Sixth Interagency Conference on Research in the Watersheds

Working Watersheds and Coastal Systems: Research and Management for a Changing Future

July 23-26, 2018
National Conservation Training Center
Shepherdstown, WV

Conference Sponsors

Welcome from the Conference Chair

Dear Colleagues,

On behalf of the Steering Committee, I welcome you to the Sixth Interagency Conference on Research in the Watersheds (ICRW).

This ICRW focuses on “working watersheds.” These so-called watersheds and coastal systems provide a wide array of useful economic goods and services (e.g., agricultural products, urban development, recreation, etc.). However, maintaining aquatic condition and functional integrity while balancing issues arising in “working watersheds” such as nutrient loading, landscape disturbance, and invasive species requires creative scientific approaches and adaptive management. The research and presentations around this broad theme to be shared at the Sixth ICRW are myriad and diverse. I look forward to the science, the communication, and the camaraderie as we all work to meet the watershed management challenges into the future.

The ICRW began in 2003 with the US Department of Agriculture-hosted conference in Walnut Gulch, Arizona, and has continued to grow and enjoy enthusiastic participation and cutting-edge scientific presentations. ICRWs have also been hosted by the US Forest Service (2006 & 2015), US Geological Survey and CUAHSI (Consortium of Universities for the Advancement of Hydrologic Science) in 2009, and the Bureau of Land Management and National Park Service in 2011. The Sixth ICRW is the first hosted by the US EPA, though the conference development and implementation is truly an effort by all the Steering Committee members and the organizations they represent.

Through your engagement, curiosity, and effort, it is my hope that this ICRW meeting will continue in the fine tradition of its predecessors.

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

With my regards,

Chuck Lane

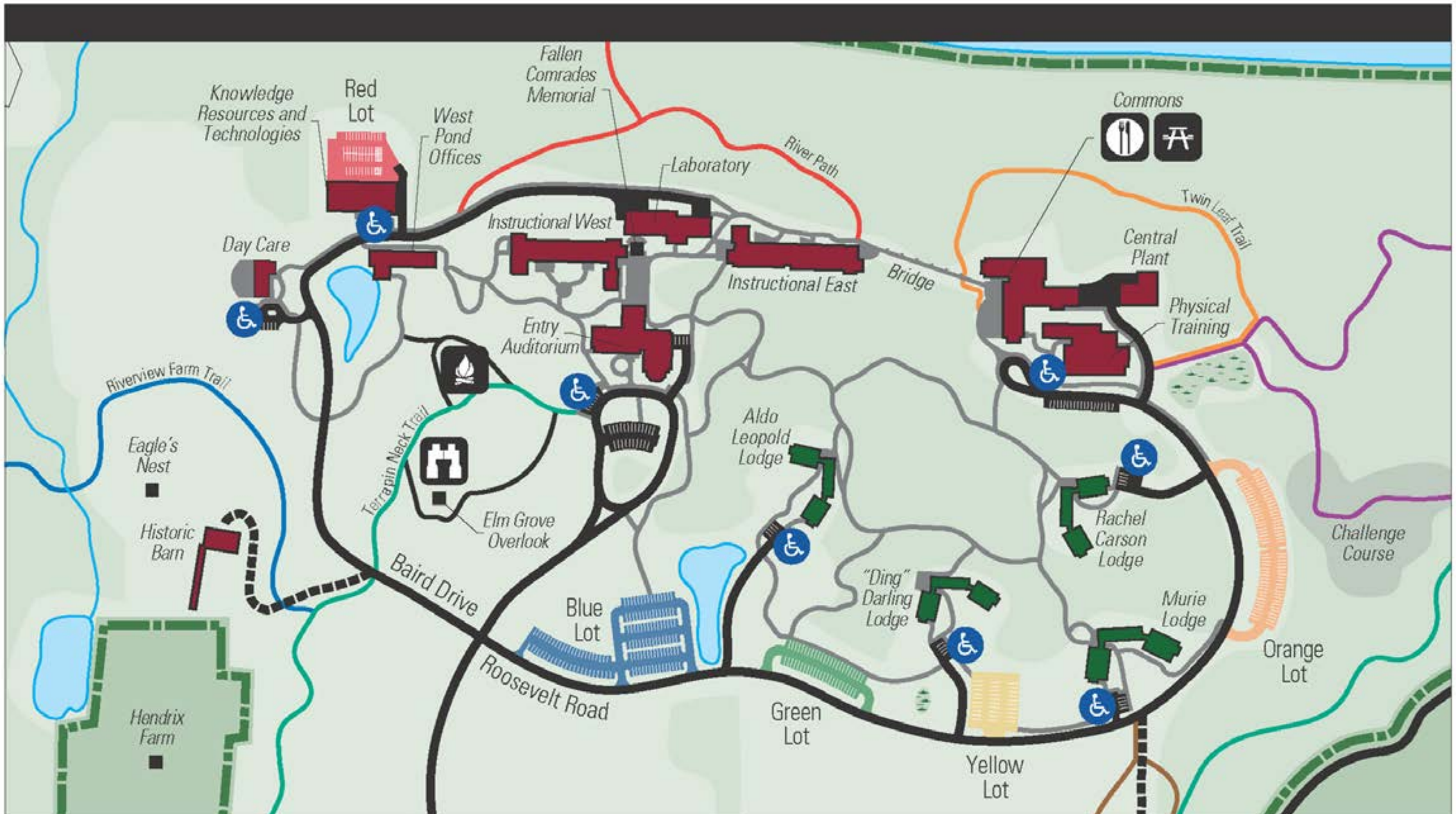
Charles Lane,
Conference Chair
US EPA Office of Research and Development
Cincinnati, Ohio

Sixth ICRW Steering Committee

Tireless Steering Committee contributions were instrumental in creating this informative and enjoyable conference. If you happen to run into any Steering Committee colleagues, be sure to thank them for their efforts!

- Laurie Alexander, US EPA
- Jerad Bales, CUAHSI
- Micah Bennett, US EPA
- David Bosch, USDA-ARS
- Emily Clark, CUAHSI
- Scott Davis, BLM
- Josh Eash, USFWS
- Randy Fowler, USFS
- Heather Golden, US EPA
- Jim Hodgson, USFWS
- Bill Kepner, US EPA
- Charles Lane, US EPA
- James Latimer, US EPA
- Tim Strickland, USDA-ARS
- Elizabeth Tran, CUAHSI
- Carl Trettin, USFS
- Rick Webb, USGS

National Conservation Training Center



National Conservation Training Center
Campus Map

- Accessible Parking
- Firepit
- Elm Grove Overlook
- Dining Hall
- Picnic Area
- Paved Trails
- Paved Roads
- Gravel Roads
- Points of Interest

Campus Store
Extension 7350
11:00 AM – 2:00 PM

Conservation Library
Extension 7304

Dining Services
Extension 7353

Breakfast	6:30 AM – 9:00 AM *Hot Food until 8:30 AM*
Lunch	11:30 AM – 1:30 PM *Hot Food until 1:00 PM*
Dinner	5:30 PM – 7:30 PM

Commons Lounge
Extension 7351
5:30 PM – 11:00 PM

Physical Training Center *Extension 7341*
Sunday – Thursday 6:00 AM – 10:00 PM
Friday 6:00 AM – 4:30 PM

Sixth ICRW Highlights

Monday, July 23rd

- Opening Plenary, **Ryan Emanuel** (North Carolina State University), ***Environmental Justice, Indigenous Rights, and Implications for Decision-Making at the Watershed-Scale and Beyond***
- Sixth ICRW Welcoming Reception (until 9:30 PM, NCTC Museum and Lobby Area)

Tuesday, July 24th

- Plenary presentations, *Current Research and Emerging Opportunities* by scientific leaders of the US EPA, USGS, USDA-ARS, USFS, BLM, and CUAHSI
    - **Anne Rea**, US EPA, Office of Research and Development Associate National Program Director
    - **Donald Cline**, USGS, Associate Director for the Water Resources Mission Area
    - **Teferi Tsegaye**, USDA-ARS, National Program Leader for Water Availability and Watershed Management Program
    - **Carl Lucero**, USFS, Landscape Restoration and Ecosystem Services Research Director
    - **Scott Davis**, BLM, Sr. Soil Scientist
    - **Jerad Bales**, CUAHSI, Executive Director
- Plenary by **Nandita Basu** (University of Waterloo), ***Landscape Legacies: Long-Term Nitrogen Trajectories in the Mississippi River Basin and Beyond***
- Plenary by **Terri Hogue** (Colorado School of Mines), ***Challenges and Opportunities in Human-Water Interactions in Urban Centers: Advancing Decision-Making Tools for Holistic Management of Water Resources***
- Policy update on "Waters of the United States" by **Rose Kwok** (US EPA Office of Water)
- Concurrent scientific sessions all afternoon
- Interactive poster session in the evening

