, flood control, climate moderation, carbon sequestration, biodiversity) have not been well recognized and studied, and the role of evapotranspiration (ET) is often underestimated. For example, ET rates generally exceed precipitation in the growing season and annual ET rates exceed runoff coefficients in natural watersheds in the southern U.S. Climate change affects watershed hydrology by directly (energy and water availability) and indirectly (species change, fire, insects and diseases) altering ET processes. Urbanization, a permanent form of land use change, affects watershed hydrology largely (in addition to increase in impervious surfaces) by reducing ET in the growing season in the humid North Carolina. Thus, accurately estimating ET is of paramount importance in global change studies that focus on quantifying the effects of land use change and climate change on land surface processes and ecosystem services. The ecosystem-level ET process is inherently complex due to the numerous controls by physical, chemical, climatic, and biological factors. The 'Paired watershed' approach has been traditionally used to quantify the role of forest vegetation cover and ET in affecting stream hydrographs for small watersheds. Fine-scale ecosystem ET flux is commonly measured together with energy and carbon flux (e.g., CO_2 , CH_4) because these fluxes are highly coupled. However, quantifying ET for a large area is still costly and uncertain. ET science remains as an imprecise one. This paper uses case studies to demonstrate that ET is critical for understanding how land cover change and global warming affect stream peak flows, water yield, and ecosystem productivity. Current issues about quantifying ET by field measurements and modeling are discussed.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Evaluating high water table hydrology and eddy covariance measurements of evapotranspiration at a newly instrumented watershed in coastal South Carolina

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A water table near the soil surface is common to southeastern US coastal forested watersheds. The high water table creates a situation where soil moisture storage occurs in both saturated and unsaturated conditions. The position of the water table is both a reflection of the balance of precipitation and evapotranspiration and a control on partitioning rainfall into ET and streamflow. Measuring ET has been the major limitation to understanding the interaction of evapotranspiration, saturated and unsaturated soil moisture storage, and streamflow in these watersheds. This paper will outline a newly instrumented watershed where an eddy-flux tower has been placed in a small (13ha) forested headwaters watershed to measure atmosphere-vegetation exchange of water. Sub-canopy measures of light and throughfall, unsaturated soil moisture sensors and a grid of shallow wells measure water movement from the canopy to the groundwater system. The tower has been active since Jan 2019, and other measures were added during June and early July of 2019. The system was active during moisture drawdowns prior to, and after the site was hit by Hurricane Dorian, with over 220 mm of rainfall, in August 2019. We monitored the development of the area of saturated overland flow spread across the watershed during the storm and the retreat of that area as ET removed water from saturated storage in the months since the storm. Vegetation on the tower footprint has been measured using FIA phase 2 plots representing slightly over a 10% sample of the tower footprint (220m radius) area. In addition large scale aerial photography has been used to map crowns and species composition across the footprint area. Longleaf pine dominates the eastern half of the footprint while a mixture of longleaf, loblolly, and pond pines are present in the western half. Following regulatory approval in February 2020, a Parshall flume was installed to measure streamflow. During the short period of operation we have seen water table drawdowns approaching 1 m and soil moisture ranging from saturation to near wilting point due to heavy rain and high PET.



WATERSHED EVAPOTRANSPIRATION IN A CHANGING ENVIRONMENT, SPECIAL SESSION, GE SUN AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Stand-level transpiration increases after eastern redcedar encroachment into the Cross-timbers

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Abstract: Eastern redcedar (*Juniperus virginiana*, redcedar) is encroaching into post oak (*Quercus stellata*)-dominated savannas and forest on the dry, western edge of the eastern deciduous forest of the USA (Cross Timbers). Redcedar is an evergreen tree that is both encroaching into canopy gaps and growing into the midstory, which results in changes in tree species composition, canopy structure, and phenology of the Cross Timbers. However, water relations and the hydrological impact associated with the deciduous oak forest's transition to an oak-juniper mixed forest remains unknown. Our objective was to determine leaf water potential, gas exchange, and stand-level transpiration and associate them with environmental variables and soil water stress. We quantified leaf-level gas exchange using a portable photosynthesis system (Li-6400, Li-Cor Inc, USA) and stand-level transpiration using sap flow systems (Dynamax Inc., Houston, TX, USA) for post oak, redcedar, and post oak and redcedar mixed stands with a similar total basal area for 20 months between May 2017 and December 2018 in a Cross-Timbers forest near Stillwater, Oklahoma.

Our results showed that post oak had greater gas exchange rates than redcedar during periods of high moisture, but both species had a similar reduction in leaf-level gas exchange during drought. Water potentials tended to be more negative in the pure redcedar stand compared to the mixed stand. The mean sap flow density of redcedar was usually higher than post oaks. A structural equation model demonstrated a significant correlation between sap flow density and shallow soil moisture for redcedar but not for post oak. At the stand level, the annual water use of the mixed stand was greater than the redcedar or oak stand of similar total basal area.

The transition of oak-dominated Cross-Timbers to redcedar and oak mixed forest will likely increase carbon and water exchange such that carbon sequestration increases but water availability for runoff or recharge to groundwater decreases. The change in canopy structure and the fuel load will have an important implication for wildfire management.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

Assessment and Decision Support for Natural Asset Management in Connecticut Coastal Watersheds to Meet Combined Water Quality and Biointegrity Goals

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The Clean Water Act emphasizes restoration and repair of dysfunctional (impaired) aquatic ecosystems caused by anthropogenic drivers, especially development, agriculture and climate change. But, addressing these multiple-driver causes, and managing the complex and pervasive mix of chemical, physical and biological pressures they deliver, remains a top science, management and policy challenge. Attaining ecosystem-level biointegrity targets requires an integrative and collective ecosystem context engendered in ecosystem-based management (EBM). This perspective is often lacking in single-stressor assessment and management protocols that commonly target only nitrogen or phosphorus; thus, more complex ecosystem outcomes that broadly support healthy watersheds and aquatic ecosystem goals are not assured.

The Biological Condition Gradient (BCG), recently consolidated in the 2016 EPA Practitioner's Guide, offers a scientifically-validated, EBM alternative that supports a whole ecosystem conceptual approach. Because watersheds and waterbodies are structurally and functionally diverse, health metrics vary with local conditions and levels of stress. BCG integrates watershed stressor effects along a gradient paired to aquatic biocondition. This provides a robust mechanism and appropriate context for site-specific benchmarking – an integrated, top-down approach to pairs overall watershed health, or condition, based on land-cover attributes to ecosystem-level outcomes of aquatic biointegrity, or biocondition, to guide watershed management.

To this end, I devised a scalable decision-support framework (DSF) using basic land cover data downloaded from UConn's CLEAR website for 160 coastal Connecticut sub-regional watersheds. Landscape asset management was guided by an index derived from the extent of natural cover in the watersheds and vegetated riparian buffers and used to set benchmarks that define the range of watershed and aquatic ecosystem conditions, targets and outcomes consistently with the BCG. The DSF tailors recommended land cover extent and buffer widths to watershed size and condition to meet the desired land-cover management target supporting biointegrity goals. Land-cover is easily translated into direct estimates of nutrient loads consistent with land cover management goals. The BCG and DSF applications provide a firm basis for nutrient-targeting, criteria-setting and Total Maximum Daily Load (TMDL) analyses, avoiding the uncertainties associated with back-calculating loads from highly-variable monitoring data. The DSF will be demonstrated for typical Connecticut coastal watersheds.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

Real-time coastal salinity index for monitoring coastal drought and ecological response to changing salinity values along the Gulf of Mexico and the Eastern Atlantic Coast

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Coastal droughts have a different dynamic than upland droughts, which are typically characterized by agricultural, hydrologic, meteorological, and (or) socio-economic impacts. Drought uniquely affects coastal ecosystems due to changes in salinity conditions of estuarine creeks and rivers. The location of the freshwater-saltwater interface in surface-water bodies is an important factor in the ecological and socio-economic dynamics of coastal communities. The location of the interface determines the freshwater and saltwater aquatic communities, fisheries spawning habitat, and the freshwater availability for municipal and industrial water intakes. The severity of coastal drought may explain changes in *Vibrio* bacteria impacts on shellfish harvesting and occurrence of wound infection, fish kills, harmful algal blooms, hypoxia, and beach closures. To address the data and information gap for characterizing coastal drought, a coastal salinity index (CSI) was developed using salinity data. The CSI uses a computational approach similar to the Standardized Precipitation Index (SPI). The CSI is computed for unique time intervals (for example 1-, 6-, 12-, and 24-month) that can characterize the onset and recovery of short- and long-term drought. Evaluation of the CSI indicates that the index can be used for different estuary types (for example: brackish, oligohaline, or mesohaline), for regional comparison between estuaries, and as an index of wet conditions (high freshwater inflow) in addition to drought (saline) conditions. The following three activities, completed in 2019, enhance the use and application of the CSI and will be presented:

A software package was developed for the consistent computation of the CSI that includes preprocessing of salinity data, filling missing data, computing the CSI, post-processing, and generating the supporting metadata.

The CSI has been computed at sites along the Gulf of Mexico (Texas to Florida) and the Southeastern Atlantic Ocean (Florida to North Carolina); and

Using telemetered salinity data, the real-time computation of the CSI has been prototyped and disseminated on the web.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

A systems approach to nitrogen remediation in a coastal watershed

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The EPA's Office of Research and Development (ORD) and its local partners are using a systems approach to deal with pervasive groundwater nitrate contamination on Cape Cod, Massachusetts. Here a sole source aquifer, loaded with nitrogen for decades, discharges to ponds, rivers and estuaries, many of which now have Total Maximum Daily Loads (TMDLs). To meet TMDL goals, towns across the Cape are pursuing traditional technologies (i.e., gray infrastructure) alongside alternatives, in coordination with a large network of public and private partners. Representatives of these groups recently participated in a problem formulation workshop, convened by ORD and the Barnstable Clean Water Coalition (BCWC), to identify current outstanding research questions and knowledge gaps impeding progress. Progress is fundamentally constrained by the existence of thousands of non-point sources, long groundwater travel times, cost and implementation of expensive solutions, issues that are further compounded by lack information on the performance and social acceptance of alternative technologies. ORD and BCWC built upon this workshop and other meetings to engage in research to inform the use of nitrogen-mitigating interventions including restoration of cranberry bogs and other wetlands, deployment of innovative/ alternative (IA) septic systems and aquaculture in a target watershed. Studies of these interventions concurrently consider nitrogen attenuation along with cost and broader impacts on people and the environment. Research plans are developed using a translational science model responsive to stakeholder needs and changing local conditions. The systems approach taken by ORD refers to multiple aspects of the research design which 1) examines connected environments across the recharge-discharge continuum of a watershed, 2) explicitly integrates social and biophysical perspectives 3) actively engages stakeholders, throughout the process, in the target and similar watersheds. This presentation explicates the mechanics, and shares some early findings, of this solutions driven research for groundwater nitrogen remediation in coastal settings.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

Water Prediction Tools for Informing Climate Adaption Strategies as a Focus of Community Engagement

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Evaluating the effectiveness of adaption strategies aimed at mitigating the negative consequences of anticipated climate change requires modeling approaches that are (1) functionally and structurally accurate, and (2) appropriately sensitive to changes in forcings, land use, and land cover over a range of potential future scenarios. Models of this type will most certainly rely heavily on physical process representations in a high performance computational (HPC) environment that allows explicit representation of multi-dimensional heterogeneity. That is to say, to investigate climate change impacts and test mitigation and adaption strategies, the complexity of nature demands the use of models that can describe the characteristics of large watersheds. In essence, these models should emphasize “getting the right answer for the right reason” using excellent coupled physics rather than parameter tuning of simplistic models that do not include change-appropriate descriptive parameters or exhibit realistic sensitivities to variation in forcing inputs. This presentation discusses recent efforts aimed at the development of such models. Rather than emphasize proprietary or “named” models, the author proposes creation of a suite of tools in an HPC environment that facilitates process-level testing and validation of coupled physics-based hydrological representations. Two examples are shown that provide a potential roadmap for engaging the research and water management communities in a productive collaboration aimed at lowering the bar for the application of supercomputers for evaluating climate change mitigation strategies in a way that fosters community involvement and applies scientific evaluation to advance “best-in-breed” modeling technologies. The proposed approach encourages evidence-based model selection for simulating diverse watersheds, and a community framework for improved process-level understanding through simulation.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

Science Needs of Arizona's Watersheds

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Watersheds are a natural unit of land management, especially in water limited environments like the West. However, a key constraint on improved management is the patchwork of ownership and interests in land and water management. As typically no single organization or agency owns or controls the land across watersheds, collaboration is needed to achieve ecosystem or landscape scale goals like planning for fire, providing habitat for wildlife, combating invasive species, and managing for water quality or to reduce risk of downstream flooding. Local, state, and federal institutions, as well as tribes, support watershed work in cooperation with individual landowners and groups. As new watershed groups are created to help growing populations deal with increasingly scarce water supplies, there is a growing impetus to apply previously learned lessons.

To support the systematic identification, sharing and application of those lessons in Arizona, the Cross Watershed Network interviewed watershed practitioners in eight state or regional watershed councils across the country, as well as ten organizations that support watershed planning and the leaders of twenty watershed management groups across Arizona. Although each watershed group is unique, many face common stressors and expressed a need for support to communicate, build capacity, collect and manage data to prioritize restoration efforts, collaborate more effectively, develop political support, and fundraise. A standard science need across Arizona is to identify management actions that address priority problems and assess the expected impacts and costs of improved management systems. Another common need is for geospatial support to identify problem areas across jurisdictions, and to consistently integrate relevant information from land management agencies, particularly the Bureau of the Land Management and Forest Service. A core group of watershed partners, through the Arizona Cross Watershed Network, is planning the first statewide summit of watershed groups to share best practices, identify priority research and management needs, and establish a sustainable mechanism for cross watershed collaboration and greater collective progress on watershed health across the state. This project will also share knowledge about Arizona statewide support for watershed planning and collaboration with similar programs in Idaho, New Mexico, Colorado, Utah, Wyoming and Montana.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

Watershed Functional Zone; Multi-type multi-scale integration for understanding watershed functioning

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Predictive understanding of watershed function and dynamics is often hindered by the heterogeneous and multiscale fabric of watersheds. Recent advances in remote sensing has revolutionized the way we characterize watersheds from bedrock to canopy such as LiDAR and multispectral/hyperspectral technologies for high-resolution topography/geomorphology, and plant species/structure. In addition, airborne electromagnetic surveys provide subsurface structure and properties across watersheds that were previously characterized only through borehole data. However, there is still a challenge to integrate all these datasets for understanding watershed organization and for estimating and predicting integrated watershed functions such as ecosystem responses to climatic perturbations and nutrient exports.

This study explores a variety of machine learning techniques – unsupervised learning such as hierarchical clustering and autoencoders as well as supervised learning such as random forest – to gain quantitative understanding of watershed organization and functions. We hypothesize that (1) the co-evolution of watershed terrestrial systems creates co-variability among subsurface/surface spatial features (such as topographic, plant, snow and geological metrics), (2) we can reduce the parameter dimensionality by exploiting such co-variability, and (3) we can identify several representative landscapes – watershed functional zones – that capture distinct characteristics of those co-varied properties and associated watershed functions. We demonstrate our approach using airborne electromagnetic survey, LiDAR, snow survey, hyperspectral data collected over the East River Watershed (near Crested Butte, CO, USA). Results show that unsupervised learning is powerful to identify the surface/subsurface co-variability such as bedrock fracturing and plant species over the watershed, and identify several key zones that capture watershed-scale heterogeneity. Supervised clustering results shows that the elevation, aspect and geology are the key controls on both drought sensitivity and nitrogen export, and that we can map watershed “functioning” zonation, and predict nitrogen export in unmeasured sub-catchments based on spatial features and annual peak SWE.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

Next-generation monitoring and research for resilient ecosystems and natural resources

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Efforts to establish baseline monitoring of natural and socio-economic systems in the United States have accelerated during the past 10 years. Optimizing new scientific information for supporting resource management decisions and sustaining ecosystem services will require improvement and integration of existing monitoring capabilities to enhance the frequency and type of data collected. This enhanced baseline data, coupled with predictive models and state-of-the-art technology will greatly improve our capacity for early warning of hazards and early detection of trends. The USGS is developing a “next-generation water observing system” (NGWOS) designed to provide high-fidelity, real-time data and modeling on water quantity and quality necessary to address daily water operations; water emergencies; and broad water management concerns. Initial NGWOS implementation in the Delaware and Upper Colorado River Basins is applying innovative strategies for network design to track change in whole river basins. The network implements monitoring at locations representing the range of physical, chemical, biological, and socio-economic conditions observed. This novel, multi-scale, inter-disciplinary approach to observing network design could enable data integration among multiple networks nationally and internationally, with the goal of detecting, understanding, and addressing changes in complex socio-ecological systems.



INTEGRATING SCIENCE AND WATERSHED DECISION MAKING, RICK WEBB MODERATOR

From Forests to Faucets: A drinking water utility's approach to protecting its source through watershed management

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The Watershed Management Program (Program) is Central Arkansas Water's (CAW) source water protection program for its two water supply reservoirs, Lake Maumelle and Lake Winona. Combined, these watersheds cover 115,520 acres total and contain 16 square miles of reservoir-surface water, of which, CAW owns not only the reservoirs (over 10,000 surface acres), but also an additional 14,000 acres of property—all of which is managed by CAW and this Program.

Established from the Lake Maumelle Watershed Protection Plan, adopted in 2007, this program and has received national recognition as a leader in managing natural resources for the purpose of drinking water protection. When the Plan was finalized and adopted, the CAW Board established a clear vision for watershed protection where the utility and community would strive to "maintain [a] long-term, abundant supply of high quality drinking water for present needs and continuing growth of the community ... and [provide] an equitable sharing of costs and benefits for protecting Lake Maumelle."

CAW staff strives to meet the challenges of this vision and implement its core values. The Program's goals are to protect, restore, and enhance the natural environment of the two watersheds through a variety of pollution prevention, watershed, and source water protection approaches as part of an overall strategy to maintain and enhance ecological and community sustainability. In the more than decade since the Plan's adoption, CAW has been hitting the task of watershed protection from all fronts. By expanding protection efforts from simple land acquisitions, to active forest and natural resource management practices, CAW is becoming a leader and model for watershed protection.



WATERSHED RESPONSE TO CHANGE, ELIZABETH KEPPELER MODERATOR

Changing Climate Variance: Implications for the United States Eastern Deciduous Forest

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Contemporary climate analyses rarely include equivalent attention to combined variance of hot (cold) and drought (extreme wetness) over time. This is of concern given little is known about how increasing (or decreasing) climate total variance may affect short and long-term ecosystem productivity. Investigations in the Eastern Deciduous Forest (EDF) biome stretching from the eastern (north-east West Virginia) to the midwestern United States (mid-Missouri) were undertaken to quantify rates and directions of climate variable changes. Analyses included long-term data sets (e.g. 1906-2016) from multiple locations using historic climatology, global change modeling, and other regional data sources. A cross-system EDF analysis during growing season months showed that mean net ecosystem exchange (NEE, $\mu\text{mol}/\text{m}^2/\text{s}$) was -5.76, -3.22 and -3.52 in 2009 during a period of extreme wetness, and -4.68, -2.18, and -0.09 respectively, in 2012 (extreme drought) at ecosystem flux sites in Harvard forest, Morgan Monroe forest, and central Missouri, respectively. This finding suggests that at the western edge of the EDF net ecosystem exchange (NEE) may be more adversely impacted (relative to east) by ongoing increased precipitation, precipitation variance and excessive wetness. In the eastern portion of the EDF, analyses showed an increasingly wet and temperate climate characterized by warming minimum temperatures, cooling maximum temperatures, and increased annual precipitation that have accelerated during the second half (1959 to 2016) of the period of record relative to the first half (1958-2016). Median air temperature and dew point values decreased with elevation at a rate of $5.2^\circ\text{C km}^{-1}$ and $3.5^\circ\text{C km}^{-1}$, respectively consistent with decreasing vapor pressure deficits (-0.30 kPa km^{-1}). Results imply that excessive (persistent) wetness may become the primary ecosystem stressor associated with climate change in the distinct Appalachian region of the EDF. Ultimately, collective results indicate rapidly changing (spatially heterogeneous) climate variance throughout the EDF. This work therefore serves as an alert to the need for studies of potential impacts of total climate variance on forest and agricultural ecosystem health and productivity. This is important to ensure sustainability of ecosystem services, health, and productivity in a swiftly changing climate across the broader EDF region and similar temperate forest ecosystems globally.