Wednesday, July 25th

- Scientific Field Excursions (half- and full-day)
- Sixth ICRW BBQ and Gala

Thursday, July 26th

- Plenary by **Beth Boyer** (Penn State University), ***Advancing Understanding of the Critical Zone: Lessons from Long Term Watershed Studies***
- Concurrent scientific sessions until noon
- Plenary by **Emily Bernhardt** (Duke University), ***Where Land Use Legacies and Global Change Collide: The Ecosystem Impacts of Salt Water Intrusion in Coastal Agricultural Landscapes***
- Conclusion and "Passing the Gavel" to the USDA-ARS, hosts of the Seventh ICRW

Sixth ICRW Plenary Speakers

ENVIRONMENTAL JUSTICE, INDIGENOUS RIGHTS, AND IMPLICATIONS FOR DECISION-MAKING AT THE WATERSHED SCALE AND BEYOND

Ryan E. Emanuel, North Carolina State University

Since the 1990s, federal agencies in the US have used environmental justice analyses to help determine how regulated environmental activities and decision-making may affect vulnerable human populations. Ideally, these analyses serve as tools that help agencies begin to identify and address ways in which activities and decisions could disproportionally affect poor people and people of color. By paying attention to the results of environmental justice analyses, agencies help ensure that the voices and concerns of these people are not overlooked, as they have been for most of the history of environmental decision-making in the US. However, standards for environmental justice analyses vary among agencies and even within agencies. Despite the availability of state-of-the-art tools, agencies sometimes employ weak or flawed environmental justice analyses that lack the ability to identify disproportionate impacts on vulnerable populations. Flawed analyses not only exacerbate existing injustices, but they also fail to serve regulators, project applicants, and the public, all of whom depend on these tools for accurate decision-making.

I examine this situation from the perspective of non-federally recognized American Indian tribes impacted by a regulated energy project in the eastern US. Here, an accurate environmental justice analysis could have alerted regulators to disproportionately large impacts on American Indians whose ancestral and modern territories are affected by the project. With such knowledge, regulators could have pursued formal consultations with tribal governments, per federal policy guidance, to gather information about the unique cultural and environmental concerns of indigenous peoples during the decision-making phase of the project. Instead, a flawed analysis led to incorrect conclusions about environmental justice and decisions that excluded relevant indigenous knowledge and perspectives. I use the case study to draw general conclusions about the need for rigorous environmental justice assessments and, where applicable, meaningful, government-to-government consultations with indigenous peoples for decision-making at watershed scales and beyond. I highlight lessons for environmental justice from the history of federal stream and wetland policies, and I discuss ways in which environmental justice analyses may benefit from tools and methods from the hydrologic modeling community.

Ryan Emanuel is an Associate Professor and University Faculty Scholar in the Department of Forestry and Environmental Resources at North Carolina State University. He is an environmental scientist with over 30 peer-reviewed journal publications, including a recent publication in the international journal Science on “Flawed environmental justice analyses”. Dr. Emmanuel’s research focuses mainly on two-way interactions between hydrological and ecological processes in natural and human-altered environments. An enrolled member of the Lumbee Tribe, Emanuel works to broaden participation of American Indians and other underrepresented groups in the environmental sciences. In recent years, this work has expanded from outreach and education among young people to partnerships with tribal governments and inter-tribal organizations that seek to address issues related to environmental quality, environmental justice, climate change, and related public policies affecting indigenous peoples.

LANDSCAPE LEGACIES: LONG-TERM NITROGEN TRAJECTORIES IN THE MISSISSIPPI RIVER BASIN AND BEYOND

Nandita Basu, University of Waterloo

Global flows of reactive nitrogen (N) have increased significantly over the last century in response to land-use change, agricultural intensification and elevated levels of atmospheric N deposition. Despite widespread implementation of a range of conservation measures to mitigate the impacts of N-intensive agriculture, N concentrations in surface waters are in many cases remaining steady or continuing to increase. Such lack of response has been attributed to legacy N stores in subsurface reservoirs that contribute to time lags between conservation measures implemented on the landscape and water quality benefits realized in receiving water bodies. It has remained unclear, however, what the magnitudes of such stores might be, and how they are partitioned between shallow soil and deeper groundwater reservoirs. In the present work, we have synthesized data to develop a comprehensive, 214-year trajectory of N inputs to the land surface of the Mississippi River Basin (MRB) as well as the Susquehanna and other watersheds draining into the Chesapeake Bay. Based on this dataset, we have used the ELEMeNT model – which pairs a simulation of soil nutrient dynamics with a travel time-based approach – to reconstruct historic nutrient yields at the outlets of these watersheds and to model future N-loading under a range of scenarios. Our results show significant N loading above baseline levels in both watersheds before the widespread use of commercial N fertilizers, largely due to 19th-century conversion of natural forest and grassland areas to row-crop agriculture. By quantifying the magnitudes of legacy N accumulation in soil and groundwater pools, the model results also highlight the dominance of soil N legacies in MRB and groundwater legacies in Chesapeake watersheds. Our modeling of future scenarios indicates that even if agricultural N use were to become 100% efficient, it would take on the order of decades to meet policy goals for improving water quality. Our results suggest that significant time lags should be anticipated when aiming to reduce N export, and that both long-term commitment and large-scale changes in agricultural management practices will be necessary to meet such goals.

Nandita Basu is an Associate Professor in the Departments of Civil and Environmental Engineering and Earth and Environmental Sciences at the University of Waterloo. Her research focuses on a broad range of issues related to water in human-impacted environments: from problems of nutrient pollution in intensively farmed regions to drought in water-stressed areas of India. Dr. Basu uses tools from environmental science, engineering and the social sciences to improve our ability to sustainably manage water resources. Nandita's current research focuses on the legacies of nutrients that accumulate in anthropogenic landscapes, and lead to time lags between implementation of watershed conservation measures and stream water quality improvement. Her team is developing statistical and deterministic models that can quantify these time lags and help to identify adaptive management strategies to minimize watershed response times. Nandita is an Associate Editor for Hydrological Processes and Hydrology and Earth System Sciences, and the Chair of the AGU Water Quality Technical Committee. Dr. Basu also currently leads a $1.7M project on "Lake Futures: Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds" where she brings together natural and social scientists with regulation agencies and conservation authorities to address water quality questions in the Great Lakes watersheds.

CHALLENGES AND OPPORTUNITIES IN HUMAN-WATER INTERACTIONS IN URBAN CENTERS: ADVANCING DECISION-MAKING TOOLS FOR HOLISTIC MANAGEMENT OF WATER RESOURCES

Terri S. Hogue, Colorado School of Mines

Urban environments are facing multiple challenges in order to improve water quality and increase potential local water supplies. Many of these challenges can be addressed through better management of stormwater and urban runoff. With climate change, increasing competition for scarce water resources, and limited federal water infrastructure funding, it is imperative that cost-effective, multi-benefit approaches are undertaken to meet urban water management needs. Prioritizing stormwater infrastructure projects is daunting. In addition to complying with water quality standards, agencies must also consider factors such as regulating peak flows, life cycle costs, environmental impacts, and co-benefits to the environment and community. The implementation of Best Management Practices (BMPs) can help mitigate pollutant loads and storm peak flow, but can also capture additional water supplies. Stormwater modeling, generally used to assess the impact of BMPs implemented within a watershed, is useful for determining the optimal suite of BMPs to maximize decision criteria (pollutant load, flood reduction, capture volume, etc.) and minimize cost. BMPs can include small, distributed green infrastructure techniques or larger, centralized grey infrastructure. The current presentation will overview recent work in coupled human-water interactions in urban centers, including work on development of an integrated decision support tool, i-DST, that allows for the optimization and comprehensive life-cycle cost assessment of grey, green, and hybrid stormwater infrastructure. The framework evaluates optimal stormwater runoff management by taking into account diverse economic, environmental, and societal needs. After identifying a suite of optimal solutions that vary the percentage of stormwater routed to green vs grey infrastructure, a multi-criteria assessment (MCA) matrix is used to link the different alternatives with their ancillary ecological and social benefits (co-benefits). Results from applications in Denver, Colorado and Los Angeles, California will be highlighted. Our goal is to provide a more holistic review of infrastructure alternatives, and assess the scale of anticipated co-benefits, to decision-makers in urban communities across the United States.

Terri S. Hogue is a Professor and Department Head in the Department of Civil an Environmental Engineering at the Colorado School of Mines. Dr. Hogue received her Ph.D. from the Department of Hydrology and Water Resources at the University of Arizona. Her research focuses on understanding hydrologic and land surface processes, with an emphasis on human interactions with water cycling and management. Projects include urban and ecosystem dynamics, wildfire impacts on water supply, and hydrologic response to climate change. Recent work includes assessment of water sustainability related to oil and gas production for shale plays in the western U.S. She has received research funding from EPA, NSF, NASA, USGS, NOAA, USDA, BLM and The Nature Conservancy, as well as various state and local agencies. She currently leads a $2.6 million EPA National Priorities grant on development of decision support tools for optimization of gray-green urban infrastructure and life cycle assessment. Dr. Hogue is a member of the National Academies Board on Atmospheric Sciences and Climate (BASC) and also serves on the editorial board for the American Geophysical Union Water Resources Research journal.

ADVANCING UNDERSTANDING OF THE CRITICAL ZONE: LESSONS FROM LONG TERM WATERSHED STUDIES

Elizabeth W. Boyer, Pennsylvania State University

This talk presents a historical and contemporary perspective on research at experimental watersheds worldwide. Over a century of research, long-term observations, and experimentation in watersheds reveals complex linkages among inputs, storages, and outputs of water and solutes, as well as the underlying processes controlling their behavior. Results highlight the importance of hydrological transport, geochemical weathering, biogeochemical processing, seasonality, and lag times controlling the fate and transport of elements in the critical zone. Observational data from watershed studies can be used to parameterize models of ecohydrology and water quality, and combined with synoptic data from remote sensing (and other sources of "big data") toward quantifying coupled hydrological and biogeochemical cycles at regional and global scales.

Elizabeth W. Boyer is an Associate Professor of Water Resources in the Department of Ecosystem Science and Management at the Pennsylvania State University. She is also Director of the Pennsylvania Water Resources Research Center, and Assistant Director of Penn State Institutes of Energy & the Environment. Prior to her current position, Boyer served on the faculty at the State University of New York at Syracuse and at the University of California at Berkeley. She holds a B.S. degree in Geography from the Pennsylvania State University, and M.S. and Ph.D. degrees in Environmental Sciences from the University of Virginia. Dr. Boyer's work explores the status and trends of water quality of streams, rivers, and estuaries in response to factors such as atmospheric deposition, climatic variability, land use, and watershed management. She has published over 60 peer reviewed articles and over 20 chapters and reports. Dr. Boyer serves on the Board of Directors of the Consortium of Universities for the Advancement of Hydrological Sciences, Inc., serves on several advisory panels of the U.S. Environmental Protection Agency, and serves as an editor of the international journal Hydrological Processes.

WHERE LAND USE LEGACIES AND GLOBAL CHANGE COLLIDE: THE ECOSYSTEM IMPACTS OF SALT WATER INTRUSION IN COASTAL AGRICULTURAL LANDSCAPES

Emily S. Bernhardt, Duke University

For many mid-latitude coastal regions across the globe, climate change models predict increased drought and hurricane intensity. Severe droughts and wind surges can increase the upstream extent of brackish water and the peak salinity of coastal freshwater marshes, swamps, and tidal creeks across the world. The spatial extent of these saltwater intrusion events is increasing through time as a result of both gradual sea level rise and the construction of the artificial drainage networks built to support coastal farming. Saltwater intrusion is leading to dramatic changes in the chemistry of freshwater wetlands and low lying agricultural fields. Seawater has high salinity and high alkalinity waters that are rich in base cations and low in organic matter while the majority of freshwater coastal wetlands are acidic with high concentrations of colored organic matter. The resultant mixing of widely divergent waters leads to rapid changes in water chemistry. Cations in seasalts (i.e., Mg^{2+} and Na^{2+}) can displace soil bound ammonium (NH_4^+) and lead to flocculation of DOM through cation bridging, enhancing legacy N exports while reducing the energetic links between land and sea. Slower changes also accumulate as sea salt enrichment of soils leads gradually to the salinization, alkalinization and sulfidation of sediments and soils. Because of drought and event loading of marine salts we expect significant landward migration of brackish throughout much of the coastal plain well in advance of significant sea level rise. The consequences of salt water intrusion for the large standing stocks of organic matter currently stored in coastal freshwater wetlands and for the legacy deposits of fertilizer nitrogen are likely to have profound impacts on coastal waters and future soil fertility.

Emily S. Bernhardt is the Jerry G. and Patricia Crawford Hubbard Professor of biogeochemistry in Duke's Department of Biology. Dr. Bernhardt's research is motivated by a desire to understand how our use of watersheds alters energy and nutrient cycling in receiving streams and wetlands and the extent to which management efforts can reverse, ameliorate or improve aquatic ecosystem structure and function. Emily's research group is currently examining the impacts of fertilizer legacies and saltwater exposure in coastal wetlands; the downstream impacts of surface coal mining; the role of emerging contaminants in degrading urban streams; and the effects of nanomaterials on ecosystems. Emily has been recognized for her scholarly productivity and impact with the 2004 H.G. Hynes Award from the Society for Freshwater Science; the 2013 Yentsch-Schindler award from the Association for the Sciences of Limnology and Oceanography; and the 2015 Mercer Award from the Ecological Society of America. She was named a Fellow of the Ecological Society of America in 2018.

Sixth ICRW Schedule-at-a-Glance

Monday, July 23, 2018		
Registration, Conference Opening Plenary and Reception		
2:00 PM – 6:45 PM	Registration	NCTC Lobby Area
5:30 PM	NCTC Commons Open for Dinner (On Your Own)	
6:00 PM	Informal Gathering in NCTC Museum and Lobby Area (Cash Bar Available)	
6:45 PM	Conference Opens	NCTC Auditorium
6:45 PM – 7:45 PM	Opening Plenary: Ryan Emanuel (North Carolina State University), **Environmental Justice, Indigenous Rights, and Implications for Decision-Making at the Watershed-Scale and Beyond**	NCTC Auditorium
7:45 PM – 9:30 PM	Welcoming Reception (Cash Bar)	NCTC Museum Area and Lobby

Tuesday, July 24, 2018		
Morning Plenary Sessions, Afternoon Concurrent Sessions, and Evening Poster Session		
7:30 AM – 5:30 PM	Registration	NCTC Lobby Area
8:30 AM	Morning Plenary Sessions Open	NCTC Auditorium
8:30 AM – 10:15 AM	**Agency and Organization Plenary: Current Research and Emerging Opportunities**	
	US EPA: Anne Rea (Associate National Program Director, Safe and Sustainable Water Research Program, Office of Research and Development)	
	USGS: Donald Cline (Associate Director, Water Resources Mission Area, U.S. Geological Survey)	
	USDA – ARS: Teferi Tsegaye (National Program Leader for the Water Availability and Watershed Management Program, USDA Agricultural Research Service)	
	USFS: Carl Lucero (Director, Landscape Restoration and Ecosystem Services Research, US Forest Service)	
	BLM: Scott Davis (Sr. Soil Scientist, Bureau of Land Management)	
	CUAHSI: Jerad Bales (Executive Director, Consortium of Universities for the Advancement of Hydrologic Science)	
	Q&A Session	
10:15 AM – 10:30 AM	Coffee Break (NCTC Lobby Area)	
10:30 AM – 11:30 AM	Plenary: Nandita Basu (University of Waterloo), **Landscape Legacies: Long-Term Nitrogen Trajectories in the Mississippi River Basin and Beyond**	NCTC Auditorium

Tuesday, July 24, 2018 (Continued)						
11:30 AM – 12:30 PM	Plenary: Terri Hogue (Colorado School of Mines), **Challenges and Opportunities in Human-Water Interactions in Urban Centers: Advancing Decision-Making Tools for Holistic Management of Water Resources**					NCTC Auditorium
12:30 PM – 12:45 PM	Policy Update: Rose Kwok (US EPA Office of Water), **Updates on the "Waters of the United States" Rulemaking Efforts**					NCTC Auditorium
12:45 PM – 2:00 PM	Lunch (NCTC Commons)					
2:00 PM – 3:30 PM	Concurrent Sessions in Instructional East (IE) and Instructional West (IW)					
	IE 103	IE 105	IE 107	IE 201	IW 151	IW 160
	Wetland Trends in Coastal Watersheds: Drivers, Effects, and Adaptive Management	**Watershed Research and Management in a Changing Climate**	**Coastal Habitats and Resources: Management, Protection, and Restoration**	**Monitoring Aquatic Systems from Daily to Decadal Scales: Advances and Applications**	**Managing and Characterizing Complex Aquatic Systems across Different Land Uses & Spatial Scales I**	**Novel Approaches and Applications in Hydrologic Modeling for Watershed Research**
3:30 PM – 4:00 PM	Coffee Break (NCTC Instructional East and West Foyer)					
4:00 PM – 5:30 PM	Concurrent Sessions in Instructional East (IE) and Instructional West (IW)					
	IE 103	IE 105	IE 107	IE 201	IW 151	IW 160
	Wetland Trends in Coastal Watersheds: Drivers, Effects, and Adaptive Management	**Watershed Research and Management in a Changing Climate**	**Coastal Habitats and Resources: Management, Protection, and Restoration**	**Monitoring Aquatic Systems from Daily to Decadal Scales: Advances and Applications**	**Managing and Characterizing Complex Aquatic Systems across Different Land Uses & Spatial Scales I**	**Novel Approaches and Applications in Hydrologic Modeling for Watershed Research**
5:30 PM	NCTC Commons Open for Dinner (On Your Own)					
6:30 PM – 8:30 PM	**Poster Session (NCTC Gallery)**					