WATERSHED RESPONSE TO CHANGE, ELIZABETH KEPPELER MODERATOR

Combined effect of non stationary stressors in Choctawhatchee Watershed

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The hydrological processes and water balance in Upper Choctawhatchee River Watershed were modeled using the Soil and Water Assessment Tool (SWAT) from 1986 to 2015 to investigate the impacts of climate and land use change. Future daily rainfall and temperature, for next three decades, were simulated using CanRCM4 to provide SWAT model the climatic forcing to project stream flow. Projections were established under three different climate ensembles of different representative concentration pathways (RCPs) and one landuse scenario. The landuse scenario was built according to the current landuse change trend to reflect both management and unsupervised practices. Calibration and sensitivity analyses and bias correction were satisfactory. Model calibration metrics including p-factor, r-factor, NSE, and R₂ are 0.58, 0.53, 0.74, and 0.75 respectively. Results from simulated historic hydrologic processes reveals evapotranspiration (ET) as the most dominant pathways for water loss (ET/Precipitation=0.58). Surface runoff plays a major role in modulating the processes where 77% of the Total Flow is Baseflow. Projected climate impacts demonstrate higher temperature and seasonal change (longer periods between rainfall events) which reflects as strained water resources in projected stream flow. These changes, subsequently, influence the growth and crop and forest productivity in the region. Under the landuse scenario, ET decreases to 41% of the precipitation, and surface runoff drastically increases to 89% of the Total Flow and 60% of the precipitation. Surface water levels and infiltration rates significantly increase and decrease respectively which poses vulnerabilities to flood prone areas. Relying on rainfall for farming (irrigated row crops area makes less than 1.7% of the agricultural area) in combination with reduced agricultural landuse and increased urban area and population, will likely make the water use efficiency critical. The model has demonstrated satisfactory performance capturing the hydrologic parameters and can be used for further modelling of water quality (NPS and PS pollution) to determine the sustainable conservation practices.



WATERSHED RESPONSE TO CHANGE, ELIZABETH KEPPELER MODERATOR

Long-term low flow responses to evolving timber harvest techniques in the Pacific Northwest

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In the Pacific Northwest seasonal low flows have important implications for aquatic species, drinking water supplies, and water quality. Regionally, long-term observations from experimental watersheds suggest summer flows are declining due to climate change and land management. Results from multi-decadal studies suggest that historical timber harvest practices typically resulted in an initial period of increased summer streamflow followed by a gradual but variable return to baseline flow, and later streamflow deficits. These later deficits during forest regrowth are of particular concern in the region. Because contemporary forestry differs from historical practices in important ways, a mechanistic understanding of harvest effects is needed to shed light on expected future conditions.

To better understand the impacts of contemporary forest management, we need to know how the water balance components are altered during the full 40 to 80 year span of harvest rotation. While the most immediate post-harvest effects (0 to 10 years) are well-documented, few studies document effects beyond the first decade. We review results from several important catchment studies in Oregon and California focusing on water balance components (precipitation, evapotranspiration, and storage change) and discuss variations in response associated with geography, rainfall, forest type, and harvest methods.

Research underway at the Caspar Creek Experimental Watersheds (coastal northern California) is designed, in part, to address knowledge gaps in our understanding of the processes that influence seasonal low flows. Collaborative studies investigate watershed responses across a range of forest stand density reduction treatments (25 to 75 percent reduction in basal area) implemented from 2017 to 2019. In addition to quantifying harvest effects on streamflow, experiments examine how harvest intensity influences the routing of water from hillslopes to streams, and how precipitation and fog inputs are partitioned among evapotranspiration, soil moisture, groundwater, and streamflow. Using historic measurements of water balance components, a Distributed Hydrology Soil Vegetation Model and River Basin Model (DHSVM-RBM) has been calibrated to analyze changes in stream temperature due to forest harvest practices and is being calibrated to analyze streamflow changes, as well. Such efforts are crucial to understanding how contemporary forest harvest practices may impact summer streamflow in future decades.



WATERSHED RESPONSE TO CHANGE, ELIZABETH KEPPELER MODERATOR

Field-based assessment of an urbanized montane headwater catchment: the impact of watershed-wide green stormwater infrastructure retrofits

JOSHUA ROBINSON & PHILIP ELLIS, ROBINSON DESIGN ENGINEERS

Most stormwater research in the southeastern US has occurred near the major academic research institutions located within the Piedmont. As a result, performance standards and design guidelines for green stormwater infrastructure (GSI) and other types of stormwater control measures (SCMs) do not readily transfer to the steep mountain environment, which is characterized by shallow soils, steep gradients, and intense rainfall. To provide insight into regionally-specific performance standards and design guidelines for GSI and SCMs, we established an experimental watershed in Asheville, NC.

We collected storm event measurements of creek stage, discharge, and sediment concentration within a first-order mountain stream draining approximately 100 acres of developed headwaters. These measurements were collected before and after the construction of six green stormwater infrastructure (GSI) retrofits upstream throughout the watershed. The experimental watershed is fully contained within the campus of Givens Estates, a retirement community of the United Methodist Church. The project is funded by the NC Clean Water Management Trust Fund, and the project is sponsored by RiverLink, an Asheville-based non-profit dedicated to promoting the environmental and economic vitality of the French Broad River and its watershed.

This presentation will provide an overview of the experimental watershed and project history, outline the goals of the grant-funded project, and present data from storm event measurements before and after implementation of GSI retrofits—which reduced pollutant sediment output by as much as 61 percent. The presentation will also describe the applicability of the research, and how the lessons learned through this project can benefit the design of GSI projects in the difficult montane landscapes of the Southern Appalachians.



WATERSHED RESPONSE TO CHANGE, ELIZABETH KEPPELER MODERATOR

Lessons Learned from Stream Restoration Partnerships in North Carolina: A State Forestry Agency's Perspective

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Since mid-2000s, the North Carolina Forest Service has hosted and participated in multiple stream restoration projects on some of the 65,000+ acres of lands under its management. These projects were made possible through fostering and sustaining active partnerships across agencies, academia, and the private sector. Internal stakeholder acceptance is a key first step to building support within an organization. Stream restoration requires a long-term investment and commitment to resource management to sustain the restored functions afterwards. Funding stream restoration is a hurdle that often can be overcome by actively pursuing opportunities, engaging prospective funding partners early and often, and demonstrating a proven track-record of efficient, reliable, and transparent project management. Taking a holistic approach before attempting a restoration project, to assess overall water resources on your tract of land, allows prioritization of needs and opportunities while demonstrating thoughtful planning. Collaborating with technical experts who are recognized as leaders in their field of practice helps to assure success in stream restoration planning, design, engineering, and construction. Making the restoration site available for training, education, research, and outreach will foster improved relationships. Stream restoration, much like forestry, is a classic example of adaptive management wherein a project manager must be adept at overcoming unexpected challenges, while addressing variable concurrent factors. Stream restoration has become an important tool for enhancing watershed resiliency, and this field of expertise continues to broaden in its application. Sharing lessons learned from restoration projects should help facilitate improved rates of project success, identify areas of challenge, and foster greater acceptance.



WATERSHED RESPONSE TO CHANGE, ELIZABETH KEPPELER MODERATOR

Analyzing long-term effect of gully erosion on land degradation in Upper Blue Nile basin, Ethiopia

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Gully erosion is one of the main causes of land degradation, particularly in the drought-prone regions of Ethiopia. This study assessed spatio-temporal changes of gully length and density in watershed pairs in Guder, Aba Gerima, and Dibatie sites, which are representative highland, midland, and lowland agro-ecologies in the Upper Blue Nile basin of Ethiopia. Aerial photographs (1957, 1982) and very high resolution satellite images (QuickBird, IKONOS, Worldview-2, SPOT-7, and Pleiades) of the six watersheds, along with field survey results, were used in the analyses. The aerial photographs were scanned and orthorectified using ENVI 4.3 image analysis software, and gullies were mapped by visual image interpretation in the ArcGIS environment. Rates of increase in gully length in Guder (36.9 m yr^{-1}) and Aba Gerima (33.6 m yr^{-1}) were almost double the rate in Dibatie (17.8 m yr^{-1}) from 1957 to 2016 or 2017, and over the same period, gully density similarly increased by 5.9, 5.4, and 3.7 m ha^{-1} in Guder, Aba Gerima, and Dibatie, respectively. The higher rates in Guder and Aba Gerima could reflect the long history of cultivation and human settlement in those sites, whereas agricultural activity became widespread in Dibatie only after implementation of the national resettlement program in the 1980s. Moreover, although gully density tended to increase over time in all six watersheds, in the three watersheds (one in each paired watershed) where soil and water conservation measures had been introduced, the rate of increase was lower than in those where no such measures were implemented. In addition, gully distribution was linked to land use and landscape position; gully density was higher in cultivated areas and where slope gradients were gentle. The results of this study indicate that careful site-specific identification of factors controlling gully initiation and development is crucial so that appropriate management strategies can be developed for these three sites and for other areas with similar agro-ecologies in the Upper Blue Nile basin.



WATERSHED RESPONSE TO CHANGE, ELIZABETH KEPPELER MODERATOR

Ecosystem water service of tropical island under the changing climate regimes and the altered land cover/use

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Impact of changes in land cover/ use and climate on hydrological service of tropical watersheds is one of the focal research topics in both hydrology and global change. Both landscape composition and configuration are important features of LCLUC, and they interactively impact the hydrological service of tropical watersheds in the context of changes in climate regimes. Puerto Rico is a tropical island in the Caribbean, the freshwater supply from upland watersheds is essential in both meeting the demands of water consumption for over 3 million population and feeding the coastal wetlands to combat saltwater intrusion. The capability of sustainable freshwater supply is facing great challenge under changing climate regimes and land cover/use over the island. To address this, we adopted the Soil and Water Assessment Tool (SWAT) model to the watersheds feeding major wetlands in both wet and dry regions, and investigated the ecohydrological processes in response to climate changes and LCLUC. We calculated annual stream discharge and annual big stream discharge with risks of flooding and severe soil erosion, defined as the sum of daily discharge greater than 95 percentiles. We emphasized how the changes in landscape composition and fragmentation, and the projected climate in the next 50 years will alter ecohydrological processes. Land cover change plays more important roles in regulating the big discharges (risk of flooding) than altering the annual discharges (freshwater supply). Based on the downscaled climate models for Puerto Rico (Hayhoe 2013) for IPCC 3 emission scenarios of A2 (isolated development, little collaboration), A1B (collaboration between countries with balanced energy use), and B1 (economic globalization with high technology development), the watersheds of Rio Grande de Loiza at Caguas in the mountains and Rio Culebrinas in the northwest both showed consistently decreasing discharge (freshwater supply) in the next 50 years. The average annual rate of decreasing is -0.64 and -1.27 M ton y^{-2} for Rio Grande Loiza and Rio Culebrinas watersheds, respectively. Prompt and rational management of freshwater resources over the island and of mountainous watersheds is mostly needed to tackle the impacts of changes in climate and land use/cover for sustainable ecosystem water services of the island.



BEDROCK FLOW AND REACTIONS: IMPLICATIONS FOR ECOHYDROLOGY AND WATERSHED EXPORTS, SPECIAL SESSION, BHAVNA ARORA, BEN GILBERT CHAIRS AND MODERATORS

Groundwater Sourcing and Age Distributions in a Colorado River Headwater Stream

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Headwater basins of the Colorado River are vulnerable to climate change. Increasing air temperatures, longer lasting droughts, and climate induced forest die-off alter land-surface interactions, snow dynamics, and hydrologic partitioning in space and time. Changes in the timing, intensity and duration of water inputs directly impact groundwater recharge, subsurface flow paths and residence times with consequences for riverine water and solute exports. Feedbacks between these processes are poorly constrained in mountain watersheds due to a lack of data characterizing surface dynamics and subsurface properties. To combat data challenges, we combine high resolution snow observations with chemical and isotopic water concentrations, groundwater dissolved-gas tracers, and numeric models to explore first-order controls on groundwater flux to streams, age of hydrologically active groundwater, and baseflow age-distribution sensitivity across gradients in climate and watershed characteristics in a Colorado River headwater basin (24 km²). Results indicate that groundwater is a critical and stable source of water to this mountain stream with preferential recharge zones established in the upper sub-alpine that are partially decoupled from annual climate variability and resilient to historic drought. Baseflow ages estimated using dissolved concentrations of SF₆, N₂, and Ar in stream water suggest a median age of approximately 10 years. This aligns with ages estimated with dissolved gases in perennial springs (7±4 years), and in shallow (20±12 years) and deep groundwater wells (50±11 years). To match gas tracer age estimates, groundwater flow must be partitioned, in part, to deeper flow paths as dictated by hydraulic properties of the fractured granodiorite. Hydrologic model results also suggest the watershed operates on a precipitation threshold near the basin's historic median value. With drier conditions, the ratio of recharge to hydraulic conductivity is reduced, water tables drop, and the basin moves away from topographically-controlled groundwater flow toward recharge-controlled groundwater flow. Under these conditions, baseflow ages become older and increasingly sensitive to small changes in net recharge as a function of aridity or forest change. Therefore, as this mountain system moves toward more arid conditions, the compensatory effects of groundwater to mountain streams will shift toward longer timescales with implications on water and environmental management.



BEDROCK FLOW AND REACTIONS: IMPLICATIONS FOR ECOHYDROLOGY AND WATERSHED EXPORTS, SPECIAL SESSION, BHAVNA ARORA, BEN GILBERT CHAIRS AND MODERATORS

A Scale-Aware Modeling Framework to Quantify Subsurface Geochemical Exports and River Water Quality

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To enable effective water resources management, watershed-scale models are needed for predictive understanding of downstream river water quality. However, watershed-scale models are computationally strenuous and inadequately represent finer-scale heterogeneity and, therefore, are likely to misrepresent critical processes. Here we present a scale-aware modeling framework harnessing the versatility of artificial intelligence and machine learning approaches along with mechanistic modeling to develop a predictive understanding of coupled surface- and sub-surface watershed-scale hydro-biogeochemical dynamics. This study aims at developing a scaling relationship between bi-directional exchange and biogeochemical transformations at the terrestrial-aquatic interfaces (TAIs) and across watershed and river landform features characterized by various sinuosity and amplitude of meanders, topography, and residence times. To capture bi-directional exchange and biogeochemical transformations at TAIs, we carried out three-dimensional reactive flow and transport simulations using a reactive transport solver – PFLOTRAN for a 10-meander system in the upper East River watershed. This area is part of the Watershed Function Scientific Focus Area Site of Berkeley Lab and is located within a high elevation catchment in western Colorado. Simulation results demonstrate that bi-directional exchange and biogeochemical transformations of redox species such as oxygen, nitrate, and iron follow the power-law nature of the distribution of sinuosity, amplitudes of meanders, and residence times. Results further demonstrate that scaling exponents typical for meanders are significantly different for oxidizing and reducing conditions. Efforts are underway to predict subsurface geochemical exports and downstream river water quality of the more extensive East River system by making use, in part, of the high-performance computing platforms provided by PFLOTRAN and the NERSC.



BEDROCK FLOW AND REACTIONS: IMPLICATIONS FOR ECOHYDROLOGY AND WATERSHED EXPORTS, SPECIAL SESSION, BHAVNA ARORA, BEN GILBERT CHAIRS AND MODERATORS

Hysteresis Patterns of Watershed Nitrogen Retention and Loss over the past 50 years in United States Hydrologic Basins

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River corridor systems in snow-dominated, mountainous regions often express complex biogeochemistry and river water nutrient indicators as a function of hydrologic exchange variability and snowmelt conditions. Watershed ecological control points (ECPs) (e.g. hyporheic zones, riparian hollows, stream bed bedrock fractures) are important for solute and nutrient processing at small scales, yet can have major impacts on large scale watershed exports. A major motivating factor for our work is a five-year concentration-discharge (C-Q) time series which display declines in inorganic nitrogen over time as well as down the watershed network, indicating the importance of the passive versus active transient nature of these ECPs. In our research, we develop a predictive understanding of the subsurface and surface controls on hyporheic biogeochemical behavior through data-model integration. We investigate a loose-coupling strategy for hyporheic systems that allows river gross primary productivity (GPP), hillslope runoff, and bedrock contributions to augment hyporheic zone function. We apply this model to the hyporheic zone along the East River, Colorado. Across the hyporheic zone and floodplain, we measured surface and subsurface gases, geochemistry, isotopes, and used this data to constrain our model in the presence of transient hydrological flow conditions. A Bayesian approach was used for the river model that allows GPP, respiration, and diffusion parameters to vary with season, constrained by radiation, barometric pressure, water depth, temperature, pH, DIC, and atmospheric CO₂. These river simulations were used as boundary conditions to test the dynamic nature of the hyporheic zone in response to projected future temperature and atmospheric CO₂ representing carbon emission futures, and to compare future and current hyporheic zone processing. Our data coupled with the predictive power of our numerical model reveal that hyporheic zones can serve many different roles throughout the year and indicate the importance of hyporheic cycling as a critical control point on watershed scale exports. The reliance of active versus passive ECPs on the timing of meltwater infiltration, including the possibility of a longer vernal window under future climate change indicates the importance of ECPs as controls of river-based indicators of river corridor hydrobiogeochemical function.



BEDROCK FLOW AND REACTIONS: IMPLICATIONS FOR ECOHYDROLOGY AND WATERSHED EXPORTS, SPECIAL SESSION, BHAVNA ARORA, BEN GILBERT CHAIRS AND MODERATORS

Modeling Reactive Transport, Weathering and Critical Zone Evolution at the Hillslope Scale

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The architecture of the critical zone results from the coupled interactions between bedrock weathering, regolith production and erosion. We present coupled numerical models of reactive transport, weathering and erosion at the hillslope scale to improve understanding of the evolution of critical zone architecture and the functioning of the critical zone. The modeling approach incorporates both vertical and lateral hydrologic flowpaths in saturated-unsaturated flow, chemical weathering, and geomorphic rules for soil production and transport. Alterations in both solid phase (plagioclase to clay) and water chemistry is tracked along hydrologic flowpaths. The resulting weathering patterns are strongly controlled by hydrologic forcing. In a dry end-member climate, weathering is shallow and surface-parallel, whereas in a wet end-member climate, weathering occurs to significant depths, controlled by the channel depth. Exploration of intermediate cases reveals that the weathering pattern is strongly governed by the ratio of the weathering front speed (controlled by the recharge rate), and the erosion rate. The system transitions between the dry and wet end-member behaviors at a weathering front speed to erosion ratio of approximately 1. While the behavior in the dry end-member case can be explained largely based on one-dimensional weathering front propagation, the wet end-member case cannot be realistically explained without invoking the role of lateral groundwater flow. We also consider the influence of deep circulating groundwater flow paths on critical zone evolution and the generation of weathered profiles.



BEDROCK FLOW AND REACTIONS: IMPLICATIONS FOR ECOHYDROLOGY AND WATERSHED EXPORTS, SPECIAL SESSION, BHAVNA ARORA, BEN GILBERT CHAIRS AND MODERATORS

Spatial distribution of pyrite oxidation under valley and ridge

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The spatial distribution of weathered rock across landscapes strongly influences how water and solutes are routed throughout the landscape. The oxidative weathering of pyrite (OWP) is usually the earliest alteration reaction observed in many formations, which defines the regolith-bedrock interface. To understand the controls on the evolution of weathering profiles that underlie hilly and mountainous regions, we investigated the spatial distribution of the OWP reaction front at the Shale Hills catchment in central Pennsylvania using geochemical measurements on materials recovered from boreholes across the catchment. As a subcatchment of the Susquehanna Shale Hills Critical Zone Observatory, intensive field monitoring and measurements of surface water and groundwater hydrology and aqueous chemistry in the past decade allow us to test how the reaction front recorded in rock is related to flow path and solute fluxes.

The V-shaped Shale Hills catchment contains an ephemeral, westward-flowing stream. The bedrock of the catchment is mainly composed of Fe-rich, organic-poor Rose Hill shale (Silurian-aged) with more interbedded carbonate and sandstone near the outlet of the catchment. Under the ridge, the depletion of pyrite occurs sharply across a front above the water table, but OWP also occurs in haloes around deeper fractures in the saturated zone, presumably where those fractures are connected, allowing oxygenated water to flow. Under the valley, the OWP initiates at ~ 20 m below the water table and completes at ~ 6 m below the water table, which results in a ~14 m wide reaction front. Such a wide reaction front of OWP under the valley is consistent with the proposed flow path at Shale Hills: O₂-rich interflow occurring in the upper fractured zone (5-8 m below land surface) mixes with deeper O₂-poor groundwater along the stream channel. The concentrations of pyrite-derived sulfate and carbonate-derived divalent cations (Ca²⁺ and Mg²⁺) increase downstream, which indicates the OWP and carbonate dissolution is highly coupled.