Sixth ICRW Schedule-at-a-Glance

Wednesday, July 25, 2018		
ICRW Field Trips and Evening BBQ Gala		
7:30 AM	**RAFTING ONLY** Organize for Departure (Pick Up Lunches, etc.); RAFTING departs at 8:00 AM	NCTC Lobby Area
8:00 AM	**ALL OTHER TOURS** Organize (Pick Up Lunches, etc.); Departure at 8:30 AM	NCTC Lobby Area
Selection of Box Lunches Provided		
Afternoon	Field Trips Return to NCTC	NCTC Lobby Area
5:30 PM – 7:30 PM	Sixth ICRW BBQ and Gala	NCTC Servery (Commons Area)

Thursday, July 26, 2018					
Plenary and Concurrent Sessions, "Passing the Gavel," Adjournment					
7:30 AM – 10:00 AM	Registration				NCTC Lobby Area
8:30 AM	Morning Plenary Sessions Open				NCTC Auditorium
8:30 AM – 9:30 AM	Plenary: Beth Boyer (Penn State University), **Advancing Understanding of the Critical Zone: Lessons from Long Term Watershed Studies**				
9:30 AM – 10:00 AM	Coffee Break (NCTC Lobby Area)				
10:00 AM – 12:00 PM	Concurrent Sessions in Instructional East (IE) and Instructional West (IW)				
	IE 105	IE 107	IE 201	IW 151	IE 160
	Water Quality Research in the Appalachia Region	**Watershed Evapotranspiration in a Changing Environment**	**Waters at the Border – Science, Management, and Policy Challenges for Transboundary Watersheds**	**Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales II**	**Using Long-term Data on Assessing Extreme Climatic Events Effects on Watershed Processes, Functions and Management Practices**
12:00 PM – 1:00 PM	Lunch (**1.0 hrs**, NCTC Commons)				
1:00 PM – 2:00 PM	Plenary: Emily Bernhardt (Duke University), **Where Land Use Legacies and Global Change Collide: The Ecosystem Impacts of Salt Water Intrusion in Coastal Agricultural Landscapes**				NCTC Auditorium
2:00 PM	Conclusion and Passing the Gavel for the Seventh ICRW, Conference Adjourns				

Sixth ICRW Detailed Concurrent Sessions

Tuesday, July 24, 2018			
2:00 PM – 5:30 PM	**Coastal Habitats and Resources: Management, Protection, and Restoration**	**Instructional East 107**	
Moderator	**Lisa Vandiver (NOAA)**	**Presenter**	**Affiliation**
2:00 PM	The Tampa Bay Story: Fostering Collaborative Partnerships to Restore an Urban Estuary	Gary Raulerson et al.	Tampa Bay Estuary Program
2:15 PM	A Brief History of the Chesapeake Bay Program & How It's Facilitating the Recovery of One of the Bay's Most Important Habitats: Submerged Aquatic Vegetation	Brooke Landry et al.	Maryland Department of Natural
2:30 PM	Ridge to Reef Integrated Terrestrial & Marine Monitoring to Assess the Impact of Watershed Restoration on Marine Sediment Dynamics & Coral Reef Sedimentation in St. John, US Virgin Islands	Sarah Gray et al.	Environmental & Ocean Sciences, University of San Diego
2:45 PM	Diary of a Pacific Island Stream Monitor	Kathryn Graziano and Anne Kitchell	Horsley Witten Group
3:00 PM	Understanding and Measuring Changes in Coastal Resilience: Lessons from the DOI Hurricane Sandy Response Program	Peter Murdoch et al.	U.S. Geological Survey
3:15 PM	Making Our Science Accessible: Engaging Stakeholders to Participate in Coastal Wetland Restoration Decisions Using Web Mapping Applications	Justin Saarinen et al.	New College of Florida
3:30 PM – 4:00 PM	**Coffee Break**	**Instructional East and West Foyers**	
4:00 PM	Benthic Habitat Metrics as Indicators for Linking Watershed Restoration to Coral Reef Habitats	Lisa Vandiver	NOAA
4:15 PM	Water Clarity Criteria for Seagrass Protection in Sarasota Bay, FL: An Optical Model and Assessment Tool	L.K. Dixon et al.	Mote Marine Laboratory
4:30 PM	Seagrass Ameliorates Coral Physiological Performance Under OA Conditions	Emily Hall et al.	Mote Marine Laboratory
4:45 PM	Pollutant Inputs to Coastal Environments and their Regulation from an Endangered Species Act Perspective	Pat Shaw-Allen	NOAA Fisheries, Office of Protected Resources
5:00 PM	Using Endangered Species Act Consultations as a Tool to Improve Water Quality and Monitoring in Coral Reef Ecosystems	Lisamarie Currubba	NOAA Fisheries, Office of Protected Resources
5:15 PM	**PANEL**: Coastal Habitats and Resources: Management, Protection, and Restoration		

Sixth ICRW Detailed Concurrent Sessions

Tuesday, July 24, 2018			
2:00 PM – 5:30 PM	**Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales I (Tuesday Presentations)**	**Instructional West 151**	
Moderators	**Ana Garcia and Jennifer Keisman (U.S. Geological Survey)**	**Presenter**	**Affiliation**
2:00 PM	Landscape Features and Processes Affect Aquatic Nutrient Dynamics in a Regional-Scale River Basin	Samson Mengistu et al.	National Research Council, US
2:15 PM	Pooled Monitoring – A Novel Approach that Pools Funding to Support Research to Answer Key Restoration Questions vs. Site/Project Specific Monitoring in the Chesapeake Bay	Sadie Drescher and Jana Davis	Chesapeake Bay Trust
2:30 PM	Drivers of Orthophosphate Trends in Tributaries to Chesapeake Bay	Rosemary Fanelli et al.	U.S. Geological Survey
2:45 PM	Exploring Drivers of Regional Water-Quality Trends Using Differential Spatially Referenced Regression – A Pilot Study in the Chesapeake Bay Watershed	Jeffrey Chanat & Guoxiang Yang	U.S. Geological Survey
3:00 PM	Delineation of Wetland Hydrologic Hot Spots Using Large-Scale Models	Adnan Rajib et al.	ORISE Research Program and US EPA
3:15 PM	The Conservation Effects Assessment Project (CEAP) Watershed Assessments: A Synthesis of Measuring and Understanding the Effects of Conservation Practices within Watersheds	Lisa Duriancik et al.	USDA - NRCS
3:30 PM – 4:00 PM	**Coffee Break**	**Instructional East and West Foyers**	
4:00 PM	Strengthening Resiliency in Coastal Watersheds: A Web-Based GIS Map Viewer Decision Support System	Anne Kuhn and Jane Copeland	US EPA
4:15 PM	Strategies to Address Endocrine Disruption in Fish and Wildlife in the Chesapeake Bay Watershed	Kelly Smalling	U.S. Geological Survey
4:30 PM	Where the Map Meets the Mud: Watershed Assessment	Matt Royer et al.	Penn State Agriculture and
4:45 PM	Assessing the Impact of Wildland Fire on Runoff and Erosion using the Automated Geospatial Watershed Assessment Tool	Phillip Guertin et al.	University of Arizona
5:00 PM	Quantifying the Benefits of Land Conservation on Water Supply in the Catawba-Wateree Watershed	Michele Eddy et al.	RTI International

Sixth ICRW Detailed Concurrent Sessions

Tuesday, July 24, 2018			
2:00 PM – 5:30 PM	Monitoring Aquatic Systems from Daily to Decadal Scales: Advances and Applications	Instructional East 201	
Moderators	James Latimer (US EPA) and Rick Webb (USGS)	Presenter	Affiliation
2:00 PM	Seasonal Disconnect Between Hydrology and Retention Drives Riverine N Export in Western Oregon	Jana Compton et al.	US EPA
2:15 PM	Using Nitrogen Isotopes of Chironomidae as an Index of Nitrogen Sources and Processing within Watersheds as Part of EPA's National Aquatic Resource Surveys	J. Renée Brooks et al.	US EPA
2:30 PM	Nutrient Export from Highly Managed Coastal Watersheds: Lessons Learned from Long-Term Monitoring Data	Yongshan Wan	US EPA
2:45 PM	Assessing Physiochemical and Biological Condition of Rivers and Streams within the Mississippi River Basin and Sub-Basins	Richard Mitchell et al.	US EPA
3:00 PM	Relating Watershed Land Use to Benthic Invertebrate Condition in the Virginian Biogeographic Province, USA	Marguerite C. Pelletier et al.	US EPA
3:15 PM	The National Ecological Observatory Network Aquatic Sampling: Dissolved Gas Concentrations, Stratification Conditions in Lakes, and Reaeration Rates in Streams	Kaelin Cawley & Keli Goodman	National Ecological Observatory
3:30 PM – 4:00 PM	**Coffee Break**	**Instructional East and West Foyers**	
4:00 PM	How Best to Address the Challenge of Geology Along an Agricultural Reach of the Arkansas River in Colorado?	Carleton Bern et al.	U.S. Geological Survey
4:15 PM	Hydrogeochemical Changes and Watershed Degradation Induced by Hemlock Loss in Northeastern Riparian Forests	Kanishka Singh et al.	Cornell University
4:30 PM	Advancing Continuous Streamflow and Water Quality Monitoring Networks in the Coastal Plain, Waccamaw River Watershed, South Carolina	Benjamin Thepaut	U.S. Geological Survey
4:45 PM	Temporal Disturbance at the Micro Scale: Natural and Anthropogenic Impacts on Seepage Across the Sediment-Water Interface	Don Rosenberry	U.S. Geological Survey
5:00 PM	Open		