BEDROCK FLOW AND REACTIONS: IMPLICATIONS FOR ECOHYDROLOGY AND WATERSHED EXPORTS, SPECIAL SESSION, BHAVNA ARORA, BEN GILBERT CHAIRS AND MODERATORS

Geospatial Modeling Approach to Determine Potential Sinkholes Risk Probability and Soil Subsidence Analysis

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Sinkholes are common and naturally occurring geologic feature in Florida, South Georgia and South Alabama and being intensified by improperly managed ground water withdrawal for agricultural, industrial, and domestic use. Similarly, ground/soil subsidence occurs by excessive exploitation of aquifers. Both are a major geohazard in United States and the world. Karst topographic terrain, a major reason of sinkholes formation, evolves through dissolution of the bedrock (limestone) and development of efficient underground drainage. Sinkhole openings have major environmental consequences, i.e., polluting groundwater when sinkholes opens in superfund and landfill site locations. Soil subsidence causes severe human infrastructures damage triggering important economic losses. The main goal of this study is to develop an automated geospatial model to determine the potential vulnerable locations for sinkholes and locations of soil subsidence in south Georgia and northern Florida. Five types of geospatial data – Geology, gSSURGO (soil), land cover (NLCD 2011), aquifer, and USGS groundwater well were collected, geoprocessed, and analyzed in ArcGIS ModelBuilder to obtain the final sinkholes spatial vulnerability map of the study area. Another model was created developing DEM from latest LiDAR data of the region and overlaying with 10 and 30m DEMs of 2000 and 1980s, respectively. Geology layer was reclassified into classes of carbonite, loose sediments, and clastic sedimentary rocks of different sinkholes risks. The soil Permeability and Drainage features, surface interpolated aquifer top-depth and groundwater well depth layers, and land cover layer were and reclassified according as sinkhole vulnerability layer. Each reclassified layers were assigned sinkholes risk potential weights, developed through thorough literature review and personal expertise. All the weighted layers were analyzed integratively using weighted sum function of ArcGIS to obtain final classified sinkholes risk probability raster. Historical Sinkholes spatial data were used to validate our results. Amazingly, 85% accuracy were obtained from the study. It was also observed that metric level soil subsidence has occurred in the study area. The study would provide decision support for environmental managers, land-use planners, and other stakeholders for watershed management.



REMOTE SENSING OF WATERSHEDS AND RIPARIAN SYSTEMS, MIKE COSH MODERATOR

Soil moisture monitoring at ARS Long-Term Agroecosystem Research sites

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Soil moisture monitoring has experienced a great increase in visibility and importance with the advent of recent satellite missions. In 2002, soil moisture monitoring began in earnest across several watersheds operated by the Agricultural Research Service, including Walnut Gulch (AZ), Little Washita (OK), Little River (GA), and Reynolds Creek (ID). These networks were able to establish the baseline accuracy of the AMSR-E product with an accuracy of $0.06 \text{ m}^3/\text{m}^3$ which met the mission requirement. Two additional missions with improved performance characteristics further demonstrated the utility of the watersheds for calibration and validating global soil moisture products. In 2012, the Soil Moisture Ocean Salinity mission was validated using these ARS watersheds with an accuracy of $0.043 \text{ m}^3/\text{m}^3$. In 2015, the Soil Moisture Active Passive (SMAP) mission was launched with the largest coordinated cal/val program yet to be established for soil moisture. A total of six ARS watersheds were included in the set of core validation sites out of fifteen total and the overall accuracy was demonstrated to be $0.038 \text{ m}^3/\text{m}^3$. When SMAP produced a new gkm soil moisture product, ARS watersheds again provided the necessary data records for calibration and validation, proving the accuracy of the new products to be $0.037 \text{ m}^3/\text{m}^3$. The utility of improved soil moisture products has provided for great advances in hydrologic science and benefitting society in a multitude of ways. Soil moisture satellite products are being used to improve drought analysis. Soil moisture products from SMOS and SMAP have been used to improved flood forecasting as well. Soil moisture products are being incorporated operationally to improved continental National Weather Service Noah Models. Currently eight ARS watersheds are conducting satellite scale soil moisture calibration and validation activities at increasingly smaller scales, bringing soil moisture monitoring down eventually to the management scale. This presentation will be a review of the impact and value of soil moisture monitoring at ARS Long Term Agro-ecosystem Research sites.



REMOTE SENSING OF WATERSHEDS AND RIPARIAN SYSTEMS, MIKE COSH MODERATOR

The nature of land-cover changes to aquatic buffers in the Midwestern USA: 25 years of Landsat analyses (1993-2017)

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Important biogeochemical processing and flow-attenuation occurs in surface and near-surface inflows surrounding – or buffering – aquatic systems. Hence, modifications to areas buffering waters can have profound impacts on quantity, quality, and seasonal inundation in a given water body, as well as implications for the condition of downstream systems. To understand timing, extent, magnitude, and frequency of change in buffer areas (90-meter) surrounding waters of the Midwestern US, we analyzed the full archive of three Landsat path/row image combinations totaling 31 years of data for ~100,000 km² including areas of high urbanization (i.e., Chicago, IL, and St. Louis, MO) and agriculturally dominated landscapes (i.e., Peoria, IL). We used the Continuous Change Detection and Classification (CCDC) algorithm, which identified instances of land-use/land-cover (LULC) change throughout the continuous Landsat archive for each 30-m pixel. We trained a random forest classification algorithm using the 2001 National Land Cover Dataset, binned the data into six LULC classes, and analyzed continuous LULC change with CCDC from 1993-2017.

Though relatively small as a percent of the image, the spatial extent of the LULC modifications is substantial (e.g., developed lands increased by 280 km² in the Chicago image, whereas ~300 km² of forested land was converted to other LULCs in the St. Louis image). While change was consistent for the ~110,000 waterbody buffers analyzed across all three images, LULC change in buffering areas frequently occurred at much greater rates than LULC change calculated image-wide. For instance, buffer LULC changed to developed lands at 2x the rate in the Chicago image and 3x in the Peoria image. Forested and grasslands buffering waters were converted to other LULCs at 7x and 3x, respectively, the image-wide rate of change in the Chicago image. However, not all LULC change was conversion to development or agricultural classes, as waterbody expansion in the buffers occurred at rates of 13-70x image-wide rates across the three images. The greatest change occurred most frequently in buffers surrounding the smallest waters (<0.1 ha), though this varied by image.

Changes wrought to areas buffering waters likely affect processes within a given water as well as cumulatively modify downstream conditions. Therefore, incorporating water buffer LULC dynamics into large-scale modeling and empirical studies will improve the physical representation of the landscape and affect research on aquatic nutrient and hydrologic dynamics.



REMOTE SENSING OF WATERSHEDS AND RIPARIAN SYSTEMS, MIKE COSH MODERATOR

Fine-resolution mapping of surface water and wetland inundation dynamics in the Prairie Pothole Region

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The Prairie Pothole Region of North America is characterized by millions of depressional wetlands, which provide critical habitats for globally significant populations of migratory waterfowl and other wildlife species. Due to their relatively small size and shallow depth, these wetlands are highly sensitive to climate variability and anthropogenic changes, exhibiting inter- and intra-annual inundation dynamics. Moderate-resolution satellite imagery (e.g., Landsat, Sentinel) alone cannot be used to effectively delineate these small depressional wetlands. By integrating fine spatial resolution Light Detection and Ranging (LiDAR) data and multi-temporal (2009-2017) aerial images, we developed a fully automated approach to delineate wetland inundation extent at watershed scales using Google Earth Engine. Machine learning algorithms were used to classify aerial imagery with additional spectral indices to extract potential wetland inundation areas, which were further refined using LiDAR-derived landform depressions. The wetland delineation results were then compared to the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) geospatial dataset and existing global-scale surface water products to evaluate the performance of the proposed method. We tested the workflow on 993 HUC-10 watersheds with a total area of 750,000 km² in the Prairie Pothole Region. The results showed that the proposed method can not only delineate the most up-to-date wetland inundation status, but also demonstrate wetland hydrological dynamics, such as wetland coalescence through fill-spill hydrological processes. Our automated algorithm provides a practical, reproducible, and scalable framework, which can be easily adapted to delineate wetland inundation dynamics at broad geographic scales.



REMOTE SENSING OF WATERSHEDS AND RIPARIAN SYSTEMS, MIKE COSH MODERATOR

Actions and plans to quantify the “Invisible Giant” – Evapotranspiration – in Florida water budgets

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The US Geological Survey (USGS) Caribbean-Florida Water Science Center has pursued a multi-decadal strategy to better quantify evapotranspiration throughout the State of Florida. Evapotranspiration – a substantive component of the water budget accounting for roughly 75 percent of annual rainfall in Florida – warrants this pursuit. USGS efforts in Florida to quantify evapotranspiration began in the 1990s with a network of micrometeorological stations to measure the evapotranspiration flux at high resolution (daily to sub-daily) at the field scale, providing substantive data on this elusive component of the water budget and its relation to environmental variables of land cover, solar insolation, weather/climate, and water availability. Beginning in 2005, the USGS and partners merged high resolution spatially-distributed, satellite-derived solar insolation data with field- and North American Regional Reanalysis-derived meteorological data to provide spatially- and temporally-continuous surrogates of daily evapotranspiration – reference and potential evapotranspiration – at 2-kilometer resolution throughout the State of Florida. These data are critical drivers of estimates of agricultural water use and of hydrologic simulation for the purpose of water management. The quality of spatially- and temporally-continuous satellite-derived actual evapotranspiration over Florida, as estimated by the USGS Simplified Surface Energy Balance – operational (SSEBop) approach, is now being evaluated through independent estimates of actual evapotranspiration – from water budget estimates and micrometeorological station measurements. Future studies include “mining” of the actual evapotranspiration product SSEBop to derive functional relations between evapotranspiration and environmental drivers, expansion of the geographic domain of these efforts to include areas of adjacent states to allow seamless inter-state hydrologic analyses, and projection of evapotranspiration estimates into the future to acknowledge climate and landscape changes.



REMOTE SENSING OF WATERSHEDS AND RIPARIAN SYSTEMS, MIKE COSH MODERATOR

Remote-sensed Demonstration of Ecosystem Services in the Great Pee Dee Basin, South Carolina

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THE NATURE CONSERVANCY

The Great Pee Dee watershed in northeastern South Carolina contains over 600,000 acres of floodplain forests, which provide important ecosystem services of flood retention and pollutant capture. The Nature Conservancy and partners endeavored to demonstrate pollutant capture services to a broad range of Great Pee Dee stakeholders whose support is important to its mission of natural land conservation. This desired support is both political and financial. However, demonstrating ecosystem services for water quality is very difficult with traditional sampling approaches. Advances in remote sensing of water quality are overcoming the challenge of identifying source and sink areas of various point and non-point source pollutants. In this project, we employed remote-sensed water quality images and post-processing to demonstrate turbidity capture services performed by floodplain forests along the Great Pee Dee. Turbidity in river flows passing through forested floodplain reaches was consistently reduced across four discrete hydrologic events including large and small regional floods, and thunderstorm-driven pulses. This visually-driven portrayal of ecosystem services in action was also very engaging for river stakeholders, and is spurring conservation action for land protection and management in the watershed.



REMOTE SENSING OF WATERSHEDS AND RIPARIAN SYSTEMS, MIKE COSH MODERATOR

An evaluation of ECOSTRESS products on a temperate montane humid forest

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Mountain landscapes provide water for much of the World's population, but plant water use trajectories are difficult to predict in complex terrain with high species diversity. Technologies embodied in NASA's Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission may provide critical data for understanding hydrologic cycling in these forested mountain areas. Measurements from eddy flux towers have provided the bulk of performance evaluation for ECOSTRESS data products to-date, but most flux towers are located in flat terrain, sampling relatively homogeneous vegetation. In this study, the accuracy of ECOSTRESS' Level 2 instantaneous Land Surface Temperature (LST) and Level 3 PT-JPL evapotranspiration (ET) estimates were evaluated against an eddy covariance tower and five climate stations at the USDA Forest Service's Coweeta Hydrologic Laboratory, located in the southern Appalachian Mountains of western North Carolina. Frequent cloud cover limited ECOSTRESS data, there were 30 of 100 cloud masking images that covered more than 80% of the study area by the end of 2019. We compared the hourly surface air temperature observations at the five climate stations with ECOSTRESS LST, and found that they agreed reasonably well ($R^2 = 0.86$ and $P < 0.001$ for the high-quality ECOSTRESS measurements, clear sky and accuracy < 2 °C). For instantaneous ET, there were only sixteen estimates (50% of valid LST estimates with clear sky and accuracy < 2 °C) at our study site. We found that ECOSTRESS tended to consistently overestimate both instantaneous and daily ET, which may mainly result from the coarse ancillary inputs and the diurnal cycling upscaling method. Our study comprehensively evaluated the accuracy of ECOSTRESS products and pointed out the possible error sources, which will help ECOSTRESS mission to improve the accuracy of ECOSTRESS products further and provide a reference for other ECOSTRESS data users.



FACETS: FLORIDAN AQUIFER COLLABORATIVE ENGAGEMENT FOR SUSTAINABILITY, SPECIAL SESSION, WENDY GRAHAM MODERATOR

Stakeholder-Driven Modeling in Support of Groundwater Sustainability: the Floridan Aquifer Collaborative Engagement for Sustainability (FACETS) Project

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The Upper Floridan Aquifer (UFA) is among the largest, most productive aquifers in the world and is a vital regional resource shared between Florida, Georgia, and Alabama. The UFA supports agricultural activities worth >\$7.5 billion and supplies drinking water to more than 10 million people but faces significant threats to water quality and quantity, which could potentially harm food security, fiber production, and vital ecosystem services. The Floridan Aquifer Collaborative Engagement for Sustainability (FACETS) project is bringing scientists and a diverse group of stakeholders together in a Participatory Modeling Process (PMP) to understand the economic-environmental tradeoffs associated with alternative climate, land use, Best Management Practice (BMP) adoption, and policy scenarios, with the ultimate goal of understanding changes needed to achieve agricultural water security and environmental protection. Scenario analyses results are being incorporated into public willingness-to-pay and producer willing-to-accept surveys to develop BMP adoption/land use change supply and demand curves, which will inform the development of policies and incentives to bring about changes in land use and water management. This session will highlight successes and challenges of the first two years of this five-year project including field experiments to measure yields as well as water and nutrient balances of alternative cropping systems and BMPS; co-development of biophysical and economic models to simulate agricultural/silvicultural production, water quality and quantity, and economic conditions for baseline and alternative future scenarios in the region; and use of social learning research to shape the design of the Participatory Modeling Process.



FACETS: FLORIDAN AQUIFER COLLABORATIVE ENGAGEMENT FOR SUSTAINABILITY, SPECIAL SESSION, WENDY GRAHAM MODERATOR

Predicting Precision Nitrogen Side-dress Applications for Maize with a Simulation Model

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Consistent maize (*Zea mays* L.) yields of near 16,000 kg/ha is a goal of many growers in the state of Georgia, USA. To achieve this goal, a common practice is to increase the application rates of fertilizers and irrigation water. However, recent experiments conducted in this area have shown that nutrients and water are not always the limiting factors in achieving higher yields and that high fertilizer rates result in nonpoint source pollution, particularly critical in watersheds areas.

This research focus on increasing nitrogen use efficiency (NUE) by using the STICS (Simulateur multi-disciplinaire pour les Cultures Standard) model (INRA, France) to simulate plant uptake and soil nitrogen dynamics to estimate the need of side-dress nitrogen applications. The model was selected for its high adaptability compared to most similar models. Model inputs include general parameters, plant parameters, soil parameters, initial conditions, crop management information and weather data. Model outputs include soil water content (mm³ mm⁻³) and soil NH₄⁺ and NO₃⁻ (kg ha⁻¹). The model was calibrated and validated using data from a study conducted during 2018 in southern Georgia, where nine combinations of six management strategies – three fertilization and three irrigation management strategies, were tested.

The experiment was repeated, and the model validated, during 2019 using a fertilization treatment with five side-dress applications scheduled according to model predictions of soil mineral N. Overall, model validation was determined to be good as values of the evaluation indices were similar to those from calibration. The presentation describes the model performances. Following the 2019 experiment, the model will be incorporated into the SmartIrrigation Corn App, a smartphone application for scheduling irrigation in corn. The modified application will allow growers to schedule both irrigation and side-dress applications of nitrogen increasing profitability and sustainability. This research is part of the FACETS (Floridian Aquifer Collaborative Engagement and Sustainability) project funded by a grant from the United States Department of Agriculture – National Institute of Food and Agriculture.



FACETS: FLORIDAN AQUIFER COLLABORATIVE ENGAGEMENT FOR SUSTAINABILITY, SPECIAL SESSION, WENDY GRAHAM MODERATOR

Economics of Best Management Practices to Improve Water Quality and Quantity in the Upper Floridan Aquifer

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Long-term economic and environmental sustainability of agriculture is necessary for its economic contribution to southwest Georgia, north central Florida and southeast Alabama; an area where the Upper Floridan Aquifer (UFA) is a vital resource of water. As populations and demand for water increases, water security has become an issue to agricultural and residential users. As a result, environmental regulations to ensure water quality and availability were signed into law and litigation between Georgia and Florida escalated to the United States Supreme Court. Water use and management practices are critical to the future of the landscape supported by the UFA. Alternative land use practices need to be identified and implemented to improve water quality and ensure water use efficiency. By interviewing extension agents and agricultural producers, enterprise budgets were developed to reflect the current land use management practices in the UFA for cotton, peanuts, corn, hay and pasture. These enterprise budgets documented cultural practices for agricultural production in the region. Farm-scale production costs and revenues associated with the current and alternative best management practices (BMP) were also included in the enterprise budgets. Bundles of BMPs were evaluated at three scenario levels: intensive, typical and minimal implementation of resource saving technologies. Economic simulation analysis was conducted using @Risk software to compare the alternative BMP scenarios and the impact of these scenarios on profitability. The software enabled 500 iterations to be run for each crop and scenario. Preliminary simulation results indicate that minimizing crop inputs was not necessarily the optimal approach for maximizing crop net returns per acre. Implementation of bundles of BMPs can have a positive effect on profitability as well as water quality and quantity.



FACETS: FLORIDAN AQUIFER COLLABORATIVE ENGAGEMENT FOR SUSTAINABILITY, SPECIAL SESSION, WENDY GRAHAM MODERATOR

Scrutinizing Significance of Trees in Watershed Modeling

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Forests can cover significant portion of watersheds and affect rainfall interception, water losses through evapotranspiration (ET), soil moisture dynamics, surface runoff, aquifer recharge, nutrient leaching, and sediment exports to streams. Despite their critical role in the hydrologic cycle, tree growth is either ignored or superficially considered in hydrological models. We postulate that stand attributes deserve more attention in hydrologic modeling. To that end, this study aims to improve the plant database of a widely applied watershed model, the Soil and Water Assessment Tool (SWAT). To accomplish this goal, we parameterized SWAT with species-specific parameter values derived from publicly available remote-sensing products, field measurements, and literature review. Several studies have identified unrealistic parameter values related to tree growth prediction in SWAT (e.g. BLAI, BIO_E, T_BASE). Although this issue has been somewhat addressed through the calibration of few model parameters and code modifications, to the best of our knowledge, no study carried out a detailed parameterization of trees in SWAT by utilizing observations and/or literature. Here, we applied the SWAT model at multiple scales to simulate leaf area index (LAI), biomass accumulation, and ET of loblolly pine (*Pinus Taeda L.*) and slash pine (*Pinus elliotti*) under varying management, soil, and climate conditions. Tree growth related parameters in SWAT were calibrated at field level for multiple loblolly and slash pine plantations across Alabama, Georgia, and Florida. Model skills in predicting these processes were tested using MODIS LAI and ET derived data, as well as field measured total biomass. Since phenological parameterization is difficult due to lack of observations across large areas (e.g. watersheds), we transferred the improved parameter estimates from the field plots to nearby forested watersheds with observed streamflow data. Models based on improved parameterization and default parameterization were compared to assess the effects of enhanced forest model representation on hydrology and water quality. The utilization of multiple state variables for model calibration (e.g. LAI, ET, and biomass) increases the model robustness and reduces the uncertainties associated with water balance predictions. We conclude that enhanced tree dynamics in watershed models is necessary for increased model reliability in watersheds having significant forest cover.



FACETS: FLORIDAN AQUIFER COLLABORATIVE ENGAGEMENT FOR SUSTAINABILITY, SPECIAL SESSION, WENDY GRAHAM MODERATOR

Impact of land use change and different management practices on nitrate loading to groundwater in Santa Fe River Basin

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The Santa Fe River basin (SFRB), encompassing 3584 square kilometers in north-central Florida, is dominated by forest and agricultural (primarily corn, peanut, hay, pasture) land uses. The Upper Floridan Aquifer (UFA) is the key water source that supports agricultural production, domestic supply and ecological sustainability in SFRB. In a significant portion of the SFRB, the UFA is unconfined, overlain by sandy soil and associated with high permeable fractured limestones which causes rapid recharge by rainfall and also makes it susceptible to $\text{NO}_{3-\text{N}}$ infiltration from various point and non-point sources. Non-point sources such as N fertilizer and organic manure from pastures are of particular concern in SFRB. Basin Management Action Plans (BMAPs) that have been developed to meet the mandated numeric nutrient criterion (NNC) of 0.35 mg/l $\text{NO}_{3-\text{N}}$ in springs and rivers in the SFRB estimated that a 35% reduction in $\text{NO}_{3-\text{N}}$ leaching to UFA is needed.