Sixth ICRW Detailed Concurrent Sessions

Tuesday, July 24, 2018			
2:00 PM – 5:30 PM	**Novel Approaches and Applications in Hydrologic Modeling for Watershed Research**	**Instructional West 160**	
Moderators	**David Bosch (USDA-ARS) and Bill Kepner (US EPA)**	**Presenter**	**Affiliation**
2:00 PM	Characterizing Depressional Wetland Storage in a Watershed: Linking Remote Sensing and Hydrologic Modeling Approaches	Jay Christensen et al.	US EPA
2:15 PM	Contrasting SWAT Predictions of Watershed-Level Streamflow and Nutrient Loss Resulting from Static Versus Dynamic Atmospheric CO_2 Inputs	Kpoti Gunn et al.	USDA-ARS
2:30 PM	Modeling Violations of the Nitrate Standard for Public Drinking Water Across the Conterminous United States	Michael Pennino et al.	US EPA
2:45 PM	Regression-Based Rainfall-Runoff Modeling of Semi-Arid Ephemeral Watersheds: Analysis of High Resolution Long-Term Rainfall and Nested Watershed Properties in Walnut Gulch	Menberu M. Bitew et al.	USDA-ARS
3:00 PM	Modeling Impacts of Inter-Basin Transfers on Water Supply Distribution for National Forest Lands and the Conterminous United States	Kai Duan et al.	University of Minnesota
3:15 PM	Rangeland Watershed Research for the West	Philip Heilman et al.	USDA-ARS
3:30 PM – 4:00 PM	**Coffee Break**	**Instructional East and West Foyers**	
4:00 PM	Comparison of the Critical-Depth Method with Conventional Indirect Methods of Computing Peak Discharge in Mountain Streams: Evaluation of the 2013 Flood in the Colorado Front Range	Robert Jarrett	U.S. Geological Survey (Retired)
4:15 PM	Modeling Urban Hydrology and Green Infrastructure using the AGWA Urban Tool and the KINEROS2 Model	Yoganand Korgaonkar et al.	University of Arizona
4:30 PM	Mapping Stream and Floodplain Geomorphic Characteristics with the Floodplain and Channel Evaluation Toolkit (FACET)	Marina Metes et al.	U.S. Geological Survey
4:45 PM	Integrating LiDAR Data and Google Earth Engine for Mapping Watershed-Scale Wetland Hydrological Dynamics	Qiusheng Wu and Charles Lane	Binghamton University

Sixth ICRW Detailed Concurrent Sessions

Tuesday, July 24, 2018			
2:00 PM – 5:30 PM	Watershed Research and Management in a Changing Climate	Instructional East 105	
Moderator	Tanya Spero (US EPA)	Presenter	Affiliation
2:00 PM	Projecting Regional Climate Change for Air Quality and Water Quality Applications	Tanya Spero et al.	US EPA
2:15 PM	Developing Intensity-Duration-Frequency (IDF) Curves from Modeled Meteorological Fields to Inform Storm Water Management under Future Scenarios	Anna Jalowska & Tanya Spero	US EPA
2:30 PM	Soil Moisture Scaling Function Development for the Little River Experimental Watershed	Michael H. Cosh et al.	USDA – ARS
2:45 PM	Impacts of Potential Changes of Land Use, Climate, and Water Use for Water Availability, Coastal Carolinas	Ana Maria Garcia and Laura Gurley	U.S. Geological Survey
3:00 PM	QSWAT Modeling for Forecasting Hydrologic Behavior in a Coastal Forested Watershed in the Global Climate Change Setup	Sudhanshu Panda et al.	University of North Georgia
3:15 PM	Can Mountainous Terrain within Puerto Rico Buffer the Projected Subtropical Precipitation Decline?	Jared Bowden et al.	North Carolina State University
3:30 PM – 4:00 PM	**Coffee Break**	**Instructional East and West Foyers**	
4:00 PM	The Value of Long-Term Research at USGS Research Watersheds	James Shanley et al.	U.S. Geological Survey
4:15 PM	Trends in Water Yield Under Climate Change and Urbanization in the U.S. Mid-Atlantic Region	Glenn Moglen et al.	USDA – ARS
4:30 PM	Implications of Climate and Emissions Changes on Atmospheric Nitrogen Deposition to the Chesapeake Bay Watershed	Patrick Campbell et al.	US EPA
4:45 PM	Thirty Years of Phosphorus Dynamics in Nine Watersheds Contributing to the Chesapeake Bay	Karen Rice and Aaron Mills	U.S. Geological Survey
5:00 PM	Climate Change in West Virginia and Implications for Appalachian Food Deserts	Evan Kutta et al.	West Virginia University
5:15 PM	Why Is There So Much Mercury in Permafrost? When and Where Will It Go If It Thaws?	Paul Schuster et al.	U.S. Geological Survey

Sixth ICRW Detailed Concurrent Sessions

Tuesday, July 24, 2018			
2:00 PM – 5:30 PM	**Wetland Trends in Coastal Watersheds: Drivers, Effects, and Adaptive Management**	**Instructional East 103**	
Moderator	**Megan Lang (US Fish and Wildlife Service)**	**Presenter**	**Affiliation**
2:00 PM	Calculating the Economic Benefits of Coastal Wetlands	Susan-Marie Stedman	U.S. Fish and Wildlife Service
2:15 PM	Coastal Wetland Resource Change and Drivers as Quantified by the National Wetlands Inventory Wetlands Status and Trends Project	Megan Lang et al.	U.S. Fish and Wildlife Service
2:30 PM	The Interagency Coastal Wetlands Workgroup: Exploring Challenges and Opportunities in Coastal Wetland Management	Jennifer Linn and Dominic MacCormack	US EPA
2:45 PM	Increased Hydrologic Connectivity: Consequences of Reduced Water Storage Capacity in the Delmarva Peninsula (U.S.)	Daniel McLaughlin et al.	Virginia Tech
3:00 PM	Assessment of Wetland Conservation Program Effectiveness in the Mid-Atlantic Lower Coastal Plain Region of the U.S.	Greg McCarty et al.	USDA-ARS
3:15 PM	Effects of Climate Change on Coastal Wetlands: Adaptive Management Case Studies from the National Wildlife Refuge System	Scott Covington & Kurt Johnson	U.S. Fish and Wildlife Service
3:30 PM – 4:00 PM	**Coffee Break**	**Instructional East and West Foyers**	
4:00 PM	Dynamic Surface Water Extent (DSWE): An Operational Satellite-Based Product for the Synoptic Assessment of More Than 30 years of Intra-Annual Variations in Watershed and Wetland Inundation	John Jones	U.S. Geological Survey
4:15 PM	Evaluating Recent Landsat-Based Map Products for Surface Water and Wetland Information	Zhiliang Zhu	U.S. Geological Survey
4:30 PM	Quantifying Wetland Inundation Dynamics in Coastal Watersheds Using Virtual Constellations of Optical and Radar Earth Observation Satellites	Ben DeVries et al.	University of Maryland
4:45 PM	**PANEL**: Wetland Trends in Coastal Watersheds: Drivers, Effects, and Adaptive Management		