A basin scale model was developed and calibrated to predict SFRB river flow and $\text{NO}_{3-\text{N}}$ concentrations for the time period 2000-2010 using the USDA Soil and Water Assessment Tool (SWAT). The calibrated model was then used to assess $\text{NO}_{3-\text{N}}$ leaching and $\text{NO}_{3-\text{N}}$ river concentrations for a range of alternative land use and nutrient and water management practices. Preliminary results show that adoption of reduced nitrogen fertilizer rates and improved irrigation management for existing agricultural land uses and/or conversion from more intensive (row crops, grazed pasture) to less intensive (hay and forest) land uses, can significantly reduce $\text{NO}_3\text{-N}$ leaching in the SFRB.



FACETS: FLORIDAN AQUIFER COLLABORATIVE ENGAGEMENT FOR SUSTAINABILITY, SPECIAL SESSION, WENDY GRAHAM MODERATOR

The importance of process representation for simulating coupled surface-ground-water flow: a comparison of SWAT, SWAT-MODFLOW, and DISCO

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We have developed a SWAT-MODFLOW model for the Santa Fe River Basin within the framework of the USDA funded Floridan Aquifer Collaborative Engagement for Sustainability (FACETS) project, which aims to understand land use changes needed to achieve agricultural water security while meeting environmental regulations.

The Soil and Water Assessment Tool (SWAT) is a powerful tool that can simulate the effects of land management practices on water quantity and water quality. Recently, SWAT has been coupled with the USGS groundwater flow model MODFLOW to overcome its limitations with respect to subsurface flow. In the SWAT-MODFLOW model, SWAT handles the surface and soil water component whereas MODFLOW handles the subsurface water component.

To guide our modeling effort we compared our SWAT-MODFLOW model to some other models. Since we have to build a stand-alone SWAT model as a requisite to the SWAT-MODFLOW model, we can compare SWAT and SWAT-MODFLOW and explore if the SWAT-MODFLOW model simulates groundwater contributions to streams more correctly. In addition, we also compared the SWAT-MODFLOW model to a DisCo model in which surface and subsurface flow are coupled fully implicitly and are governed by the diffusive wave equation and the Richards' equation, respectively. While the DisCo model cannot simulate the effects of land management practices as needed for our project, it is a more-physically based flow model than SWAT-MODFLOW. As such, we expect that this model can provide insights into possible limitations of SWAT-MODFLOW. Preliminary results show all models perform reasonably well in terms of simulated stream flows. We discuss the limitations and benefits of the different models. In addition, we illustrate how having multiple models for the same region was beneficial for the development of the SWAT-MODFLOW model.



FACETS: FLORIDAN AQUIFER COLLABORATIVE ENGAGEMENT FOR SUSTAINABILITY, SPECIAL SESSION, WENDY GRAHAM MODERATOR

The integration of Social Learning and Facilitation methods to enhance | stakeholder engagement for the FACETS project

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Addressing complex environmental problems demands approaches that transcend multiple disciplines and span various scales of inquiry. Much research and practice to date explores ways to make the problem-solving space inclusive and transparent in order to develop solutions that are more holistic and relevant to stakeholders. Emergent from these studies and experiences are innovations in methods, strategies, and processes to guide successful integration of stakeholder input into environmental problem solving. We contribute to this evolving body of literature and argue for combining social learning research with adaptive process design and management. We suggest a new practice of continuous monitoring, documentation, and collaborative reflection for fine-tuning stakeholder engagement and facilitation. Such adjustments encourage deeper communication and balanced participation to elicit input and build dialog across a diversity of project team members. The Floridan Aquifer Collaborative Engagement for Sustainability (FACETS) project brings together teams of bio-physical and social scientists from across the southeastern US with stakeholders representing farming, forestry, local government, and conservation in a participatory modeling process. Together, project participants develop and examine future pathways and tradeoffs associated with ensuring economically sustainable agriculture and silviculture in North Florida and South Georgia while also protecting water quantity and quality of the Floridan Aquifer. This paper discusses the theoretical framework and methods of the social science and process management team (composed of anthropologists and professional facilitators). We highlight the opportunities and challenges associated with creating, managing, and maintaining an engaged group of stakeholders and scientists navigating a participatory modeling process.



CONSERVATION EFFECTS ASSESSMENT, LISA DURIANCIK MODERATOR

Overview of the Impacts of CEAP for the First 15 Years

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In 2003, the USDA Natural Resources Conservation Service partnered with USDA Agricultural Research Service and other agencies to create the Conservation Effects Assessment Project (CEAP) to quantify the environmental effects of conservation practices (CPs) and programs and develop the science base for managing the agricultural landscape for environmental quality. Recently, a CEAP Special issue entitled "Measuring and Understanding the Effects of Conservation within Watersheds" that focuses on the findings of the ARS Benchmark and other watersheds for the first 15 years of CEAP was proposed. An overview of the major findings of the papers in the special issue will be presented. The results of a synthesis of the effects of CPs on soil and water resources at various spatial scales reported in the papers in this special issue and pertinent papers outside the special issue will be presented. Other impacts of CEAP, not related to CPs, will also be presented.



CONSERVATION EFFECTS ASSESSMENT, LISA DURIANCIK MODERATOR

Comparisons of radar, bubbler, and float water levels in the Goodwater Creek Experimental Watershed

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Multiple means of measuring and recording stream stages ensure that a backup is available if the primary equipment fails. Since the advent of flow bubblers and dataloggers, a common set up included a flow bubbler and datalogger as the primary equipment and a float-driven sensor along with paper charts as the backup device. Radar based systems could be a useful primary or secondary measurement device. Multiple evaluations of radar measurement systems exist for lake or ocean tide water levels but few were conducted for smaller streams. The paper compares water levels measured at the outlet of the 72-km² Goodwater Creek Experimental Watershed with a radar, a flow bubbler, and a float-driven sensor. Field data showed diurnal variations caused by the radiation on the radar unit during sunny low flow days and eliminated by insulation around the radar unit. At high stages, the float and shaft system produced an oscillating pattern of increasing magnitude as the stage increased. Overall, the differences between radar and bubbler values are proportional to stage and to the magnitude of these oscillations. The difference between the radar and bubbler value can be used to quantify the uncertainty of the stage measurement. In addition, the relationship between this difference and stage provides a means to correct past stages measured with a bubbler without having to read 30 years of chart.

[1] Intergovernmental Oceanographic Commission (2016). Manual on sea level measurement and interpretation, vol. V: Radar gauges. In (Vol. 5, pp. 220). Paris, France: United Nations Educational, Scientific and Cultural Organization.

[2] Fulford, J. M., & Davies, W. J. (2005). Radar Stage Uncertainty. In Impacts of Global Climate Change (pp. 1-11).



CONSERVATION EFFECTS ASSESSMENT, LISA DURIANCIK MODERATOR

Agricultural producers' willingness to accept payments for improving water resources in the Florida Aquifer

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Increased adoption of best management practices (BMPs) by agricultural producers is a potential tool for improving water resource conditions. However, the economic feasibility of this approach is largely unknown in watersheds connected to the Florida aquifer. This study assessed the farm and forest-level economic tradeoffs associated with a suite of proposed BMPs for typical agricultural enterprises and crop rotation in S. Georgia and N. Florida (row crops, planted pines, and hay). We then surveyed producers to determine what level of incentive payments would be required to ensure their participation in voluntary BMPs, which often require high start-up and/or installation costs and can affect farm and forest yields. The survey included economic valuation questions designed to understand producer preferences in an elicitation format known as Best-Worst Choice modeling. Results of the survey are used to estimate a supply curve for water resource improvements from producers as a function of price, and in the context of a hypothetical payments program, can predict levels of producer participation and the subsequent changes in water resource conditions in the study area.



CONSERVATION EFFECTS ASSESSMENT, LISA DURIANCIK MODERATOR

Ecological Effects of Agriculturally-Sourced Colored Dissolved Organic Matter in Two Mississippi Watersheds

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Colored dissolved organic matter (CDOM) can be a significant component of water quality that is often overlooked, especially in agricultural landscapes where eutrophication and erosion are viewed as the most pernicious sources of water quality impairment. Influxes of agriculturally-sourced CDOM typically occur during large storm events coinciding with crop drying prior to harvest (crop-sourced CDOM) and/or with top soil erosion after harvest and tillage (erosion-sourced CDOM). In the current study, surface water quality of two agricultural watersheds in western Mississippi, Beasley Lake and Roundaway Lake, were monitored from 2017-2019 and included suspended solids, nutrients, CDOM, algae and dissolved oxygen. Crop-sourced CDOM influxes occurred in Roundaway Lake during August 2017 and September 2018 producing hypoxic conditions (dissolved oxygen $<2\text{mg/L}$) in an upstream reach, lasting days to weeks and coinciding with inhibition of algal photosynthesis. Erosion-sourced CDOM occurred every year of monitoring in both watersheds, strongly correlating with total suspended solids ($r > 0.70$). Using classification and regression tree (CART) analyses, erosion-sourced CDOM in Beasley Lake significantly influenced algal biomass and photosynthesis in conjunction with nutrients and seasonality. By comparison, both crop-sourced CDOM and erosion-sourced CDOM in Roundaway Lake influenced algal biomass and photosynthesis in conjunction with nutrients and seasonality. In general, more terrestrial-derived CDOM with greater molecular weight and increased color decreased algal biomass and inhibited algal photosynthesis in both watersheds. Study results indicate that reduction of both nutrients and inputs of colored dissolved organic matter into agricultural water bodies is necessary to help mitigate hypoxia and stabilize primary productivity in agricultural watersheds.



CONSERVATION EFFECTS ASSESSMENT, LISA DURIANCIK MODERATOR

A Novel Transient Tracer for Assessing Watershed Lag Time and Agricultural Nitrogen Fate

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Groundwater transit time measurement is important for understanding the time span required for conservation practices applied to agricultural landscapes to influence the stream water chemistry in watersheds. Standard measurement methods of water lag time are limited to groundwater because of the volatile nature of the transit tracers commonly employed. We recently discovered a non-volatile tracer that can accurately quantify stream water at an outlet and greatly decrease the uncertainties associated with translation of measurements into estimates of watershed lag time. This advancement was the result of a fortuitous reformulation of the commonly-used herbicide metolachlor from racemic to the S-chiral form in 1999 to increase product herbicidal activity. Metolachlor is metabolized to metolachlor ethane sulfonic acid (MESA), and the parent chirality is retained. MESA is very stable and highly soluble in soil and aquifer sediment and therefore acts as a conserved transport analog of agricultural nitrate. The chiral ratio of MESA in a water sample is measured, and using a two end-member model, allows for calculating the MESA pool into pre- and post-1999 formulation components. Application of a suitable transit model permits estimates of water transit age as well as age of associated nitrate. Chiral MESA analyses of water samples collected in the Choptank River watershed over the period from 2005 to 2019 demonstrated the utility of chiral MESA to fractionate nitrate into two age pools because of strong correspondence between the chiral signal and observed stream nitrate dynamics. This methodology will provide watershed transit times useful for assessing effectiveness of conservation practices on surface water chemistry and watershed export of agricultural contaminants.



CONSERVATION EFFECTS ASSESSMENT, LISA DURIANCIK MODERATOR

Advancing Conservation Effects Assessment in Watersheds: Delivering Outcomes for the Farm Bill

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There are many expectations in the recent Farm Bill regarding outcomes of conservation, for watersheds, water quality, water scarcity as well as other resource concerns addressed by USDA Conservation Programs. Efforts to assess conservation effects in watersheds and on water resources need to produce credible data. They need to be conducted over the long-term, yet expectations dictate they also need to provide timely results to be applied to adaptive management of agricultural systems. Assessments should be used to build more resilient agriculture, in the face of extreme events. Assessments should inform watershed and conservation planning at local levels, and at the same time, outcomes should inform program design and delivery approaches at larger scales. How can this broad range of expectations across spatial and temporal scales be best addressed going forward with science, assessment and data analysis efforts to yield credible results to support agency mandates? What additional capacity is needed to better accomplish this, building on existing efforts, while advancing our ability to speak to outcomes of conservation efforts and advancing our capacity for enhanced planning and more effective watershed efforts?



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

ARS Watkinsville, GA. 1937-2012. Legacy of 75 Years of Watershed Research

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The ARS Research Center in Watkinsville, GA, was established in 1937 as one of fifteen regional federal soil and water conservation experiment stations. Research addressed negative impacts of historic soil erosion in the Southern Piedmont. Pioneering work was conducted in soils, hydrology, conservation tillage, cropping systems, cover crops, rotations, forage and pasture management, and integrated soil and water management systems leading the conservation movement in the Southeast and other countries. Benefits such as increased soil carbon, improved soil physical condition and infiltration, improved N use efficiency, increased farm level economic stability, and increased yields were demonstrated. Pesticide transport studies in agricultural runoff were conducted in collaboration with EPA. The potential for soil CO₂ sequestering through conversion of degraded lands to pastures was established. Risks associated with using broiler litter as fertilizer were found to be reduced with good management practices. Historical databases were used to predict management effects on soil and water losses and to define regularity of agricultural and hydrologic droughts. Curve numbers in standard tables for no-till were shown to be 10+ units greater than should be. Flue gas desulfurization gypsum was found to be safe for agricultural use including to help reduce runoff P losses from broiler litter applied on pastures. Participatory water quality research in two large watersheds, related agricultural land use and management practices to spatial and temporal distribution of nutrients, sediment, and fecal coliforms, and was recognized as a prototype for evaluating agricultural TMDLs. Ponds within agricultural landscape were shown to reduce microbial population levels at the outflow, providing the potential to locate high risk practices (winter birthing pastures for cow-calf systems, etc.) upstream of these catchments to reduce movement below ponds. The Center's long-term research plots, fields, and watersheds served as a technology transfer sites providing information to NRCS, grower groups, numerous university students, and other national and international researchers. The research contributed to development and testing of erosion, water quality, and hydrologic models, including USLE, RUSLE, RUSLE2, CREAMS, WEPP, WEPS, and RZWQM. The center was transferred to the University of Georgia in 2012 but the legacy continues.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Advancing Understanding of Total and Reactive Phosphorus Concentration and Suspended Solids Particle Size Class

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The correlation of soil to nutrient losses from upland areas to receiving water bodies continues to be an important, yet often confounding, source of error in watershed planning. In particular, loadings of suspended solids and phosphorus (Total P and soluble reactive SRP) have been reported in many studies. However, the relationships between P and SRP and specific soil particle size classes remain largely unknown. This study was initiated to develop an empirical relationship between P, SRP and suspended solid concentrations and particle size (mg/L and μm , respectively) in a representative Appalachian mixed-land-use watershed. Event-based water samples ($n = 128$) were collected from agricultural, urban and forested reaches in West Run Watershed, located in Morgantown, WV, USA. Preliminary analyses show average P and SRP concentrations of 0.4 and 0.31 mg/L for P and SRP, respectively, while minimum and maximum concentrations ranged from 0.0 - 5.03 mg/L (P) and 0.0 - 4.56 mg/L (SRP). Average, minimum, maximum and standard deviation (SD) values of turbidity were 27.82, 0.46, 621 and 74.35 NTU, respectively. Mean, minimum, maximum and SD values of total suspended solids (TSS) were 25.3, 0.0, 402.0, 26.6 mg/L respectively. On average, 93 %, 33 %, and 0.0 % of particle size classes for all samples were below or equal to 62.23 μm , 5.5 μm and 0.072 μm , respectively. Preliminary analyses further indicate that highest P and SRP concentrations corresponded to particle size classes below 62.23 μm and above 0.072 μm . Ongoing analyses will include elucidation of which particle size classes corresponded most significantly ($\alpha = 0.05$) with P and SRP. This work is important given that phosphorus has been identified as a principal driver of degraded aquatic health in fresh water. Results of this investigation will provide quantitative information that will advance the ability of land managers and policy makers to target specific practices that may reduce particle size class transport and remediate the fate of total and reactive phosphorus.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Improved site-specific allometric equations for *Robinia pseudoacacia*

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Robinia pseudoacacia is an early successional nitrogen (N)-fixing tree, native to the Southeastern US. It is widespread in the southern Appalachians, particularly following disturbance, and can be a significant source of new N to recovering forests. Average N-fixation rates range from 2–9 kg N ha⁻¹ year⁻¹, depending on stand age and density of *Robinia* stems. *Robinia* is a functionally important tree species, not only because it fixes N and increases soil N availability, but also because it has more conservative daily water use than other common early successional trees, such as *Liriodendron tulipifera*. Because *Robinia* plays an important role in southern Appalachian forest dynamics and ecosystem processes, models are needed to accurately predict its aboveground biomass and sapwood area.

We developed allometric equations for *Robinia pseudoacacia* to predict aboveground biomass (leaf, wood) and sapwood area based on measurements of diameter and height. We compiled data across three research studies, 16 trees, ranging in diameter from 6.0 to 58.5 cm diameter at breast height (dbh). All trees were destructively harvested, dry biomass of leaves and stems measured, and C and N concentration of all tissues were estimated. We present these equations to provide improved site-specific forest biomass estimates.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Characteristics of flow events that influence phosphorus and nitrogen loads from ranchlands of South-central Florida

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South central Florida faces major challenges in protecting water quality and wetland ecosystems in the face of encroaching development and significant agricultural production. Beef cattle ranches are the largest land use in the Lake Okeechobee watershed, and although nutrient loads from cattle pastures are low relative to other land uses on a per area basis, the large acreage of ranches makes them a significant contributor to overall nutrient loads. Even though best management practices and other management techniques have been implemented to improve nutrient run-off from ranches, high variability between flow events still occurs suggesting that there are other factors that may be affecting nutrient discharges from ranchlands. The objective of this study was to use a model selection approach combined with multivariate regression analyses to reveal the main factors affecting ranchland nutrient loads using data collected during the Florida Ranchlands Environmental Services Project. In general, across three ranches and eight catchments, large flow events discharged greater nutrient loads; for both P and N the top five flow events accounted for one third of the P discharges and one quarter of the N discharges over the three year study (n=62). Differences between sites contributed to variation in nutrient loads for both unit area loads and flow-weighted loads. However, even though site variation had a strong effect in all models, we still detected strong effects of other factors. Peak flow intensity consistently was retained in regression models and had the highest effect size in relation to other variables on unit area P and N loads. This supports implementation of management techniques to slow down flow rates to aid in reducing both P and N release. Adaptively managing for large flow events by creating more storage space (e.g. Releasing water and raising board heights) before anticipated large storm events may also help to reduce total P discharges from ranchlands.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Application of Remote Sensing Drought Indicators for Monitoring Drought and Streamflow

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This project analyzes the in-situ drought indices the Palmer Drought Severity Index (PDSI) and the Standardize Precipitation Index (SPI) and the remote sensing drought indices, the Vegetation Condition Index (VCI) and the Soil Moisture Condition Index (SMCI) in predicting streamflow anomalies. data for the growing season (April-September) from 2003 through 2017. Growing season data from 2003-2017 were compared on a climate division basis for climate divisions in the four states of Kansas, Missouri, Nebraska, and Iowa. Results show that SMCI is significantly correlated with PDSI and SPI more than VCI in the region. The Percentage of Discharge Anomalies (PDA) were used to compare streamflow discharge with each index over the time frame for each climate division. PDA tended to match closest to SPI and PDSI. VCI and SMCI changes followed a more annual cycle. Results suggest that PDSI and SPI can reasonably (statistically significant) predict streamflow changes in most climate divisions. VCI showed significant correlations in the western parts of the study region while SMCI showed higher significance overall in monitoring PDA over the study region.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Incorporating Human Dimensions in Long-Term Agroecosystem Research Network

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The USDA Long-Term Agroecosystem Research (LTAR) network, established in 2014, consists of eighteen sites located across the US. Currently, most agricultural science in the US focuses on improving productivity and efficiency. The LTAR network is unique in that the experimental, multi-scalar, and long-term research also addresses sustainable intensification of agroecosystem productivity, climate change, environmental conservation, and promotion of prosperity. The incorporation of a Human Dimensions working group will be instrumental in achieving the overarching goals of the LTAR network by including social, economic, cultural, and other human community-based components of long-term agroecosystem research.

The overall goal of this research is to engage stakeholders in the contribution of human dimensions components to evaluating business as usual (BAU) systems and envisioning aspirational (ASP) systems. The research will develop methods and indicators to assess impacts to rural prosperity and human well-being; identify opportunities and barriers to the adoption of sustainable agroecosystem management strategies; and develop and deliver knowledge, tools, and products to facilitate the adoption of aspirational agricultural production strategies and innovations. In the initial phase, the objectives are to review the relevant literature and existing indicator frameworks. Preliminary findings identifying secondary data for use as indicators in the LTAR network will also be described. Methodological scenarios for identifying representative BAU and ASP systems will be identified in cooperation with other LTAR working groups to help address the uncertainty and complexities decision-makers face.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Water Footprint of Agricultural Crops: A Meta-analysis on Current Understanding and Future Perspectives

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Agriculture, the most water intense production system, which is the backbone of the economy for many countries, extracts two-third of water from lakes, rivers, and aquifers. Agricultural crop water requirements vary between crops. The Water Footprint (WFP) is a measure of freshwater consumption in food production and its impacts on water resources by individuals, communities, and businesses. It is partitioned into green WFP that denotes rainwater use and blue WFP, ground, and surface water. The present study focuses on the current understanding of the WFP concept, different phases, methodologies adopted, and the accounting from peer-reviewed literature from a qualitative perspective. A meta-analysis was done from published articles related to the agricultural WFP of crops from the google scholar database for 2006 to 2020. The results show that majority of the studies have focused on the WFP accounting phase, with a focus on the sustainability assessment phase in recent years. The progress of WFP research shows an increase in studies related to impact assessment, specifically for blue water. Therefore, future studies should consider green water impact assessment also in the analysis. Besides, WFP assessments may be done within the framework of water-food-energy nexus for a complete understanding of water resource and environmental management decisions.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS
**Evapotranspiration in a Subtropical wetland savanna using low-cost Lysimeter,
Eddy Covariance and Modeling approaches**

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Evapotranspiration (ET) constitutes the largest loss of water from subtropical humid ecosystems, yet is beset with high uncertainty as there is not much information on wildland plant species water use. This study measured daily ET using low-cost lysimeters for single species as well as mixed grassland and wetland communities typical of Southcentral Florida wetland savannas. These values were then compared with ET estimates from an eddy covariance tower onsite as well as with commonly used vapor transport-based ET models for the region such as FAO Penman-Monteith. Both weighing-type and water level lysimeters showed the expected increase in ET over the growing season, barring an uncharacteristic dip in May owing to extreme cloudiness, which was also picked up by the eddy flux and ET model estimates. Annual ET from lysimeters (800-1200mm) was similar to model estimates (1000-1200mm) while the eddy covariance ET estimates were characteristically lower (740mm). Thus, low-cost lysimeters can be used to calibrate regional ET models and can be particularly useful in data-poor regions of the world."



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Impacts of pasture, hay, and row crop management systems on groundwater quality and quantity in the Santa Fe River basin, Florida

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The Upper Floridan Aquifer, which underlies all of north Florida, is threatened by over-pumping and nutrient enrichment. In the Santa River Basin, north Florida, agriculture has been identified as a large groundwater user and a primary source of nutrients in groundwater and the springs and rivers it feeds. Grazed pasture, hay and row crops are the major agricultural land uses in the Santa Fe basin, occupying approximately 12%, 4% and 5% of the basin area respectively. The main objectives of this study were to quantify the water and nutrient footprints for grazed pasture, hay and row crops in the Santa Fe Basin using the Soil and Water Assessment Tool (SWAT). SWAT was calibrated and validated using available experimental data for corn-peanut rotations (Zamora et al, 2018) and Bermuda grass (Graetz et al 2006; Overman et al, 1991), then used to evaluate yield, net groundwater recharge, and nitrate leaching over a range of management systems commonly used for each of these land uses. Results showed that for corn-peanut rotations different management systems produced approximately equivalent yields, but large variations groundwater recharge and nitrate leaching. For pastures different management systems produced approximately equivalent yields and groundwater recharge, but large variations in nitrate leaching. Hay management systems showed large variation in yields, but small variation in groundwater recharge and nitrate leaching. Results of this study should be useful for incentivizing growers to adopt management practices with lower water and nutrient footprints, and for estimating the land use and land management changes required to achieve aquifer, spring and river protection in the Santa Fe Basin.



POSTER SESSION, PHIL HEILMAN AND OLIVA PISANI MODERATORS

Putting the Research Catchments on a Map: An Overview of Research Sites that have Shaped Knowledge in Trans-Disciplinary Research

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Long-term catchment studies have profoundly influenced science, policy, management, education, and public perception of natural resources around the world. Despite the legacy, some catchment studies have been decommissioned, while others face uncertain futures. In an environment of change, we need them more than ever. This poster represents a collaborative effort to promote the catchment studies, and to highlight the potential for global watershed research through comparison of data from long-term, place-based research watersheds. To that end, we provide this map showing locations of research catchments from around the globe, including those featured here at the Seventh ICRW, in hopes it will stimulate discussion about the state of catchment sciences and the sites that make the science possible. We encourage the ICRW participants to add other research watersheds to the map that are not yet represented. Over the coming year the project leaders will begin to reach out to all participants regarding opportunities to collaborate in the creation of a virtual network of watershed science.



COASTAL PLAIN WATERSHEDS, STEVE GOLLADAY MODERATOR

Little River Experimental Watershed History

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Long-term, watershed-scale hydrologic and climatic data are invaluable for natural resource and environmental planning and management. Historically, long-term hydrologic records have proved critical for flood forecasting, water conservation and management, agricultural and drought planning, and addressing critical environmental and water quality issues. As directed by Senate Document 59, the U.S. Department of Agriculture Agricultural Research Service established several regional watershed hydrology research centers across the nation in the 1960s. The Little River Experimental Watershed (LREW) in the Coastal Plain physiographic region in south-central Georgia was established as one of these centers in 1967. This region is an important agricultural production area for the U.S. The primary intent of the LREW site was to develop an improved understanding of basic hydrologic and water quality processes on Coastal Plain watersheds and to evaluate the effects of agricultural management practices on the region's natural resources and environment. Long-term (up to 51 years), research-quality streamflow data have been collected for up to nine flow measurement sites. The establishment, operation, and critical findings from the LREW research network were documented from a historical perspective.



COASTAL PLAIN WATERSHEDS, STEVE GOLLADAY MODERATOR

Peak Flow Characterization for the Little River Experimental Watershed

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Peak-streamflow estimates are required for assessment of flood risk, flood-plain management, and cost-effective design of structures. A lack of understanding of peak-streamflow responses of watersheds can lead to extreme economic impact and in some cases loss of life. In watersheds with shallow water tables, peak-streamflow is heavily influenced by available water storage in the subsoil. Available storage is influenced by topography, geology, vegetation, antecedent rainfall, and climatic season. Accurate streamflow estimates must incorporate accurate representations of the available storage. We examined forty-seven (1972-2018) years of streamflow data from the Little River Experimental Watershed (LREW) to determine peak flow characteristics and relationships to antecedent moisture conditions. The LREW is located near Tifton, Georgia, in the Coastal Plain physiographic region of the U.S. Flow within the watershed is heavily influenced by saturation in the surficial aquifer. Peak flow events from this period of record were examined based upon antecedent rainfall, aquifer saturation, and climatic season. Cumulative frequency distributions of observed average daily flows were determined and compared to other regional watersheds. Maximum daily flows were examined to determine the period of the year when they were most likely to occur and how they related to antecedent moisture conditions.



COASTAL PLAIN WATERSHEDS, STEVE GOLLADAY MODERATOR

A methodology for developing a compound flooding model using long term data collection and basic stochastic hydrology

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Coastal regions across the globe have become increasingly susceptible to flooding impacts associated with urbanization, hydromodification, changing weather patterns, and tropical storm systems. However, when flooding occurs in coastal environments, it can rarely be attributed to one single hydrologic driver. In many cases, flooding in this environment can be considered as “Compound Flooding;” that is flooding that results from the combined effects of several different hydrologic behaviors, specifically rainfall-runoff processes and tidal forces. The complex flood behaviors of systems affected by both tidal forces and rainfall-runoff processes are often simulated using hydrology and hydraulic modeling software packages. The process of developing and operating computational models capable of accurately simulating these behaviors is resource intensive, and without proper calibration and verification, these models are capable of grossly misrepresenting system behaviors. As an alternative, this study presents a method for predicting general flood behaviors using simple mathematical models developed using field data collection, long-term monitoring, and basic statistical hydrology analyses.

For this study, water level and rainfall depth recording instrumentation were installed along a tidally influenced tributary of the Ashley River, called Church Creek, located in Charleston, SC. Using data collected from this gage station, along with publicly available data from a series of gages operated by federal science agencies, a series of mathematical analyses were used to isolate the effects of tide and rainfall-runoff on the peak water level of Church Creek. After isolating the separate effects of these two processes, a “Compound Flooding Function” was developed for predicting the peak water level in Church Creek based on the peak tide in the Ashley River and a multi-day rainfall total in the watershed. Using the function, joint-probability analyses were then used to investigate the recurrence of flooding based on a range of tide conditions and rainfall depths.



COASTAL PLAIN WATERSHEDS, STEVE GOLLADAY MODERATOR

Adaptive management for aquatic species recovery in the Apalachicola-Chattahoochee-Flint river basin

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The Apalachicola-Chattahoochee-Flint (ACF) river basin, from headwaters in north Georgia, to the Apalachicola Bay and estuary, is a focal geography in the Southeast with numerous listed and at-risk species; allocation of water for multiple uses in the ACF basin has been contentious and the subject of a legal battle among the States for decades. The Supreme Court ruling on the FL v. GA original action was issued in June 2018, and new hearings were initiated in November 2019; the legal process continues. However, working collaboratively among Department of Interior partners, US Army Corps of Engineers (USACE), and other stakeholders is critical to achieving desired Fish and Wildlife Service recovery and conservation outcomes in the basin. Consequent to a new USACE Water Control Manual, the Service prepared a Biological Opinion for six unionid mussels and Gulf Sturgeon and an adaptive management (AM) process for water management operations has been initiated to minimize take of the listed species. In this paper we describe the set-up phase for adaptive management that has proceeded with a steering team and a large expert stakeholder group. Subject matter experts developed Conceptual Ecological Models that link biotic responses to water management operations including levels of uncertainty in the management system. Through the AM process and monitoring, appropriate water management alternatives will be identified and incorporated into future conservation planning.



COASTAL PLAIN WATERSHEDS, STEVE GOLLADAY MODERATOR

Strengthening resiliency in coastal watersheds by protecting ecosystem services: A web-based GIS map viewer decision support system.

ANNE KUHN (US EPA) AND JANE COPELAND (US EPA) AND MARISA MAZZOTTA (US EPA)

To promote and strengthen the resiliency of coastal watersheds in the face of increasing extreme weather events and development, ecological outcomes as well as socioeconomic issues need to be considered. A coastal watershed resiliency decision support system (DSS) is being developed to strengthen the resiliency and sustainability of coastal communities. The DSS integrates measures of ecosystem goods and services (EGS) and ecological integrity within a geospatial platform, allowing for spatially-explicit analysis of individual ecological units and their associated EGS at multiple scales, combined with socio-demographic data important to resilience and vulnerability assessment. The DSS and the metrics within it are intended to promote a more integrated and structured assessment of coupled ecosystem service and human wellbeing improvements that could result from different desired end states, resilience goals, or stages of restoration and resilience planning. The DSS provides web-based and mobile applications developed for a range of users from technical users to the general public. The framework integrates EGS or benefits and associated metrics (protection against extreme events/floods, water quantity/quality protection, habitat protection and open space conservation), considered important in informing decision-making to strengthen community resiliency and inform community restoration and revitalization goals. Using a Rapid Benefit Indicators (RBI) approach the DSS produces a set of indicators (scoring factors) and an evidence-based platform to help decision makers identify which community assets and vulnerabilities (contaminated sites within communities; vulnerable populations) are being protected or enhanced by existing EGSs in their watershed, and to assess the relative contribution of proposed EGS improvements or restoration options to improve social and ecological resilience. The easily understandable and comparable RBI metrics in the DSS allow users to compare and assess the impact of different restoration options and to (re)assess progress at different stages of restoration or improvement. Translating ecosystem services to resilience, and ecosystem service improvements to strengthen resiliency fills an important capability gap for resilience planning professionals in coastal states and communities.



COASTAL PLAIN WATERSHEDS, STEVE GOLLADAY MODERATOR

Longleaf pine forest restoration increases isolated wetland hydroperiod in the Gulf Coastal Plain of southeastern US

STEVE GOLLADAY , BRIAN CLAYTON , STEVEN BRANTLEY , CHELSEA SMITH , JILL QI , DAVID HICKS

JONES CENTER AT ICHAUWAY

Geographically isolated wetlands (GIWs) are well known as “hotspots” for biodiversity and other ecosystem services, making their value on landscapes disproportionate to the area they occupy. GIWs are dependent on regular cycles of inundation and drying which makes hydrology a primary controlling variable for sustaining functions and associated ecosystem services. Although human activity has degraded GIWs in many regions, relatively little work has focused on upland management as a way of sustaining, or even improving, GIW structure and function. We present a case study of longleaf pine forest restoration, by hardwood removal, on the characteristics of wetland hydroperiod over a 10 year study. Our study wetland, W51, is 0.89 ha with a catchment area of 31.2 ha located on a ~11,400 ha private forest in Baker County Georgia (31.250 N, 84.495 W). Beginning in 2006, continuous water level and climate data were recorded in the wetland and adjacent well transects across the wetland catchment. In autumn 2009, hardwoods were removed or deadened in the catchment resulting in a 37% reduction in basal area. The effects on the hydrologic system were measured through 2016 by examining pre- and post-removal water levels, water yield-ecosystem (WYe), and standardized recession rates (RRstd). The study included periods of above and below normal rainfall. Generally, wetland hydroperiods began in December and ended in May, but varied with rainfall pattern and amount. Hardwood removal increased WYe and decreased RRstd resulting in greater catchment water availability as reflected in water levels. Hardwood removal affected both the ascending and recessing limbs of wetland hydroperiods, substantially increasing the availability of ponded water in the wetland. Our results provide direct measures of changes in wetland hydrologic characteristics associated with forest management and subsequent changes in forest water demand. Better understanding these relations has implications at both the local scale, i.e., managing critical aquatic habitat for wildlife populations, and at a regional scale, i.e., providing support for landscape scale connectivity and water yields.



WATERSHED RESPONSE TO INTENSIFYING PRECIPITATION EXTREMES AND ADAPTATION STRATEGIES: SCIENCE AND MANAGEMENT CHALLENGES, SPECIAL SESSION, ANNA JALOWSKA AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Watershed Management and Hazard Mitigation Planning: Collaborative Benefits in a Changing Climate

MAHTAAB BAGHERZADEH AND PERRY THOMAS

KENTUCKY DIVISION OF WATER

With the increase in frequency and duration of severe weather events becoming the new normal, communities are facing growing pressure to develop plans that protect vulnerable populations and infrastructure. In Kentucky, and elsewhere around the nation, flooding and water quantity are issues of considerable concern. Within the goals of protecting water quality and controlling water quantity are solutions that are dual purpose, thereby providing a unique opportunity to strengthen mitigation and management efforts. Extreme rain events can exacerbate runoff of water quality-degrading pollutants, such as sediments and nutrients (e.g., Kaushal, et al. 2014). Green infrastructure that provides filtration of pollutants from stormwater runoff may also slow flows and improve infiltration reducing erosion and flooding. Authored every five years, federally-mandated Hazard Mitigation Plans (HMPs) aim to prevent, mitigate, and/or respond to high-risk climate events, like flooding. Successful HMPs build partnerships involving governmental agencies, non-governmental organizations, businesses, and the public; identify management strategies and implementation approaches; increase awareness of hazards through outreach and education programs; and synthesize all these efforts to effectively communicate priorities to leverage funding. These plans tend to involve water quantity-focused initiatives, and historically do not engage in watershed-based management approaches that would integrate water quality considerations. Like HMPs, Watershed Plan (WSP) development utilizes a phased approach: data collection, assessment and targeting, and strategy development and implementation establishes a plan that reflects the interdependency of natural resource uses, wide-ranging stakeholder interests, and ecosystem functions and services. Analogous to HMPs, they rely on committed stakeholder partnerships, geographic focus, scientifically sound management practices, and coordinated education and outreach strategies. However, water quantity is often not emphasized in WSPs, as their primary goals are to improve water quality metrics. Given the parallels between watershed and hazard mitigation planning, collaboration can provide a thorough and enhanced planning process that expands available funding sources, better informs selection and implementation strategies, and increases public awareness of the link between water quality and quantity issues. In this presentation, we describe how federal and state agencies partner with universities, regional planners, and municipalities in Kentucky to dovetail watershed and hazard mitigation plans.



WATERSHED RESPONSE TO INTENSIFYING PRECIPITATION EXTREMES AND ADAPTATION STRATEGIES: SCIENCE AND MANAGEMENT CHALLENGES, SPECIAL SESSION, ANNA JALOWSKA AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Spatial downscaling of precipitation data using advanced machine learning at the watershed scale

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Precipitation data serves as a critical forcing input for hydrology models. The highest available spatial resolution is 800 m (PRISM) for the continental United States, whereas higher resolution precipitation (<100 m) inputs are needed for enhanced predictive capabilities. Here we present a machine learning framework to spatially downscale available coarse-resolution precipitation (~12.5 km) from NLDAS-2 models by utilizing point measurements of precipitation available from several NOAA and NRCS weather stations in the Upper Colorado Water Resource Region (UCWRR). First, we aggregate weather station data and subject them to quality control to identify missing records. We impute missing station data by learning co-variability with stations that have complete records. Next, we use weather station data to generate high-resolution (~100m) gridded precipitation estimates that serve as a ground-truth for downscaling. We consider weather station data both near to and far from an area of interest to investigate inherent multi-scale spatial patterns that influence precipitation. Finally, we train an algorithm that undertakes the actual spatial downscaling. At every step, we leverage (i) high-resolution spatial features such as elevation and vegetation, and (ii) seasonal variations, and use Random Forests to identify the relative importance of different features. Preliminary results indicate that the proposed approach enables us to generate and downscale to high-resolution precipitation with reasonable accuracy. We observe that precipitation patterns in UCWRR are influenced by elevation and seasons. However, additional features are needed (e.g., cloud cover, topographic slope) to accurately quantify the spatial and temporal factors affecting precipitation at fine scales. This work was supported by the ExaSheds project funded through the DOE Office of Science.



WATERSHED RESPONSE TO INTENSIFYING PRECIPITATION EXTREMES AND ADAPTATION STRATEGIES: SCIENCE AND MANAGEMENT CHALLENGES, SPECIAL SESSION, ANNA JALOWSKA AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Extreme Events Simulated by Dynamical Downscaling

TL SPERO (US EPA), JH BOWDEN (NC STATE UNIV), AM JALOWSKA (US EPA, ORISE), MS MALLARD (US EPA), AND GM GRAY (NC STATE UNIV, ORISE)

Extreme weather events—such as heat waves, drought, flooding, and tropical cyclones—can have catastrophic impacts on society. These extreme events can adversely affect the economy, infrastructure, ecosystems, agriculture, transportation, air quality, and human health. Governing organizations typically account for extreme events to some degree in their planning processes to minimize the impacts of extreme events.

There is a growing consensus in the literature that extreme events are likely to intensify through this century. Consequently, more emphasis has been placed on quantifying the changes to the frequency and intensity of these events. Several modeling techniques have been used to project potential changes to weather and climate across the next century, and there are several public data sets available that are currently used by federal, state, and local agencies to aid in the decision-making process. However, not all data sets can characterize the extremes associated with these events.

In this study, the Weather Research and Forecasting (WRF) model is configured as a regional climate model, and simulations are conducted on historical (verifiable) data sets to emulate the dynamical downscaling procedure that would be applied to refine global climate model projections. Here, we use 36-km and 12-km modeling domains, and we compare categories of extreme weather events that would influence governmental planning organizations. We evaluate these WRF simulations against observations to demonstrate the trade-offs between the computational expense of 12-km modeling domain versus developing a broader ensemble at 36-km on extreme event realization.



WATERSHED RESPONSE TO INTENSIFYING PRECIPITATION EXTREMES AND ADAPTATION STRATEGIES: SCIENCE AND MANAGEMENT CHALLENGES, SPECIAL SESSION, ANNA JALOWSKA AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Changes in the Future Extreme Precipitation Using Dynamically Downscaled Simulations From 2025 to 2100 for three forested and three urban stations in Southeastern U.S. Watersheds

ANNA M. JALOWSKA, DEVENDRA M. AMATYA, TANYA L. SPERO, GENEVA M. E. GRAY,
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The increasing trend in the frequency and intensity of extreme precipitation events and associated flooding has been well documented within the Southeastern U.S. using historical climate records. Studies have also described dramatic system changes associated with the observed extreme precipitation, such as ecosystem responses to extreme flood events with a plausible regime shifts in the intensity and quantity of runoff within some watersheds. Furthermore, climate models indicate that precipitation intensification will continue to increase throughout the twenty-first century. Precipitation Intensity-Duration-Frequency (PIDF) curves are a common tool used to account for extreme precipitation events in urban, forest and environmental planning. The PIDF curves estimate a frequency of occurrence (RP) of extreme rain events based on frequency analyses of the available data. Extreme precipitation events in recent years, proved that structures designed for the traditional (historic) PIDFs, fail because they cannot facilitate an excess rainfall. To address arising challenges related to changing precipitation characteristics, regulatory and managing bodies are seeking information to prepare for future weather patterns, which can be provided by the modelling community.