Sixth ICRW Poster Session

Tuesday, July 24, 2018		
6:30 PM – 8:30 PM	ICRW POSTER SESSION	NCTC GALLERY
Poster #	Poster Title	Presenter & Affiliation
1	Literature-Based Synthesis of Nutrient Stressor-Response Relationships to Inform Assessment, Monitoring, and Criteria Development in Rivers and Streams	Micah Bennett (US EPA) et al.
2	CUAHSI Data Services: Tools and Cyberinfrastructure for Water Data Publication, Discovery, Research, and Collaboration	Liza Brazil (CUAHSI)
3	Impacts of Mountaintop Removal Coal Mining on Carbon and Nitrogen Cycling in West Virginia Headwater Streams	Roger Burke (US EPA) et al.
4	Effects of Large Wildfires on Water Quality and Water Quantity in the Southern Appalachians	Peter Caldwell (US Forest Service) et al.
5	Partnerships for Wetlands Restoration – the USFWS Coastal Program	Chris Darnell (US Fish and Wildlife Service) et al.
6	Soil Health, Soil Quality, Soil Indicators, and How the Bureau of Land Management (BLM) Uses Soil Information	Scott Davis (BLM)
7	Use of Coupled Three-Dimensional Hydrodynamic and Water-Quality Models to Simulate Nutrient and Phytoplankton Dynamics in the Barnegat Bay-Little Egg Harbor Estuary, New Jersey	Vincent DePaul (U.S. Geological Survey) et al.
8	Application of the Automated Geospatial Watershed Assessment Tool (AGWA)	Philip Guertin (University of Arizona) et al.
9	Modeling Mitigation Activities in North Carolina Watersheds	Laura Gurley and Ana Maria Garcia (U.S. Geological Survey)
10	Manure and Fertilizer Inputs to Land in the Chesapeake Bay Watershed, 1950-2012	Jeni Keisman (U.S. Geological Survey) et al.
11	*Rhododendron maximum* Removal Affects Tree Water Use, Herbaceous-Layer Vegetation and Tree Seedling Recruitment	Chelcy Miniat (US Forest Service) et al.
12	Hydrologic and Vegetation Management Influence Oxygen Dynamics, Nitrogen Processing, and Inform Water Management in Agroecosystems	Rachel Nifong (USDA-ARS) et al.
13	Land-Use-Mediated *Escherichia coli* Regimes in an Appalachian Watershed	Fritz Peterson (West Virginia University) et al.

Sixth ICRW Poster Session

14	Dissolved Organic Matter Composition in a Small Agricultural Watershed in the Atlantic Coastal Plain, Georgia, USA	Oliva Pisani (USDA-ARS) et al.
15	Modeling Drivers of Phosphorus Loads in Chesapeake Bay Tributaries and Inferences About Long-Term Change	Karen Ryberg (U.S. Geological Survey) et al.
16	Potential to Use Diatom Assemblage Responses to Inform Nutrient Reduction Benchmarks for Improving Water Quality in Mississippi Alluvial Plain Streams	Jason Taylor and Matthew Hicks (USDA-ARS)
17	Factors Affecting the Extent of Tidal Freshwater Wetlands and Associated Biogeochemical Functions	Carl Trettin (US Forest Service) et al.
18	Watershed-Scale Effects of Longleaf Pine Restoration on Water Yield and Carbon	Carl Trettin (US Forest Service) et al.
19	Simulations of Hydrology and Water Quality for Irrigated Fields Near Yakima, Washington	Rick Webb (U.S. Geological Survey)
20	A Continental-Scale Assessment of Soil Moisture Monitoring of Forest and Grassland Ecosystems in the United States	Cynthia West (US Forest Service) et al.
21	Hydrology of a Sugarcane Production System and Associated Ecosystem Services	Paul White (USDA-ARS)

Sixth ICRW Detailed Concurrent Sessions

Thursday, July 26, 2018			
10:00 AM – 12:00 PM	**Using Long-term Data on Assessing Extreme Climatic Events Effects on Watershed Processes, Functions and Management Practices**	**Instructional West 160**	
Moderators	**Jami Nettles (Weyerhaeuser Company), Devendra Amatya (USFS), and Taehee Hwang (USFS)**	**Presenter**	**Affiliation**
10:00 AM	Warming Temperature Homogenizes Landscape Vegetation Patterns at the Catchment Scale	Taehee Hwang et al.	Indiana University
10:15 AM	“The Storm Was Downright Weird”: Understanding the December 2007 Storm in Southwest Washington Using Short- and Long-term Hydro-Climatic Data	Maryanne Reiter and Jami Nettles	Weyerhaeuser Company
10:30 AM	Hydrologic Impacts of Extreme Precipitation Events on a Low Gradient Coastal Plain Watershed	David Bosch	USDA-ARS
10:45 AM	Potential Impacts of Extreme Precipitation Events on Peak Discharges at USDA Forest Service Long-term Experimental Watersheds	Shiying Tian et al.	North Carolina State University
11:00 AM	The Role of Drought in the Post-Harvest Hydrologic Recovery of a Rain-Dominated Forested Watershed	Elizabeth Keppeler et al.	US Forest Service
11:15 AM	Automated Geospatial Model Based Assessment of Erosion Vulnerability at Forest Road/Stream Crossings under Extreme Precipitation Intensities Scenario	Johnny Grace et al.	University of North Georgia
11:30 AM	Sierra Nevada Streamflow Response to Forest Fuels Treatments During the California Drought	Ryan Bart et al.	University of California – Merced
11:45 AM	Open		

Sixth ICRW Detailed Concurrent Sessions

Thursday, July 26, 2018			
10:00 AM – 12:00 PM	**Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales II (Thursday Presentations)**	**Instructional West 151**	
Moderators	**Ana Garcia and Jennifer Keisman (U.S. Geological Survey)**	**Presenter**	**Affiliation**
10:00 AM	EPA's EcoService Models Library (ESML): A New Tool for Quantifying and Valuing Ecosystem Services	Tammy Newcomer-Johnson et al.	US EPA
10:15 AM	Quantifying Floodplain Ecosystem Services	Kristina Hopkins et al.	U.S. Geological Survey
10:30 AM	EPA's ENVIROATLAS: Indicators for Working Watersheds	Anne Neale	US EPA
10:45 AM	Looking for Solutions to Water Quality Problems in the Chesapeake Bay Watershed: What Does Water Quality Trading Have to Offer	Patricia Gleason	US EPA Region 3
11:00 AM	The Urban Waters Program: A Platform for Actionable Science to Improve Cities and Their Waterways	Steve Terracciano et al.	U.S. Geological Survey
11:15 AM	Scaling Green Infrastructure to Watersheds: Current Insights and Future Directions	Heather Golden et al.	US EPA
11:30 AM	Tracking Flows of Water Through a Complex Urban System: Chicago	Laura Erban et al.	US EPA
11:45 AM	Open		

Sixth ICRW Detailed Concurrent Sessions

Thursday, July 26, 2018			
10:00 AM – 12:00 PM	Water Quality Research in the Appalachia Region	Instructional East 105	
Moderator	Jason Hubbart (West Virginia University)	Presenter	Affiliation
10:00 AM	The Experimental Watershed Study Approach to Monitoring and Managing Contemporary Mixed-Land-Use Watersheds	Jason Hubbart and Elliott Kellner	West Virginia University
10:15 AM	USEPA's OpenTERRAworks Software System - An Open-Source 2D/3D Landscape Design GIS Tool	Justin Babendreier	US EPA
10:30 AM	Cumulative Effects of Unconventional Oil and Gas Development on the Chemistry of Headwaters Within West Virginia	Kevin Eliason et al.	West Virginia University
10:45 AM	The Effects of Off-Highway Vehicles on Stream Water Quality in the North Fork of the Broad River	Chelcy Miniat et al.	US Forest Service
11:00 AM	Human Dimensions of Water Quality: A West Virginian Case Study	Jonas Levêque and Robert Burns	West Virginia University
11:15 AM	Characterization of Sub-Watershed-Scale Stream Chemistry Regimes in an Appalachian Mixed-Land-Use Watershed	Elliott Kellner et al.	West Virginia University
11:30 AM	**PANEL**: Water Quality Research in the Appalachia Region		

Sixth ICRW Detailed Concurrent Sessions

Thursday, July 26, 2018			
10:00 AM – 12:00 PM	**Waters at the Border – Science, Management, and Policy Challenges for Transboundary Watersheds**	**Instructional East 201**	
Moderators	**Jana Compton (US EPA), Jiajia Lin (US EPA/NRC), and Jill Baron (USGS)**	**Presenter**	**Affiliation**
10:00 AM 10:15 AM	Eutrophication Management in the Baltic Sea – A Partial Success?	Michelle McCrackin	Stockholm University
10:30 AM	P-Optimal Wetlands: Assessing the Capacity of Wetlands to Improve Water Quality in Great Lakes Agricultural Watersheds	Scott Bell et al.	LimnoTech
10:45 AM	Nitrogen inventories in the Nooksack-Fraser Transboundary Watershed: North American demonstration for the International Nitrogen Management System	Jiajia Lin et al.	US EPA/NRC
11:00 AM	Using Multi-media Modeling to Investigate Conditions Leading to Harmful Algal Blooms	Valerie Garcia et al.	US EPA
11:15 AM	**PANEL:** Waters at the Border – Science, Management, and Policy Challenges for Transboundary Watersheds		