This study presents analyses of the trends in extreme precipitation probabilities for 76 years in the future (2025-2100) in three forested and three urban sites in the Southeastern U.S. The Weather Research and Forecasting (WRF) model was used to dynamically downscale two global climate models to 36-km for the moderate and highest greenhouse gas emission scenario (RCP4.5 and 8.5). The dynamically downscaled global climate models used in the study (the Community Earth System Model and the Geophysical Fluid Dynamics Laboratory coupled climate model) indicate up to a 30% increase in the annual maximum precipitation by 2100, and an increased variability in the intensity and frequency of the extreme precipitation. The one-hundred-year rain quantity increased up to 108% in the 1-h duration and up to 57% in 24-h duration. These results have implications in design of storm-water management infrastructure, flood discharge estimates based on the future PIDF curves, and in transportation design and risk analysis. The study acknowledges that model uncertainties associated with model resolution or changes in spatial variability of extreme precipitation require further research.



WATERSHED RESPONSE TO INTENSIFYING PRECIPITATION EXTREMES AND ADAPTATION STRATEGIES: SCIENCE AND MANAGEMENT CHALLENGES, SPECIAL SESSION, ANNA JALOWSKA AND DEVENDRA AMATYA CHAIRS AND MODERATORS

USA Continental Scale Intensification of Sub-daily Precipitation Intensities from ARS Experimental Watersheds

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Evidence is building that precipitation is intensifying more rapidly over short time scales (up to a few hours) that may result in increasing flood peaks and soil erosion. However, the paucity of sub-daily precipitation observations has limited the number of studies investigating temporal trends to analysis using a few isolated rain gauges or to global and regional climate models. The United States Department of Agriculture (USDA)-Agriculture Research Service (ARS) Long-Term Agroecosystem Research (LTAR) network has been systematically and professionally measuring and archiving sub-daily precipitation since the mid-twentieth century and its database represents a unique opportunity to evaluate temporal changes across different hydroclimatic environments. The goals of this study are: 1) to identify temporal trends in sub-daily precipitation intensities across different climatic regions for the period 1970-2013; 2) to evaluate if reported increases in rainfall intensities at the daily and hourly time scales observed at sub-hourly durations and; 3) to quantify the impacts of more intense precipitation on agricultural lands as measured by changes in soil erosivity and erosion. Our results show positive increases in precipitation intensities in the Northeast, Midwest, and Southwest regions at sub-daily scales ranging from 10 minutes to daily. Changes in precipitation intensities are more evident for the most intense events, events happening on average once a year, in the most recent years (1993-2013) compared to the earlier (1970-1992) period.



WATERSHED RESPONSE TO INTENSIFYING PRECIPITATION EXTREMES AND ADAPTATION STRATEGIES: SCIENCE AND MANAGEMENT CHALLENGES, SPECIAL SESSION, ANNA JALOWSKA AND DEVENDRA AMATYA CHAIRS AND MODERATORS

A Comparison of Dynamical and Statistical Downscaled Climate Change Projections to Inform Future Precipitation Intensity-Duration-Frequency Curves

JARED H. BOWDEN (US EPA) ANNA JALOWSKA (US EPA), GENEVA GRAY (NCSU), TANYA SPERO (US EPA) ADAM TERANDO (USGS SECASC), RYAN EMANUEL (NCSU), JAIME COLLAZO (USGS, NCSU)

A warmer climate creates an atmosphere that is more favorable for intense rainfall. Despite this simple thermodynamic relationship between atmospheric moisture capacity and temperature, a comprehensive understanding of precipitation extremes as the climate warms is a quickly evolving science as a result of recent historical rainfall events and improved computational resources. Simultaneously, many stakeholders (e.g., engineers, natural and cultural resource managers) are considering how they should adapt to climate change. This requires stakeholders and climate scientists to work together to use the best available science for the spatiotemporal scale of the application.

This study compares dynamically and statistically downscaled projections of global climate models to inform future IDF curves. Dynamically downscaled data, which are high-resolution model experiments of the future climate, have the ability to represent non-linear physical processes like hourly precipitation at spatiotemporal scales applicable to stormwater management and design. They are also useful tools in understanding the atmospheric conditions associated with extreme events. Unfortunately, these high-resolution climate model simulations are both costly and time consuming which limits our ability to diagnose uncertainty. There are additional constraints with using simulated data from many dynamical downscaling, such as inheriting biases from the global climate model. On the other hand, statistically downscaled projections are computationally efficient, can remove the global climate model bias, and available for many future realizations to investigate the issue of uncertainty. Statistically downscaled methods still have drawbacks. Climate stationarity is assumed, and data are limited to fewer parameters at daily temporal intervals which restricts the applicability for extreme sub-daily precipitation analysis.

Here we will compare two future downscaled realizations of the Community Earth System Model (CESM) using the dynamical and statistical downscaled methods for three forested watersheds from 2025-2100. The highest greenhouse gas emission scenario (RCP8.5) is examined to investigate a plausible, worst-case scenario. We will illustrate similarities and differences between these two methods for deriving future IDF curves and investigate the advantages of having sub-daily precipitation from dynamically downscaled simulations.



WATERSHED RESPONSE TO INTENSIFYING PRECIPITATION EXTREMES AND ADAPTATION STRATEGIES: SCIENCE AND MANAGEMENT CHALLENGES, SPECIAL SESSION, ANNA JALOWSKA AND DEVENDRA AMATYA CHAIRS AND MODERATORS

Effects of species conversion on hydrology and nutrient cycling in the central Appalachians

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In 1973, a 55-acre watershed at the Fernow Experimental Forest in West Virginia was planted with 2-0 Norway spruce (*Picea abies*) seedlings, in order to evaluate the effects of conifers on streamflow and water quality. Considerable effort was needed to ensure survival of the Norway spruce "island" in the sea of hardwoods. After forty-five years of tree growth and stand development, we report the impacts of the forest type conversion on water yield, water quality, stand and biomass development, soils, and nutrient cycling within the watershed. Conversion from hardwoods to Norway spruce resulted in significant decreases in annual water yield, relative to the reference watershed. Stream water quality was also significantly altered, with virtually no nitrate being detected in the stream water and a significantly lower stream pH, in contrast to the other Fernow watersheds. The stream channel has also been altered as a result of changes in flow regime. The forest floor in the spruce watershed exhibits an accumulated mass and increased carbon and nitrogen storage. However, mineral soil C and N storage is significantly lower relative to the hardwood reference. We discuss the implications and future plans for this unusual research project.



WATERSHED MODELING (A), DAVID GOODRICH MODERATOR

Two-dimensional continuous simulation of watershed processes using a time-area hydrology model, HYSTAR

YOUNG GU HER, UNIVERSITY OF FLORIDA

A time-area method was reformulated as a way to predict runoff hydrographs by explicitly describing spatiotemporally varied watershed processes. In a new hydrologic model, HYdrology Simulation using Time-ARea method (HYSTAR), the method was integrated with a simple routing scheme and modified curve number methods to simulate watershed dynamics. We evaluated the applicability of the time-area model in predicting the runoff processes of four study watersheds that have different landscapes, including a rolling upland (Virginia), a shallow forest wetland (Florida), and mountain forests (Brazil and South Korea). We also assessed the efficiency of parallelizing the time-area routing methods with multiple processors on a common personal computer. For demonstrating the utility of the model and further evaluating the soundness of the modeling strategy, hydrologically sensitive areas identified using model outputs were compared with the maps of topographic wetness indices. Results showed the potential of the method as a tool for watershed management planning. Finally, we discussed the limitations and future improvement directions of the model.



WATERSHED MODELING (A), DAVID GOODRICH MODERATOR

Coupled terrestrial and aquatic carbon modeling towards improved watershed sustainability assessment

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UNIVERSITY OF MARYLAND

The coupled carbon cycle across terrestrial and aquatic environments forms the basis of numerous lives on earth, holds the promise to explain gaps in the global carbon cycle, and provides essential services relevant to human and ecosystem health. The lack of watershed scale carbon models represents a critical impediment to understanding effects that human and natural factors have on our land and water resources. Here, we present an effort that puts together pieces of the terrestrial and aquatic carbon cycle at the watershed scale, by integrating multiple models, including SWAT, DayCENT, QUAL2K, and CE-QUAL-W2. We evaluate the model performance with respect to components of both terrestrial and aquatic carbon cycling processes and demonstrate its use to understand carbon budgets and ecosystem services at the watershed scale. In addition, we will discuss important parameters and processes regulating watershed carbon cycling and associated uncertainties.



WATERSHED MODELING (A), DAVID GOODRICH MODERATOR

Effect of wetland and depression water storage on continental-scale hydrologic dynamics

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Process-based model simulations of droughts, floods, and water quality in response to watershed management typically focus on integrating large, managed water bodies (such as lakes and reservoirs) into the modeling efforts. Surface water storage in small yet abundant landscape depressions – including wetlands and other small waterbodies – is largely disregarded in conventional hydrologic modeling practices. No quantitative evidence exists of how their exclusion may lead to potentially inaccurate model projections and understanding of hydrologic dynamics in response to variations in climate and land cover changes across the world’s major river basins. To fill this knowledge gap, we developed the first-ever surface depression-integrated continental-scale modeling approach, focusing on the ~450,000 km² Upper Mississippi River Basin (UMRB) in the United States. We applied a novel topography-based algorithm to estimate areas and volumes of ~455,000 surface depressions across the UMRB and then aggregated their effects per subbasin. Compared to a “no depression” conventional model, our depression-integrated model (i) improved streamflow simulation accuracy with increasing upstream abundance of depression storage, (ii) significantly altered the spatial patterns and magnitudes of water yields across 315,000 km² (70%) of the basin area, and (iii) provided realistic spatial distributions of rootzone wetness conditions corresponding to satellite-based data. These findings provide us with new insights on the effects of wetland and depression storage at large river basin scales and stimulates a reassessment of current conventional practices for continental-scale hydrologic modeling and management.



WATERSHED MODELING (A), DAVID GOODRICH MODERATOR

Modeling Interactions of Riverine Flow and Riparian Vegetation for Quantifying Recruitment and Survival of Native Vegetation in California

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Life cycles of riparian vegetation are substantially impacted by river flow regime, groundwater and morphodynamics. A riparian vegetation simulation module was developed and integrated into HEC-RAS to predict seed germination, seedling establishment, plant growth and mortality in response to fluvial processes. The HEC-RAS vegetation model was applied to both Sacramento River and Santa Ana River reaches to predict temporal and spatial changes of riparian vegetation and the interactions between flow and riparian vegetation dynamics. River hydraulics, groundwater level and five vegetation types of the study reach were simulated. Model results demonstrate that the HEC-RAS vegetation model is capable of predicting the land coverage changes of cottonwood, mulefat, riparian shrub, mixed forest, and invasive species over a long period. The model was able to capture sites for cottonwood establishment observed on certain point bars. The modeled variations of cottonwood coverage in response to dynamic flow regime facilitated managing environmental flow for riparian vegetation restoration.



WATERSHED MODELING (A), DAVID GOODRICH MODERATOR

Wetness Index based on Landscape position and Topography (WILT): Modifying the TWI to incorporate landscape position relative to water bodies

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USDA-ARS

Water and land resource management planning benefits greatly from accurate prediction and understanding of the spatial distribution of wetness. The topographic wetness index (TWI) was conceived to predict relative surface wetness, and thus hydrologic responsiveness, across a watershed based on the assumption that shallow slope-parallel flow is a major driver of the movement and distribution of soil water. The index has been extensively used in modeling of landscape characteristics responsive to wetness, and some studies have shown the TWI performs well in landscapes where interflow is a dominant process. However, groundwater flow dominates the hydrology of low-slope landscapes with high subsurface conductivities, and the TWI assumptions are not likely to perform well in such environments. For groundwater dominated systems, we propose a hybrid wetness index (Wetness Index based on Landscape position and Topography, WILT) that inversely weights the upslope contributing area by the distance to the nearest surface water feature and the depth to groundwater. When explicit depth to groundwater data are not available, height above and separation from surface water features can act as surrogates for proximity to groundwater. The resulting WILT map provides a more realistic spatial distribution of relative wetness across a low-slope Coastal Plain landscape as demonstrated by improved prediction of hydric soils, depth to groundwater, nitrogen and carbon concentrations in the A horizon of the soil profile, and sensitivity to DEM scale.



ADVANCING WATERSHED SCIENCE USING MACHINE LEARNING,
DIVERSE DATA, AND MECHANISTIC MODELING, SPECIAL SESSION,
DIPANKAR DWIVEDI CHAIR AND MODERATOR

**AI to Advance Watershed Co-Design: Toward Seamless Interactions between
Diverse, Multi-Scale Watershed Data, Models and Hardware**

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DWIVEDI, NICOLA FALCO, JULIANE MUELLER, CARL STEEFEL, SEBASTIAN UHLEMANN,
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While watersheds are recognized as the Earth's key functional unit for assessing and managing water resources, developing a predictive understanding of how watersheds respond to perturbations is challenging due to the complex nature of watersheds. This is particularly true in mountainous watersheds, where extreme lateral gradients in hydrogeology, biogeochemistry and vegetation often exist, and where perturbations (such as early snowmelt) can lead to changes in process interactions that potentially affect downgradient water, nutrient, carbon and contaminant exports. The Watershed Function Scientific Focus Area (SFA) project, which is being carried out in the mountainous East River, CO headwater catchment of the Upper Colorado River Basin, aims to develop a predictive understanding of watershed hydrobiogeochemical response to perturbations. The SFA is developing and testing several new constructs to accurately yet tractably quantify and predict multi-scale hydrobiogeochemical dynamics – from summit to receiving waters, across bedrock through canopy compartments and across terrestrial-aquatic interfaces.

One construct that the Watershed Function project is developing is the use of Artificial Intelligence (AI) to advance Watershed Co-Design, which focuses on advancing a deep and seamless marriage between diverse watershed data; mechanistic, multi-scale watershed models; and sensing networks. We illustrate recent advances in the use of AI for advancing aspects of the Co-Design vision, with examples largely associated with the East River testbed. One example includes the use of AI approaches to estimate the distribution of plant communities and microtopographic controls over plant ecosystem niches. The project is jointly assessing an unparalleled collection of vegetation and other 2D stacked watershed data layers - which together are providing 3D information about the spatial variability of bedrock porosity, soil thickness, digital elevation, vegetation characteristics, and snow thickness. For the first time, data-driven methods are being used to delineate watershed zones from these layers that have unique distributions of above-and-below ground properties relative to their neighbors. With the concept that these watershed functional zones will influence the quality and quantity of water exported from that particular parcel, intensive above-and-below ground monitoring systems have been set up in select zones to autonomously 'watch' fluids move between watershed compartments over the 4th dimension of time, revealing key spatial and temporal trends or transitions using AI. Reduced-order models are being used to accurately predict near term groundwater levels based on commonly available weather predictions. In practice, we believe that Co-Design enabled by AI, paired with data, models, and sensing networks, hold significant potential to accelerate real-time decisions and watershed management. More information about the SFA is provided at watershed.lbl.gov



ADVANCING WATERSHED SCIENCE USING MACHINE LEARNING,
DIVERSE DATA, AND MECHANISTIC MODELING, SPECIAL SESSION,
DIPANKAR DWIVEDI CHAIR AND MODERATOR

Quantifying the Influence of Matrix Diffusion in Fractured Bedrock on Solute Retention and Transport at the Hillslope Scale

HARIHAR RAJARAM
JOHNS HOPKINS UNIVERSITY

Transit time distributions provide an integrated measure of the internal transport and retention processes that control the hydrologic and biogeochemical functioning of watersheds. There is a long history of research on watershed transit time distributions, evolving from lumped parameter models introduced in the early 1980s, to more recent works that emphasize time-variable transit time distributions and increasingly high-fidelity subsurface flow and transport simulations. In many low-order watersheds, significant flow occurs through fractured bedrock and transport and retention of solutes is influenced by matrix diffusion. Interestingly, although the importance of matrix diffusion was first recognized in attempts to reconcile anomalous water ages, the contribution of matrix diffusion to long-tailed transit time distributions in watersheds is seldom explicitly highlighted. There are significant computational challenges in incorporating matrix diffusion into watershed-scale flow and transport models. We present approaches to representing the influence of matrix diffusion within the framework of flowpaths generated by integrated watershed-scale hydrologic models. We illustrate the long-tailed transit time distributions resulting from matrix diffusion in models of hillslope groundwater flow. Matrix diffusion greatly extends the time horizon over which legacy nutrients and contaminants sequestered in the rock matrix elute into baseflow. In this context, we present approaches for quantifying the influence of matrix diffusion on lag times for recovery of receiving streams. Finally, we consider the influence of matrix diffusion in the frequency domain, and discuss its potential contributions to fractal stream chemistry, i.e. observations of fractal power spectra of the form $1/\text{frequency}^\alpha$ (with α close to 1) in stream concentration fluctuations.



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DIPANKAR DWIVEDI CHAIR AND MODERATOR

**Watersheds as natural spatial units for aggregating geospatial data for a
global river bank erosion model**

JON SCHWENK, JOEL ROWLAND, KIMBERLY KAUFELD
(ALL LOS ALAMOS NATIONAL LABORATORY)

As water, sediment, and nutrients move through watersheds, they accumulate towards outlets. Predicting these fluxes thus depends not only on local conditions, but also the upstream contributions of the basin. At a global scale, quantifying these contributions deterministically remains intractable, so empirical models relating upstream watershed characteristics to quantities measured at-a-point are often used. In order to quantify these upstream contributions at global scales, we developed the River and Basin Profiler (RaBPro), which leverages the HydroBasins global watershed delineations of basins of approximately 230 km². RaBPro rapidly delineates upstream areas for any given point globally. The resulting georeferenced basin polygons are then used for aggregating basin statistics for geospatial data, such as DEMs, climate outputs, vegetation indices, etc.

We will present an example of how this data-driven framework is coupled with statistical and machine learning techniques to identify drivers of riverbank erosion across the globe. The watershed-based drivers identified as important are used to develop a globally applicable model for riverbank erosion that can help estimate riverine carbon fluxes and provide clues toward which watershed characteristics and processes are most important across different regions.



ADVANCING WATERSHED SCIENCE USING MACHINE LEARNING, DIVERSE DATA, AND MECHANISTIC MODELING, SPECIAL SESSION, DIPANKAR DWIVEDI CHAIR AND MODERATOR

Simulating Hydrology's Role in Fire Behavior

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ALEXANDRA JONKO, LANL

ELCHIN JAFAROV, LANL

ROD LINN, LANL

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Half of the world's ecoregions are fire-dependent – meaning that fire disturbances will in some way affect ecosystem services including water resources and critical habitat for threatened and endangered species. The longleaf pine ecosystem of the Southeastern United States is one example of many fire-dependent ecosystems where successive prescribed fire is currently used to manage ecosystem structure and function. However, climate change will likely affect both fire behavior and ecosystem response to fire disturbances by for example, attributing to conditions where temperature drought reduces fuel moisture loading or limits ecosystem response following fire. These new conditions will therefore change fire behavior and result in new ecosystem responses. Moreover, empirical fire behavior modeling techniques that are rooted in observations of current system dynamics will be biased toward past conditions and may not capture system behavior in novel climate conditions. Here mechanistic modeling based on the underlying physics of fire behavior and ecohydrologic response offers a possible path to understand fire-dependent ecosystem response in a climate perturbed condition. We demonstrate a proof of concept disturbance and response model (DRM) that incorporates a physics-based approach to simulating fire behavior, hydrologic conditions, and ecosystem response. The DRM is built from a fully coupled surface and subsurface hydrologic model (ParFlow) with an additional fuel moisture - energy balance component in order to resolve fuel moisture loading in varied climate conditions. Together these components provide fuel moisture conditions to a fire behavior model (FIRETEC) that resolves fire-atmosphere interactions. The fire disturbance simulated by FIRETEC then produces a fire disturbance footprint onto a longleaf pine ecosystem growth model (LLM) that simulates the growth of fire-dependent species. In turn, the LLM is used to both evaluate habitat suitability of species of concern as well as establish fuel loads for the succeeding fire disturbances. This cycled fire disturbance and response model then provides a metric to assess ecosystem condition as it evolves from successive fire disturbance. We can further demonstrate how changing fire behavior in response to unique fuel moisture profiles create different disturbance regimes, and further how those differing disturbance regimes produce altered ecosystem structure.



ADVANCING WATERSHED SCIENCE USING MACHINE LEARNING,
DIVERSE DATA, AND MECHANISTIC MODELING, SPECIAL SESSION,
DIPANKAR DWIVEDI CHAIR AND MODERATOR

Wavelet and entropy approaches for improved characterization of geochemical hot moments

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Biogeochemical hot moments are known to account for a high percentage of nutrient cycling within terrestrial and aquatic ecosystems. Despite such importance, the ability to effectively identify hot moments and their associated controls remains a significant challenge. Using a combination of hydrological, solid and aqueous geochemical, geological, microbial and meteorological datasets, as well as statistical techniques, we seek to identify relevant hot moments and quantify which properties most explain the temporal variability in solute concentrations. We present two novel classification schemes – Shannon’s entropy and wavelet-entropy to classify and systematically interrogate complex, multivariate datasets without making assumptions regarding the nature of temporal structure and dependencies implicit in these datasets. We develop and test these approaches at two sites: (1) a floodplain aquifer along the Colorado River, and (2) a high-latitude Arctic location near Barrow, Alaska. Wavelet analysis results demonstrate that seasonal perturbations (~4 months) constitute hot moments that drive biogeochemical cycling in the Rifle floodplain, with such activity confined to hot spots corresponding to the anthropogenically-contaminated zone. In contrast, a different dominant frequency (~3 months) dominates chemically-reduced zones associated with elevated concentrations of organic matter, chemolithoautotrophic activity and reduced mineral phases. These results combined with entropy statistics were used to isolate the governing transport and/or biogeochemical processes driving these hot moments. At Barrow, entropy analysis showed that soil moisture, soil temperature and growing season productivity most explained the variability in carbon fluxes over three successive years. The correspondence between biogeochemical zonation, seasonal variability, and other site-specific interactions from this study provide the key controls governing biogeochemical cycling at these sites. Importantly, these wavelet and entropy approaches are providing a simple yet tractable approach to identify temporal patterns and extract the key climatic, soil, vegetation and geomorphic features controlling carbon cycling that can then be readily incorporated into models.



ADVANCING WATERSHED SCIENCE USING MACHINE LEARNING,
DIVERSE DATA, AND MECHANISTIC MODELING, SPECIAL SESSION,
DIPANKAR DWIVEDI CHAIR AND MODERATOR

Multi-criteria, time-dependent sensitivity analysis considering hydrologic signatures, model performance metrics, and forcing uncertainty

**MENBERU B. MELES, DAVE C. GOODRICH, CARL UNKRICH, SHEA BURNS, AND
HOSHIN GUPTA**
USDA-ARS

The dynamics of parameter importance in earth systems modeling framework has been the focus of research in recent years. To investigate the changing aspects of parameter importance, we implemented the variogram analysis of response surfaces to characterize predictive uncertainty of the KINEROS₂ physically-based distributed hydrologic model in the USDA-ARS Walnut Gulch Experimental Watershed (WGEW) and Long-Term Agro-ecosystem Research (LTAR) site. Parameter importance was assessed using the absolute and relative sensitivity indices for several time-variant (throughout the simulation period) and time-aggregate (average of a simulation) model response surfaces. Parameter importance analysis of several model signature responses that represent different modeling needs and objectives such as runoff volume, sediment yield, peak runoff, runoff duration, time to peak, lag time, and recession duration. The results showed the importance of the parameters varied considerably depending on the type of the model responses of interest, size of watersheds, the depth and intensity of rainfall, the rainfall distribution, and the location of the storm from the watershed outlet. Identification of the most sensitive parameters and the factors that influence them was useful for a comprehensive understanding of process-based models, the uncertainties in model predictions, and to reduce the workload and time required during model parameterization and calibration.



ADVANCING WATERSHED SCIENCE USING MACHINE LEARNING,
DIVERSE DATA, AND MECHANISTIC MODELING, SPECIAL SESSION,
DIPANKAR DWIVEDI CHAIR AND MODERATOR

Machine Learning Tools for Predicting Freshwater Fish Populations

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OAKRIDGE INSTITUTE FOR SCIENCE AND EDUCATION AND US EPA

To address the lack of publicly available fish community data for the majority of US, lotic freshwater habitats, we developed scientific software modules and databases for predicting fish populations by NHDPlus (National Hydrography Dataset) segment. We applied machine learning techniques such as generalized boosting and local kernel smoothing regression to survey data from the EPA, USGS, and state agencies. We discuss and assess the interpretability of the models alongside predictive performance. We illustrate applications of the model for supporting management decisions that impact covariates used for fish community prediction, such as the index of watershed integrity (IWI, Thornbrugh et al. 2018). The tools are made available through the browser-based software platform named PiSCES.



ADVANCING WATERSHED SCIENCE USING MACHINE LEARNING,
DIVERSE DATA, AND MECHANISTIC MODELING, SPECIAL SESSION,
DIPANKAR DWIVEDI CHAIR AND MODERATOR

What Role Does Hydrological Science Play in the Age of Machine Learning?

GREY NEARING - UNIVERSITY OF ALABAMA

Recent experiments applying deep learning to rainfall-runoff simulation indicate that there is significantly more information in large-scale hydrological data sets than hydrologists have been able to translate into theory or models. We argue that these results challenge certain 'sacred cows' in the surface hydrology community, and may be a bellwether for the discipline as a whole. While there is growing interest in machine learning in the hydrological sciences community, in many ways our community still holds deeply subjective and non-evidence-based preferences for process understanding that has historically not translated into accurate theory, models, or predictions. The objective of this opinion piece is to suggest that, due to this failure in the surface hydrology community to develop scale-relevant theories, one possible future is a discipline based primarily in machine learning and other AI methods, with a more limited role for what we currently recognize as hydrological science. We do not want this to happen and suggest a 'grand challenge' for the community to work toward demonstrating where and when hydrological theory provides information in a world dominated by big data.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

An Investigation of Phosphorus Concentration Trends in Waters of the U.S.

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US EPA

Conflicting evidence has emerged concerning the direction and magnitude of phosphorus changes in freshwaters of the northern hemisphere. While some studies have found consistent, unexplained phosphorus increases especially in low-nutrient systems, other studies have found no such widespread phosphorus changes. By contrast, several studies have documented widespread phosphorus declines in already-oligotrophic lakes of northern countries. To further investigate temporal trends in total phosphorus concentrations in U.S. waters, we employed large-scale compilations of available monitoring data (LAGOS_NE and the Water Quality Portal). We evaluated total phosphorus data using linear and non-parametric regressions based on both individual samples and summer-mean concentrations, over various time spans (e.g., 1990-2013, 2000-2013). Distributions of slopes of TP vs. time were in general symmetrical around median values near zero, indicating a lack of predominant change in either direction (i.e., either increasing or decreasing). Investigations of time series in some individual systems suggest that apparent temporal trends derived from limited sampling are not supported by longer sequences of available data.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

Sub-Watershed Trace Element Regimes in Surface Waters of an Appalachian Mixed-Land-Use Watershed

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WEST VIRGINIA UNIVERSITY

Geochemical impacts of land-use practices remain an area of greatly needed investigation. A nested-scale experimental watershed study was conducted in an urbanizing, mixed-land-use, Appalachian watershed to advance understanding. Twenty-two study sites, characterized by contrasting land use/land cover and drainage area, were instrumented to continuously monitor stream stage. Weekly grab samples were collected from each site during the 2018 annual year, and analyzed for trace element composition (Al, Cd, Co, Cu, Fe, Mn, Ni, Pb, Zn, and As) via spectrometric methods. Additional physico-chemical parameters, including pH, were measured at the time of sampling. Data were analyzed using a suite of statistical methods, including correlation analysis and Principle Component Analysis (PCA). Results showed a trend of increasing trace element concentrations associated with legacy industrial land use practices (i.e. mining) in the mid watershed, and subsequently decreasing concentrations in the downstream direction. PCA results highlight spatial differences between elemental composition and physico-chemical characteristics of streamwater samples. Results from correlation analyses indicated varying significant ($p < 0.05$) relationships between chemical parameters and hydroclimate metrics, suggesting the influence of contrasting flow paths and constituent sources. Given the geological, topographical, and climatological similarities between the sites, and their proximity to each other, it is concluded that land use characteristics and associated hydrologic regime contrasts were the primary factors contributing to the observed results. The applied methodology can be used to advance understanding of trace element regimes in mixed-use watersheds, and to more effectively target sub-watershed-scale remediation/restoration efforts, thereby improving the ultimate efficacy of management practices.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

Relationship of water quality in a tidal freshwater stream to inputs from terrestrial watersheds

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Tidal freshwater streams occur at the nexus between the terrestrial landscape and the marine wetland and deep water ecosystems. We use Huger Creek, a 4th order tidal freshwater stream that is a portion of the headwater of the West Branch of the Cooper River, a tributary to the Charleston Estuary, as the basis for comparing water quality from 1st, 2nd and 3rd order streams that drain the forested landscape in the lower coastal plain. We used data from 2007 to 2017 from gauging stations on the Santee Experimental Forest, where the water quality parameters are part of the long-term environmental monitoring program. Concentrations of total nitrogen and dissolved organic carbon and cation in

Huger Ck and the terrestrial watersheds are positively correlated, whereas the correspondence with anions were weakly associated. The pH of Huger Creek is highly buffered compared to the terrestrial watersheds, which is attribute to higher stream calcium levels. Difference is water quality during tidal stages and extreme events will also be discussed.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

Economic Analysis of Modern Irrigation Scheduling Strategies on Cotton Production under Different Tillage Systems in South Georgia

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Row crop producers use irrigation as a vital risk managing tool to achieve higher and more consistent yield. Even though cotton is a drought-tolerant crop, producers still use irrigation to increase yield and manage production risks. The depletion of the ground water has escalated at an alarming rate due to the heavy usage of irrigation for meeting the present demand in crop production in South Georgia. Therefore, to ensure water quality and avoiding water scarcity in the near future, several modern irrigation scheduling methods are being developed and practiced. The goal of this research is to compare economic efficiency of five different irrigation scheduling methods under conservation and conventional tillage systems to identify the most profitable method.

From 2013 to 2017, a cotton field experiment was conducted in Camilla, Georgia, to compare five modern irrigation scheduling methods with dryland production (control). University of Georgia (UGA) Checkbook Method, the Smart Irrigation Cotton App, the University of Georgia Smart Sensor Array (UGA SSA), the Irrigator Pro for cotton, and the Cotton Water Stress Index (CWSI) are the five modern irrigation scheduling methods investigated under conservation and conventional tillage practices. As for the dryland control, they were only used in the conservation tillage. Four cotton varieties were used each year to assess their performance in different irrigation scheduling methods. Cotton lint yield and lint quality was measured. The market price and loan price for cotton was calculated based on fiber quality for each year. Irrigation cost will be calculated using the irrigation budgets developed by UGA Extension. Net return will be calculated by subtracting irrigation cost, harvesting, and ginning costs from the gross revenue of cotton production.

Preliminary results show that water use efficiencies were negative during wet years in 2013, and 2015 - 2017. The lint yields, seed yields and gross revenue were higher for dryland production in those wet years. Cotton App had the highest average value for gross revenue among all the irrigation scheduling methods, especially in dry years like 2014.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

How does high input maize production affect water quality?

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There is a great concern about the impact of agriculture on the environment. Most farmers' goal is to achieve the highest possible yield. In Georgia, a relatively small group of farmers have been able to achieve maize yields of around 31000 kg/ha (500 bu/ac). In addition to better varieties and the use of irrigation, higher yields are often pursued by adding more agrochemicals and more specifically, higher rates of fertilizers. The use of high rates of fertilizers can result in unintended environmental consequences as unused fertilizers can move from the soil to groundwater with leaching and to streams and rivers with surface runoff. The impact on the environment has been documented by researchers for at least the past 50 years. As farmers pursue higher yields, the threat to the environment may increase. Previous studies have tried to find ways for better management practices which could possibly minimize the environmental problems. This three-year study focused on identifying the environmental effects, regarding water quality, of pursuing high maize yields in Georgia, USA. Groundwater and surface runoff samples were being collected throughout the years and analyzed in the lab for nitrogen, phosphorus, and other parameters. The data will be used to calibrate and validate Hydrus – 1D in order to understand how the system responds to different management practices used to achieve high maize yields. Moreover, the model will be used for simulating a wide range of management scenarios in order to identify the practices which result in the highest yields with the lowest adverse environmental effects.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

In-field hydrologic properties affected by sugarcane row spacing in south Louisiana

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Sugarcane (*Saccharum spp.*), is a perennial crop cultivated on over 180,000 ha in southern Louisiana. This humid, subtropical region is characterized by high annual rainfall (1650 mm), a shallow water table (<1.5 m), and poor drainage. Sugarcane is widely cultivated in this region due to its adaptability to these challenging conditions. While most growers utilize the traditional 1.83-m row spacing, some growers have recently adopted a wider, 2.43-m row spacing. The wide row spacing increases planted area by 6% at the expense of furrow drains. However, we currently do not know how the practice affects the hydrology of the wide row system, and the potential effect on crop growth. Therefore, the objective of the research was to use meteorological and eddy flux data to compare hydrologic properties of each system between April and September, the most active growth period for sugarcane in Louisiana. Bi-phasic cane growth was linear from April thru May (0.50 cm d^{-1}) and June thru August (1.94 cm d^{-1}). Stalk counts were lower in the narrow rows ($108,000 \text{ ha}^{-1}$), when compared to the wide rows ($128,000 \text{ ha}^{-1}$). Rainfall totals for the same period were 885 and 977 mm, respectively. The mean volumetric soil moisture to 15 cm was lower for narrow rows (61.5 mm ha^{-1}), when compared to wide rows (72.7 mm ha^{-1}), but never dropped below 44.7 and 47.6 mm ha^{-1} , respectively. Evapotranspiration (ET), estimated using the FAO Penman-Monteith equation and Kc (0.4, 60 d; 1.25, 92 d), was 7% lower for narrow rows (737 mm, 4.9 mm d^{-1}), when compared to wide rows (788 mm, 5.2 mm d^{-1}). Measured ET using latent heat was 13% lower for narrow rows (436 mm, 2.87 mm d^{-1}), compared to the wide row configuration (500 mm, 3.33 mm d^{-1}), but flux-based ET was 40% (narrow row) and 37% lower (wide row), respectively, than ET estimated using the Penman-Monteith equation. These preliminary data indicate neither narrow nor wide row sugarcane appeared to be water stressed due to the relatively high amounts of rainfall observed and the reduced number of drains, as both production systems retained adequate soil moisture levels.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

Feasibility and implications of two approaches for estimating recharge from hydrologic events at the Panola Mountain Research Watershed, Georgia

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Recharge is an important process that sustains stream baseflow and impacts the availability of water resources. Recharge is often quantified by modeling or estimation from water budget analyses due to the lack of direct measurements. Hydrometric measurements from the Panola Mountain Research Watershed, a 41-hectare forested, seasonally water-limited catchment within the Piedmont Province of Southeastern United States, were used to quantify recharge during 469 storm events over a 12-year period using two approaches.

In the first approach, recharge was quantified from event water balances that included precipitation, change in shallow storage, potential evapotranspiration, and storm runoff. Approximately 23% of the events had recharge >1 cm, which was dependent upon pre-event soil moisture conditions and event precipitation. About 33% of annual recharge occurred in winter (January – March) when the watershed was wet and 33% occurred in summer (July – September) when precipitation was highest. Overall, recharge represented about 16% of precipitation. This approach appears to underestimate recharge because baseflow (as determined from a hydrograph separation) represented 21% of precipitation over the same period. Underestimates could be due to the lack of representation of the soil moisture profile variability across the watershed, the estimated soil storage depth, and the vertical resolution of the probes.

In the second approach, recharge was estimated as the change in deep storage during events as determined from a baseflow-watershed storage relationship and the change in shallow storage. The baseflow relationship was developed using a water balance approach combined with a recession analysis. This approach gave contradictory results to the water balance approach, indicating that recharge occurred predominantly during the fall (October – December; 27%) and winter (48%). This approach substantially overestimated recharge, because recharge represented about 51% of precipitation. In the winter, changes in deep storage frequently exceeded event precipitation, particularly when soil moisture conditions were near their maximums. Overestimates likely reflect expansion of variable source areas contributing to baseflow. This disconnect indicates that summer recharge does not contribute to baseflow until connectivity occurs. Improved understanding of recharge processes can provide insights for determining the sensitivity and resiliency of baseflow to droughts and potential climate change.



WATER QUALITY AND QUANTITY (B), DOUGLAS BURNS MODERATOR

Forty Years of Data: Challenges and opportunities afforded by long-term data sets

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The University of Kentucky (UK) Department of Forestry and Natural Resources has managed UK's Robinson Forest for over forty years, conducting experiments crucial to understanding the environmental impacts of land management in the region. Part of the management of Robinson Forest has been collection of precipitation and stream-water data, including precipitation quantity, precipitation chemistry, streamflow, stream-water chemistry and temperature, and air temperature. Over the years, these data have been collected and archived using various technologies, and they have been mostly inaccessible for research use—unedited and uncompiled, scattered across a number of spreadsheets and paper records. Through a partnership between the USGS and UK, precipitation data for six stations and stream data from four watersheds in Robinson Forest have been compiled, checked for transcription errors, and annotated for changes in methodologies. These data are planned for a formal USGS data series release on ScienceBase (doi:10.5066/P9FPLG1O), an online data-access platform. Improved accessibility of this valuable data set provides an important research resource for understanding water quality in reference-quality forests in the region. Analysis is ongoing; however, preliminary results suggest that these data present a valuable opportunity to evaluate linkages among atmospheric deposition of nitrates and sulfates and stream chemistry, as well as the impacts of policy, such as the Clean Air Act. Furthermore, these data will allow for analysis of long- and short-term changes in air temperature and precipitation patterns over the last 45 years.



WATERSHED MODELING (B), JEFF CHANAT MODERATOR

South Georgia Groundwater Contamination Susceptibility Determination through an Automated Geospatial Model using Combined Modeling Approach of DRASTIC and MODFLOW6

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Severe drought in recent years and unscientific use of groundwater in agriculture cause severe groundwater aquifers depletion in Georgia watersheds; thereby, increasing vulnerability to contamination. As underground aquifer level of depletion increases, there are less water for dilution of pollutants seeping through the soils. Therefore, the goal of this study was to develop a fully-automated geospatial model in ArcGIS ModelBuilder using spatial parameters associated with the DRASTIC model assisted by the results obtained from MODFLOW6 model on groundwater flow, surface-water flow, solute transport, and management optimization. The model determines the groundwater contamination spatial susceptibility (GWSS) in an 8-Digit HUC of South Georgia flat, an agricultural belt, by focusing on hydrogeologic factors according to their pollution potential. The hydrogeologic factors included in the DRASTIC model are: the depth of the aquifers water (D), the net recharge of the aquifer (R), the aquifer media (A), soil media (S), the surface topography (T), the impact of the vadose zone (I), and the overall hydraulic conductivity (C) and above all the MODFLOW6 model generated spatially varying groundwater flow (GW), surface-water flow (SW), and solute transport (ST) data. Spatial data for the DRASTIC's seven parameters were created using an advanced geoprocessing approach, as most of them are not available in usable format. For example, the R-raster was developed through a rigorous separate model development process that develops a runoff raster from the CN raster developed as a combination of the landuse raster and gS-SURGO along with NOAA-PFDS developed PIDF (100-yr, 24-hr) and a separate ET raster. Simultaneously MODFLOW6 modeling was completed to obtain the study watershed's GW, SW, and ST information to spatially represent the watershed as rasters. Delphi-method based aquifer pollution potential weight scales were developed and analyzed in the automated geospatial model, based on thorough literature review. The resultant GWSS map was developed with five (Very-low to Very-high) different susceptibility scale. This study will provide information to watershed groundwater/environmental managers to promote prudent decision support based on the susceptibility level variation inside the watershed. This study provides a detailed mechanism for spatial data development procured from authentic sources and/or obtained as model results.



WATERSHED MODELING (B), JEFF CHANAT MODERATOR

Trends in Deuterium Excess Coupled with Trends in Groundwater Levels Observed at Shingobee and Williams Lake, Minnesota Reveal Local Evaporative Processes

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U.S. GEOLOGICAL SURVEY

Global Circulation Models have three main domains simulating atmosphere, oceans, and land surfaces with horizontal resolutions of 200 to 600 kilometers. Recent efforts to downscale atmospheric resolution to permit simulation of significant updrafts and downdrafts at mesoscale resolution (4 km) have shown that model predict warmer temperatures than observed, particularly around rivers and streams. The source of this bias has been attributed to lateral flow of groundwater providing moisture to otherwise parched soils, providing water for increased evaporation and, thus, lower air temperature. We test this hypothesis by looking at deuterium excess in precipitation, which is inversely related to evapotranspiration rates, measured in precipitation collected from 2005 through 2015. The deuterium excess was measured at two weather stations near lakes just east of Akeley, Minnesota: Shingobee Lake, where large groundwater inflows occur, and the nearby Williams Lake, a closed lake with no surface water inflow or outflows and drier shoreline margins. The trends in deuterium excess for the two lakes are inversely related, with Shingobee trending downward, and Williams Lake trending upward until an inflection in 2011. That year was coincident with the end of a 2000-2011 trend of decreasing water tables in the area. After 2011, seasonal precipitation maxima in the spring and summer shifted to the fall when ET is substantially smaller, thereby increasing groundwater recharge even though the total annual precipitation did not substantially change. If this paradigm is true, grids of observed deuterium-excess could provide critical new calibration targets for a new generation of high resolution land-atmosphere models.