Sixth ICRW Detailed Concurrent Sessions

Thursday, July 26, 2018			
10:00 AM – 12:00 PM	Watershed Evapotranspiration in a Changing Environment	Instructional East 107	
Moderators	Ge Sun and Devendra Amatya (US Forest Service)	Presenter	Affiliation
10:00 AM	Evaporative Demand and Drought: Dynamics and Opportunities in Early Warning and Monitoring	Mike Hobbins et al.	NOAA
10:15 AM	Is Potential Evapotranspiration Increasing? A Comparison of Estimation Methods to Long-Term Measurements	Peter Caldwell et al.	US Forest Service
10:30 AM	Effects of Forest Composition on Components of Evapotranspiration in a Mature, Southern Appalachian Forest	A. Christopher Oishi et al.	US Forest Service
10:45 AM	Investigating Impacts of Drought and Disturbance on Landscape Evapotranspiration Using High Spatiotemporal Resolution Data	Yun Yang et al.	USDA-ARS
11:00 AM	Response of Evapotranspiration to Drought and Management in Loblolly Pine Forests on the Lower Coastal Plain in North Carolina	Ge Sun et al.	US Forest Service
11:15 AM	**PANEL**: Watershed Evapotranspiration in a Changing Environment		

Abstracts – Organized by Session

Literature-Based Synthesis of Nutrient Stressor-Response Relationships to Inform Assessment, Monitoring, and Criteria Development in Rivers and Streams

Author(s): Micah Bennett, Kate Schofield, Sylvia Lee, David Gibbs, Caroline Ridley, and Susan Norton

Affiliation(s): U.S EPA

Abstract: Eutrophication from nitrogen and phosphorus pollution is a major stressor of freshwater ecosystems globally. Despite recognition of this problem by scientists and stakeholders, synthesis of scientific evidence is still needed to inform nutrient-related management decisions and policies, especially for streams and rivers. A rigorous assessment of what is known about nutrient-stressor response relationships and modifying factors is a critical first step for identifying, managing, and restoring aquatic resources impaired by eutrophication. We conducted systematic reviews of the literature that asked: “What are the responses of chlorophyll-a, diatoms, and macroinvertebrates to TN and TP concentrations in lotic ecosystems,” and “how are these relationships affected by other factors?” We describe the reviews and discuss preliminary results based on the ~300 publications documenting cause-effect relationships between relevant nutrients and endpoints that were obtained after screening >22,000 publications from academic databases, and >4000 from other sources, for relevance, duplication, and quantitative effect sizes. These reviews provide a state-of-the-science body of evidence for assessing nutrient impacts to the most widely-used indicators of biological responses to nutrients. Disclaimer: Views expressed are the authors’ and not views or policies of the U.S.EPA.

CUAHSI Data Services: Tools and Cyberinfrastructure for Water Data Publication, Discovery, Research, and Collaboration

Author(s): Liza Brazil

Affiliation(s): CUAHSI

Abstract: Enabling research surrounding interdisciplinary topics often requires a combination of finding, managing, and analyzing large data sets and models from multiple sources. This challenge has led the National Science Foundation to make strategic investments in developing community data tools and cyberinfrastructure that focus on water data, as it is central need for many of these research topics.

CUAHSI (The Consortium of Universities for the Advancement of Hydrologic Science, Inc.) is a non-profit organization funded by the National Science Foundation to aid students, researchers, and educators in using and managing data and models to support research and education in the water sciences. This presentation will focus on two free and open-source CUAHSI-operated tools that enable: (1) enhanced data discovery online from multiple sources using advanced searching capabilities and (2) flexible publishing tools to easily share products resulting from research and/or data collection.

Impacts of Mountaintop Removal Coal Mining on Carbon and Nitrogen Cycling in West Virginia Headwater Streams

Author(s): Roger Burke, Ken Fritz, and Brent Johnson

Affiliation(s): US EPA Office of Research and Development

Abstract: Soil and vegetation disturbance associated with mountaintop removal and valley fill (MTR/VF) coal mining have the potential to alter carbon and nitrogen cycling in headwater streams. To assess this possibility, we measured sediment denitrification enzyme activity (DEA), sediment oxygen demand (SOD) and the concentration and stable carbon isotopic composition of dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) in stream water during fall, winter, spring, and summer sampling campaigns. Our measurements were conducted in 5 streams that drained nearly 100 % forested land and 5 streams that were heavily impacted by MTR/VF operations in the Twentymile Creek watershed, West Virginia (USA). We found that sediment DEA was greater and SOD lower in the MTR/VF streams than in the forested streams, but the differences were not statistically significant. We observed a weak but statistically significant correlation between DEA and SOD ($r^2 = 0.19$, $p < 0.01$). Correlation of similar strength between denitrification rate and SOD has been observed by others in aquatic sediments from various freshwater and marine environments and suggests coupling between carbon cycling and denitrification. DIC concentrations and stable carbon isotopic compositions were significantly greater in the MTR/VF streams than in respective forested streams, likely reflecting enhanced carbonate weathering accompanying MTR/VF disturbance. Although the differences were not statistically significant, DOC concentrations and stable carbon isotopic compositions were slightly greater in MTR/VF than in forested streams, likely indicating mobilization of either geogenic carbon (e.g., coal) or highly weathered soil organic matter from deep in the soil profile. Given the massive disturbance to the terrestrial ecosystem caused by MTR/VF mining, the apparently modest impacts of mining on sediment DEA and SOD suggest that carbon and nitrogen cycling in these streams may be more controlled by local (i.e., riparian) organic matter inputs than by processes occurring in the watershed as a whole.

Effects of Large Wildfires on Water Quality and Water Quantity in the Southern Appalachians

Author(s): Peter Caldwell, K.J. Elliott, J.D. Knoepp, D.R. Zietlow, J.M. Vose, P.V. Bolstad, C.F. Miniat

Affiliation(s): USDA Forest Service, Southern Research Station, Coweeta Hydrologic Laboratory

Abstract: Wildfires are landscape scale disturbances that can significantly impact hydrologic processes such as surface runoff, sediment yield, and sediment and nutrient transport to streams. In Oct and Nov 2016, unprecedented, large, drought-related wildfires (ranging from 1200 to 9700 hectares) of mixed-severity burns occurred across the southern Appalachian Mountains. We established sites in three burned and three nearby unburned, reference watersheds with the former having a mosaic of moderate and high severity fires. Our objective was to evaluate the impact of fire severity on tree mortality, stream water quality (temperature, chemistry and sediment) and quantity (yield, peak flows, and base flows). We hypothesized that wildfires would result in tree mortality, soil O-horizon consumption, greater stormflow and nutrient and sediment export compared to reference watersheds. We measured immediate and delayed tree mortality in permanent plots, stream stage and water temperature, NO_3 and NH_4, and sediment as total suspended solids (TSS) during baseflow and storm events.

Tree mortality due to the wildfires averaged 27, 27.5, and 34 % across the three burned watersheds. Plots ranged in burn severity with up to 100% tree mortality and 100% soil O-horizon removal. Soil inorganic nitrogen (NH_4 + NO_3) concentrations increased with increasing burn severity ($R^2 = 0.29$, $P < 0.001$). Stream nitrate (NO_3-N) concentrations were elevated in burned watersheds (mean 0.07 mg L^{-1}) relative to unburned watersheds (mean 0.02 mg L^{-1}); mean monthly NO_3-N in the most severely burned watershed reached 0.27 mg L^{-1}, well above the maximum monthly NO_3-N in unburned watersheds (0.06 mg L^{-1}). During storm events, stream NO_3-N concentrations in burned watersheds increased up to 300%, while unburned watersheds were less flow dependent. The flow-dependent stream NO_3-N concentrations in burned watersheds will result in greater NO_3-N export relative to unburned watersheds. Mean stream TSS concentrations were lower in burned (17.5 mg L^{-1}) than unburned (28.6 mg L^{-1}) watersheds under baseflow conditions; however, TSS concentrations collected during storm events in burned (max 9353 mg L^{-1}) greatly exceeded concentrations in unburned (max 787 mg L^{-1}) watersheds. The 2016 wildfires have thus degraded forest condition and water quality particularly during storm events.

Partnerships for Wetlands Restoration – the USFWS Coastal Program

Author(s): Chris Darnell, Samantha Brooke, Chris Eng

Affiliation(s): U.S. Fish and Wildlife Service

Abstract: Wetlands are the cornerstone of many important and complex ecosystems. Their health and distribution in watersheds provide countless benefits for fish, wildlife, and people. The USFWS Coastal Program and its partners restore wetlands, protect coastal habitats through easements, remove impediments to fish passage, and restore riparian habitat. The Coastal Program has decades of experience working on public (local, state, and federal, including National Wildlife Refuges) and private lands to align DOI, Service, and partner conservation goals and bring strategic landscape conservation to the wider conservation community. To accomplish this, our locally-based field staff works with an extensive and diverse partner network to implement on-the-ground habitat restoration projects, provide technical assistance, and build conservation capacity. Over the past decade, the Coastal Program has worked with thousands of partners to design over 4,000 habitat improvement projects addressing shared conservation goals. Through our high leveraging ratio we bring non-federal resources to the table and enlist partner support to achieve shared conservation goals. This poster will present several cases studies of successful wetland restoration, research, and management partnership projects.