WATERSHED MODELING (B), JEFF CHANAT MODERATOR

Non-Point Source Pollution Modelling under conservation practices in The Upper Choctawhatchee Watershed Using Soil and Water Assessment Tool (SWAT)

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Water quantity and quality modeling of the Choctawhatchee River Watershed was carried out using Soil and Water Assessment Tool (SWAT). Historical simulation spans over last three decades from 1990 to 2018. Several management practices were utilized to assess response of the hydrological and bio-geo-chemical processes to the changes within the practices. Calibration and sensitivity analyses were satisfactory. Model calibration metrics including p-factor, r-factor, NSE, and R^2 are 0.58, 0.53, 0.74, and 0.75 respectively. Changes in fertilizer, tillage, pesticide applications, also spatial variability of landuse and soil maps were analyzed to evaluate the non-point source and point source pollution. Considering the sustainable practices used in this study, results demonstrate significant decrease in nutrient loads. Total nitrogen and total phosphorus decreased 44% and 31%, respectively. Nitrate, Ammonium, and Nitrite in streams reduced ranging from 12% to 59%. Suspended sediment also decreased 29%. Pollutants pattern follow the precipitation pattern. Soil characteristics play a major role in the nutrient losses. All these changes will decrease the risk of eutrophication and already-imperiled ecosystem degradation. The conservation practices include managing the soil for maximum water infiltration and storage, maintaining vegetation on ditch banks and in drainage channels, and conservation tillage, strip cropping, contour farming, converting agricultural area to forest, and constructed wetlands. Evaluation of the Management practices show spatial variability through the watershed. Optimization analyses is required for developing sustainable water management practices on sub-watershed scale. The results also can be used to locate the priority monitoring regions and critical monitoring period of NPS pollution endangering surface and subsurface water quality.



WATERSHED MODELING (B), JEFF CHANAT MODERATOR

Pinpointing decadal-scale “hot spots” of legacy nitrogen storage in the Chesapeake Bay watershed using differential spatially referenced regression

JEFFREY G. CHANAT, U.S. GEOLOGICAL SURVEY

Legacy nutrient storage is commonly identified as an impediment to efforts to improve regional water quality. However, quantifying the effect of legacy storage on nutrient trends in large, mixed-land-use watersheds is problematic: Capacity for terrestrial storage varies spatially with physiography (e.g. crystalline versus sedimentary lithology) and land use (e.g. forest versus row crop agriculture), as well as vertically throughout the critical zone (e.g., above-ground biomass, root-zone, groundwater). In the aquatic realm, nutrient storage can occur in flowing water, floodplains, wetlands, lakes, and reservoirs. Moreover, the effects of storage on water-quality trends may be evident at some time scales, but not at others. I used the differential spatially referenced regression model Spatiotemporal Watershed Accumulation of Net effects (SWAN; Chanat and Yang, <https://doi.org/10.1029/2017WR022403>) to relate 1990-2010 trends in flow-normalized flux of total nitrogen at 43 sites in the non-tidal Chesapeake Bay watershed to contemporaneous changes in sources and factors influencing terrestrial/aquatic transport. I hypothesized that potential storage “hot spots” over this time scale can be identified through any combination of significant a) interactions between changes in sources and terrestrial transport factors; b) model-intercept terms suggesting a terrestrial source (or sink) other than those explicitly specified; or c) terms indicating capacity for streams and/or reservoirs to act as sources (or sinks). Using a modified “best subsets” regression approach and an information-theoretic selection criterion, I demonstrate that the available data support several plausible model structures, underscoring the challenges associated with quantifying legacy storage in large, mixed-land-use watersheds. I conclude by suggesting the additional spatiotemporal data sets that would most effectively resolve this equifinality.



WATERSHED MODELING (B), JEFF CHANAT MODERATOR

Simulating Hydrology of Current Conditions and Post-Longleaf Pine Restoration on a Coastal Forest Watershed, SC

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Hydrologic models of varying scales and complexities have been developed to assess the interrelationships between climate, topography, soil, vegetation, and land use. They are particularly useful tools in assessing the possible effects of changes in land management/use and climate variability. In this study, we use a physically distributed hydrologic model, MIKESHE, capable of describing complete hydrologic cycle including daily water table dynamics to simulate hydrology of current forest stands and effects of land cover change on water yield from a 155 ha watershed (WS77) on the Santee Experimental Forest in the lower coastal plain of South Carolina.

Restoration of longleaf pine (LLP) ecosystems is an important land management objective throughout the southeastern U.S. In contrast to commercial loblolly pine stands, LLP stands are considered to have a higher water-use efficiency and much lower stocking, potentially influencing soil moisture and evapotranspiration (ET). We have designed a field experiment employing paired watersheds in conjunction with MIKESHE hydrologic modeling to test the principal hypothesis guiding this study that the LLP restoration treatment will increase water yield due to reduced ET. Data from 2011-2018, that includes extreme rainfall and dry events, were used to test the model performance on WS77 in predicting seasonal streamflow and ET for the pre-treatment calibration with the average leaf area index (LAI) of 2.75 for current stand conditions. Preliminary results with limited field calibration yielded strong relationships between predicted and observed flow, with $R^2 = 0.85$ and Nash-Sutcliffe Efficiency (NSE) of 0.84 for daily and $R^2 = 0.96$ and NSE = 0.94, respectively, for monthly flow predictions. The predicted mean annual ET of 1099 mm (1012 mm - 1174 mm) is within the range of published data for similar sites. We will also present water table results for current conditions, besides simulated effects of LLP restoration on streamflow and ET by reducing the LAI to 1.5 for the mature LLP with lower understocking for current climatic conditions. The validated model will later be used to evaluate effects of prescribed fire, harvesting, thinning, and stand development during the post-treatment period (2020 and thereafter).



WATERSHED MODELING (B), JEFF CHANAT MODERATOR

Development of Regional Streamflow Duration Assessment Methods (SDAMs) for the United States

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Regulators and regulated entities need rapid, reach-scale methods to classify streamflow duration to implement and comply with many federal, state and local programs. For example, streamflow duration tools are needed to help make determinations of jurisdictional waters under the Clean Water Act, identify regulated waters under other statutes, inform compensatory mitigation requirements, or to appropriately apply water quality standards. We are developing rapid field assessment methods that use hydrological, geomorphological, and/or biological indicators, observable in a single site visit to classify stream reaches as perennial, intermittent or ephemeral. The objective of this effort is to test and adapt existing streamflow duration assessment methods (SDAMs) and field indicators to develop regional methods for the Arid Southwest (ASW), Western Mountains (WM), Great Plains (GP), Northeast and Southeast. A protocol that includes 32 field indicators derived from methods currently used in the Pacific Northwest and New Mexico was performed at 100 reaches in the ASW, 51 reaches in the WM and 180 reaches in the GP.

Validation of SDAMs requires study reaches with known flow duration classes. Existing hydrologic data (e.g. USGS gages) and regional expert knowledge were used to classify streams as perennial, intermittent, or ephemeral at all sites. In addition, Stream Temperature, Intermittency and Conductivity loggers were placed at sites in the WM and GP to characterize flow duration for one year. Interagency collaboration is welcome to help identify study sites in the Northeast and Southeast and to provide technical recommendations and field testing of methods throughout the method development process in all regions.



WATERSHED MODELING (B), JEFF CHANAT MODERATOR

Agricultural Greenhouse Gas Emissions in Response to Climate Change: A Basin Scale Modeling Approach

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Climate change leads to higher surface temperature and more fluctuated precipitation, which will affect agricultural production, soil greenhouse gas (GHG) emission as well as other environmental factors. Considering this changing climate, optimization of agricultural system with minimal GHGs and reasonable production has become very crucial. The objective of this study is to find the best agricultural management options in terms of grain productions and major GHG emissions in response to the current and projected future climatic scenarios. The tool used for the analysis is process based DNDC (Denitrification & Decomposition) model. The model takes the soil-climatic and cropping management inputs to determine the soil-substrates condition; which is then followed by the estimation of grain production and GHG emissions by denitrification, nitrification and decomposition sub-models. For the model input, ten GIS database are prepared to be superimposed by 147 sub-watershed grids to account for the spatial variations in soil-climatic components. The tested management options are consisted with various types of tillage, manures, residue incorporations and crop rotations for the major crops (Cotton, Peanut, Corn and Soybean) of the Choctawhatchee watershed. The future climatic scenarios are generated using change factor methodology on projected temperatures and precipitations of two timelines (2006-2035 and 2070-2099). To calculate the overall emissions, the term Global Warming Potential (GWP) is introduced which is the summation of all GHGs as CO₂ equivalents. The GWPs for each hector of land and unit grain production are determined to compare the net benefit (NB) from each scenario. For the existing cropping systems, the lowest GWPs as well as the highest Net Benefits (NBs) are seen to be associated with different amount of manure amendments from the model outputs. The long term model runs have also shown higher carbon sequestration potential (CSP) as well as soil productivity with the incorporation of manures (76%-247%), no-till (26%-64%) and crop rotations (17.5%-38%). Thus, these results can be helpful to choose most effective agricultural management scenarios with better impacts on emissions, CSPs, grain yields and NBs in response to climate change.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

Cropping patterns over two decades in the Little River Experimental Watershed, Georgia, USA

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The Little River Experimental Watershed (LREW) is at the center of the Gulf Atlantic Coastal Plain (GACP), a site of the Long-Term Agroecosystem Research (LTAR) network. Since 1997, researchers at the LREW have been surveying land cover annually for a subset of fields throughout the watershed. A primary goal of the LTAR network is to conduct experimental research and gather observations on agricultural practices that represent the region, with the goal of promoting the sustainable intensification of agriculture, increasing production while decreasing environmental impacts. However, to achieve this goal, a “business-as-usual” (BAU) baseline scenario first needs to be described, against which scientists can compare and evaluate results for new “aspirational” management systems. To characterize the BAU cropping scenario for the GACP, we examined the 20-year record of surveys in the LREW and summarized regional cropping practices. We digitized the observational data, incorporating them into a geodatabase, and used a geographic information system to analyze changes in crop type over time for a group of fields within one of the LREW sub-watersheds. We characterized the spatial distribution and frequency of crop types and described the rotational sequences for both irrigated and dryland fields for a subset of fields in the LREW. Finally, we compared our results with crop type information provided by the USDA Cropland Data Layer for the same region over the last decade to observe concordance of the national dataset with survey-derived “ground truth” for the GACP.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

Characterizing transport of natural and anthropogenic constituents in a long-term agricultural watershed in the northeastern US

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As recent technologies enable water samples to be collected at increasingly shorter time intervals, water quality data can more fully capture the range of conditions a stream experiences over time. Various metrics can be employed with the large, high-temporal resolution (i.e., sub-daily) data sets to gain insights into the hydroclimatic and biogeochemical processes affecting chemical fate and transport. These insights can be helpful in understanding the extent to which anthropogenic activities have impacted the natural response of some constituents, such as nutrients and salts, in managed landscapes. Here, nearly four years (12544 samples from 2015 to 2019) of water quality data for twelve constituents of interest were collected using three sampling strategies: (i) three times per week; (ii) high-temporal resolution flow-paced sampling to capture stormflow; and (iii) time-paced sampling with a time interval of 4 hours. Seasonal trends were investigated to understand concentration variability over time and concentration-discharge (C-Q) relationships were developed to categorize the transport dynamics of each constituent. Lorenz curves and Gini coefficients were employed to quantify the temporal inequality of the constituent loads discharged at the watershed outlet and understand the extent to which the transport behavior of geogenic constituents and those affected by anthropogenic activities differed. Overall, the results suggested that nearly all of the geogenic constituents, plus $\text{NO}_3\text{-N}$ and $\text{SO}_4\text{-S}$, exhibited chemostatic dynamics with loads overwhelmingly controlled by flow variability, whereas Al, Fe, $\text{NO}_2\text{-N}$, and $\text{PO}_4\text{-P}$ exhibited episodic transport dynamics that were likely controlled by source availability. Since the transport of $\text{NO}_3\text{-N}$ was found to be similar to the transport of common geogenic constituents for the region, this suggests that decades of agricultural activities in the watershed have led to the emergence of legacy nitrogen sources, while the episodic dynamics observed for $\text{PO}_4\text{-P}$ suggest that best management practices appear to have prevented the emergence of phosphorus legacy sources.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

Dissolved organic matter in agricultural watersheds: Spatial and temporal variability across the LTAR network

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Carbon cycling is a critical process in agricultural systems and its accurate quantification is essential for designing effective land management policies. Dissolved organic matter (DOM) represents a large component of the carbon pool in aquatic systems and agricultural practices have been shown to alter its amount, composition and bioavailability. However, the spatial and temporal relationships between DOM composition and land management practices have not been elucidated for agricultural watersheds. Therefore, we studied the variability in DOM quality of water samples collected from 14 Long-Term Agroecosystem Research (LTAR) network sites with different land use under cropland, pastureland and rangeland management. For DOM characterization, dissolved organic carbon (DOC) and total dissolved nitrogen (TDN, $\text{NO}_3\text{-N}$, and $\text{NH}_4\text{-N}$) concentration, in addition to analysis of UV-visible absorbance and fluorescence spectra were measured. Characterization of DOM was also performed by combining excitation-emission matrix fluorescence with parallel factor analysis (EEM-PARAFAC). There was a large range in both concentration and quality of the DOM, with the DOC concentration ranging from 4 to 50 mg DOC/L and the TDN concentration ranging from 0.1 to 10 mg TDN/L. The ranges in specific UV absorbance and DOM molecular weight suggest variations in DOM composition within a specific study area, and with respect to both spatial and temporal scales. The data presented emphasize that optical properties of DOM can be highly variable and influenced by environmental processes as well as land management practices. Results from this LTAR cross-site study indicate that DOM optical measurements may provide a greater understanding of organic matter dynamics and structural influences associated with nutrient and contaminant fate and transport in agroecosystems.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

Southern Plains LTAR Agroecosystem Research

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The Southern Plains (SP) Long-term Agroecosystem Research (LTAR) site is engaged in “watershed” research at three scales: small scale (1.5 ha), production scale (Avg = 6.5 ha), and medium scale (610 and 787 km²). Each of these watersheds will be described in terms of physical characteristics, instrumentation deployed, experimental design, their purpose, and, where appropriate, findings relative to the research goals of LTAR.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

Use of a simulation model for increasing agroecosystems sustainability

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Maize yield can be affected by numerous factors and because every field is different, increasing maize yield across all environments is not easy. It is crucial to implement a proper soil fertility program that will be the foundation for achieving high yields. Nitrogen (N), phosphorous (P), potassium (K), and micronutrients should be applied at the right time and right amounts to ensure no in-season deficiencies arise. Moreover, tillage method, planting date, population, and proper rotation are factors that can keep yields consistently high. Crop simulation models are one of the technologies behind precision agriculture that can assist in taking proper management decisions. In this three-year study the objectives were to measure the agronomic response of maize to high yield management practices and use crop simulation models to evaluate additional management scenarios. The main goal of this study was to determine the effect of high fertility management strategies on maize in Georgia. Two treatments regarding high fertilization rates were tested in a 1.78 ha field, located in Tifton, GA. Conventional management practices were implemented during the first year of the project while intensive ones were implemented the following two years. Soil samples were collected before and after each growing season, while tissue samples were collected during multiple growing stages from V3 to R4. The field data are being used for calibrating and evaluating the DSSAT CERES Maize model. The model is being used to conduct sensitivity analyses to identify the limiting factors in maize production and inform Georgia growers on how to sustainably intensify maize production.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

Using remote sensing and deep learning to test regional boundaries of the Gulf Atlantic Coastal Plain Long-Term Agroecosystem Research network site

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Studying long-term agricultural trends is crucial for understanding the future of food security in response to increasing global population, climatic variations, and economic demand. The United States Department of Agriculture, Agricultural Research Service (USDA-ARS) currently operates the Long-Term Agroecosystem Research (LTAR) Network to research the sustainable intensification of agriculture in the conterminous United States. The network includes the Gulf Atlantic Coastal Plain (GACP) LTAR site, a region spanning across South Georgia and into both Florida and South Carolina within the Southeastern Plains. The GACP is managed by the ARS Southeast Watershed Research Laboratory in Tifton, GA, where scientists have been observing cropping, hydrologic and climatic systems in the 334 km² Little River Experimental Watershed since 1968. This study aims to integrate remotely sensed data acquired by satellites, aircraft, and unmanned aerial systems (UAS) with field-based measurements to better understand how well the greater coastal plain area is represented by measurements within the GACP LTAR boundary. Using this approach, we will use remotely sensed data and climate variables to derive vegetation indices, crop cover classifications and indicators of ecosystem services at field, landscape and regional scales. We will characterize landscape structure and processes operating within the GACP with the goal of identifying appropriate scaling methods for the extrapolation of agricultural research results, using statistical methods to identify, validate and guide the improvement of scaling models. The coastal plain region will be evaluated in terms of its representativeness of GACP LTAR research results so as to identify realistic boundaries for the inference of results. To accomplish this, we will explore statistical and deep learning methods, such as convolutional neural networks and self-organizing maps, resolving multiple variables across various scales to produce a regional classification. In turn, the deep learning algorithms can advance efforts to define agroecoregions for the continental network of LTAR sites.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

Expanding LTAR Capabilities with Water Parcel Tracking

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The original USDA LTAR research program proposed a standardized experimental protocol at diverse locations throughout the US, where each location would set up a paired comparison between the dominant farming practice in their region (BAU) and some aspirational farming system (ASP) designed to reduce environmental impact while maintaining or increasing profitability. For most regions, identification of the dominant farming system is relatively straightforward; in ours, the Upper Mississippi basin, that is a corn/soybean rotation, with regular tillage. However, specification at the outset of a single aspirational management system that's both more profitable and more environmentally benign is a difficult challenge; if we knew what that was, it would already be in wide use. Each location has made its best guess and the long-term comparisons have begun, but there is a need to develop methods to more broadly screen other management practices to see if there are other aspirational practices that may be superior to those that we have chosen.

Toward that end, we are developing a method to map changes in water quality as a stream moves through a watershed at the scale of a 10 or 12 digit HUC, and to relate those changes to adjoining land use, management, and conservation practices. The platform for the system is an ultralight inflatable kayak, outfitted with a GPS, depth finder, optical nitrate sensor, a multi-parameter sonde, and a datalogger that interrogates the sensors at 1 s intervals. Separately, an acoustic doppler current profiler (ADCP) is used to measure flow at discrete points along the stream. ArcGIS is used to then map streamwise changes in NO_3 load, providing a water quality map that can be used in conjunction with watershed models and GIS information on land use, topography, and management practices to assess the relative water quality impacts of those practices, both positive and negative, at a range of scales.



LONG-TERM AGROECOSYSTEM RESEARCH, OLIVA PISANI MODERATOR

The role of bioavailable phosphorus loading on Lake Erie harmful algal blooms

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The National Center for Water Quality Research has been monitoring major tributaries to Lake Erie for over 44 years as a part of its Heidelberg Tributary Loading Program (HTLP). A minimum of one sample and, during storm runoff, up to three samples a day are analyzed for all major nutrients and suspended sediments from six major tributaries to Lake Erie (Maumee, Sandusky, Portage, Huron, Raisin and Cuyahoga). Long-term trends in loads and concentrations indicate that total particulate phosphorus (TPP) has decreased since the mid-1970s in the agricultural watersheds, whereas dissolved reactive P (DRP) increased drastically in the mid-1990s corresponding to the recurrence of harmful algal blooms (HABs) in Lake Erie. Yet, HAB severity since 2002 has been equally well-described by Maumee River TPP and DRP loads as well as discharge volume from March-July, which has led to confusion on management practices to reduce bloom severity. For instance, the current target load reductions for Lake Erie include both total P (75% of which is TPP) and DRP targets. The 2019 bloom season has helped resolve some of these issues. Although 2019 March-July flow and TPP loads were among the highest ever measured, DRP loads were 30% lower than expected based on flow resulting in the 5th highest loads since 2002. DRP loads were lower than expected because exceedingly wet conditions prevented much of the typical P fertilizer and manure applications from November 2018 – June 2019. Following, bloom severity in 2019 was 7.3 on a scale of 10, or the 5th highest since monitoring via satellites began in 2002. In comparison, the highest bloom severity measured was in 2015 (10.5), which had the highest March – July flow and DRP load. Yet, because most of the storm events occurred in June and July when crops were already growing, TPP loads were 30% lower than expected. These comparisons highlight the strong influence of DRP on bloom severity and the comparatively minimal influence of TPP. Management to reduce bloom intensity in Lake Erie should prioritize practices that reduce DRP losses over those that focus on erosion control.