Soil Health, Soil Quality, Soil Indicators, and How the Bureau of Land Management (BLM) Uses Soil Information

Author(s): Scott Davis

Affiliation(s): Bureau of Land Management

Abstract: By understanding that the living ecosystem diversity of soils is far greater than above-ground systems the BLM is re-engineering its strategy to be more responsive to the agency and public needs, including addressing the frequent wildfires that are impacting our sagebrush landscapes in the western United States. The Landscape Approach is a process to assist in establishing our land use planning goals and objectives in assessing and measuring our resource conditions. These steps are followed by monitoring to determine if mitigations and adaptations are needed for plan conformance.

The National Cooperative Soil Survey contains vital data for all levels of BLM's activities, programs, and initiatives addressing our landscapes and land health. It is the foundation of BLM's Assessment, Inventory, and Monitoring (AIM) process which collects the status, condition, trends, amount, location, and spatial distribution of our renewable resources. The key is our partnership with the Natural Resources Conservation Service that informs us on how soils form, their importance and how to use soils information.

Soil health is related to soil quality and land health. Soil quality and soil health are tied to BLM's land health standards, with the appropriate soil quality indicators related to the soil survey and ecological site descriptions and state transition models. Soil quality and soil quality indicators measures functions and can be a chemical, physical or biological property of a soil that is sensitive to disturbance and represents performance of an ecosystem's function. Indicators are dynamic soil properties to evaluate how well soil functions since soil function often cannot be directly measured. Hence, measuring soil quality involves identifying soil properties that respond to management, are correlated with environmental outcomes, and can be easily observed. They are chosen because they correlate with ecosystem processes, integrate soil physical, chemical, and biological properties, are accessible, observable to many users, are sensitive to management & climate, are components of existing databases, and are interpretable. For rangeland-forest health, indicators are used with management practices that manipulate vegetation, or after fire, disturbance, i.e. chemical / physical treatments, seeding, planting, etc.

In summary, soil quality indicators are important because they:
1. Help the BLM's meet its mission of land sustainability
2. Help BLM meet its land management objectives
3. Help with soil assessment methods, tools
4. To specifically assess BLM's land health standards

Use of Coupled Three-Dimensional Hydrodynamic and Water-Quality Models to Simulate Nutrient and Phytoplankton Dynamics in the Barnegat Bay-Little Egg Harbor Estuary, New Jersey

Author(s): Vincent DePaul, Frederick J. Spitz, Zafer Defne, Tim Wool, Jeffrey M. Fischer, and Mary M. Chepiga

Affiliation(s): U.S. Geological Survey, New Jersey Water Science Center

Abstract: A coupled three-dimensional hydrodynamic water-quality model is applied to the Barnegat Bay-Little Egg Harbor Estuary to better define the nutrient cycling processes and phytoplankton dynamics, as well as, to provide a tool to simulate estuarine response to external stressors. The water-quality model was calibrated to observational data collected in 2012 for dissolved oxygen, total chlorophyll a, and nitrogen and phosphorus species, and validated with an independent data set collected in 2012. A near-natural condition simulation, with reduced watershed loading representing conversion of developed land to forest, was run using the coupled models.

Comparisons of 2012 measured and simulated data show that water-quality distribution patterns are adequately reproduced throughout the system. Analysis of simulated nitrogen concentrations indicate broad areas of moderate to substantial impairment throughout the north, consistent with in-bay measured data and estimated loading from the watershed. Simulated chlorophyll a concentrations of 10 µg/L or greater, indicative of a eutrophic estuary, are widespread throughout the northern segment of the estuary. Simulated total and dissolved inorganic phosphorus concentrations increase along the salinity gradient from north to south. Simulated dissolved oxygen concentrations, while moderately higher than observed data in the surface layer, are consistent with monitored seasonal and spatial trends. Results also indicate that while the system is primarily nitrogen-limited, phosphorus limitation can occur in areas of the northern segment where inorganic nitrogen loading is substantial.

Results from the near-natural condition simulation indicate significant differences in bay-water quality from the 2012 baseline simulation, with the largest differences in the north where estimated load reductions are greatest. Differences in summertime depth averaged water–column concentrations are most significant for total nitrogen and dissolved nitrate, which decreased by approximately 15 and 60 percent, respectively, when averaged throughout the estuary, and by 30 and 87 percent, when averaged throughout the northern segment. Simulated total chlorophyll a concentrations are 36 percent lower throughout the estuary and are 64 percent lower in the northern segment. Simulated near-natural total phosphorus concentrations showed little difference from baseline conditions. Results also indicate little change in simulated dissolved oxygen concentrations, suggesting the importance of sediment diagenesis (or other factors) to oxygen availability in the system.

Application of the Automated Geospatial Watershed Assessment Tool (AGWA)

Author(s): D. Philip Guertin (University of Arizona), David C. Goodrich (USDA -ARS), I. Shea Burns (UA), Yoganand Korgaonkar (UA), Jane Barlow (UA), Benjamin Olimpio (UA), Carl Unkrich (USDA-ARS), William Kepner (U.S. EPA)

Abstract: The Automated Geospatial Watershed Assessment tool (AGWA, see: https://www.epa.gov/water-research/automated-geospatial-watershed-assessment-agwa-tool-hydrologic-modeling-and-watershed or www.tucson.ars.ag.gov/agwa) is a GIS interface jointly developed by the USDA-Agricultural Research Service, the U.S. Environmental Protection Agency, the University of Arizona, and the University of Wyoming to automate the parameterization and execution of a suite of hydrologic and erosion models (RHEM, KINEROS2 and SWAT). Through an intuitive interface the user selects an outlet from which AGWA delineates and discretizes the watershed using a Digital Elevation Model (DEM). The watershed model elements are then intersected with terrain, soils, and land cover data layers to derive the requisite model input parameters. The chosen model is then run, and the results are imported back into AGWA for graphical display. AGWA results from multiple simulations can be used to examine relative change over a variety of input scenarios (e.g. climate/storm change, land cover change, implementation of BMPs, present conditions and alternative futures). This allows managers to identify potential problem areas where additional monitoring can be undertaken or mitigation activities can be focused. Application examples of AGWA will be presented including post-fire assessment, implementation of rangeland BMPs, green infrastructure, and future change analysis. Versions of AGWA are available for ESRI ArcGIS 9.x, 10.x, and Pro.

Modeling Mitigation Activities in North Carolina Watersheds

Author(s): Laura Gurley and Ana Maria Garcia

Affiliation(s): U.S. Geological Survey

Abstract: The North Carolina Department of Environmental Quality (NCDEQ) has implemented several strategies for basin-wide nutrient management, yet gaps remain in understanding the complexities of nutrient and sediment transport. In particular, improved assessment of the status of nutrient loadings to lakes and estuaries is needed, including characterizing nutrient and sediment sources, relative contributions, and identifying additional monitoring needs. In addition, the NCDEQ Division of Mitigation Services (DMS) uses watershed planning to identify the best locations to implement stream, wetland, and riparian-buffer restoration. As part of this process, DMS develops River Basin Restoration Priority (RBRPs) plans to identify priorities for the protection and restoration of water quality. To better understand the influences of human activities and natural processes on surface-water quality, the U.S. Geological Survey (USGS) developed the SPARROW (SPAtially Referenced Regressions On Watershed attributes) (Schwarz and others, 2006; Alexander and others, 2008) modeling framework to relate water-quality monitoring data to upstream sources and watershed characteristics that affect the fate and transport of constituents to receiving surface-water bodies. The core of the model consists of using a nonlinear-regression equation to describe the non-conservative transport of contaminants from point and nonpoint sources on land to rivers, lakes and estuaries through the stream and river network. A SPARROW modeling framework is being developed specifically for North Carolina to support decision-making for watershed restoration activities. In this presentation we illustrate the process, showcasing specific restoration datasets and activity metrics such as extent of riparian buffer and easements. We also present preliminary results for incorporated as explanatory variables in the baseline total N, total P, and TSS NC-SPARROW models.

Manure and Fertilizer Inputs to Land in the Chesapeake Bay Watershed, 1950-2012

Author(s): Jeni Keisman, Olivia H. Devereux, Andrew E. LaMotte, Andrew J. Sekellick, Joel D. Blomquist

Affiliation(s): U.S. Geological Survey

Abstract: Understanding changing nutrient concentrations in surface waters requires quantitative information on changing nutrient sources in contributing watersheds. For example, the proportion of nutrient inputs reaching streams and rivers is directly affected by when and where those nutrients enter the landscape. The goal of this report is to contribute to the U.S. Geological Survey's efforts to describe spatial and temporal patterns in nutrient inputs to the landscape in the Chesapeake Bay watershed, thereby informing efforts to understand changes in riverine and estuarine conditions. The magnitude, spatial variability, and changes over time in nutrient inputs from manure and fertilizer were evaluated in the context of changes in land use and agricultural practices from 1950 through 2012 at three spatial scales: the entire Chesapeake Bay watershed, the 53 8-digit Hydrologic Unit Codes (HUC8s) contained within the watershed, and a set of 7 regions that were determined by aggregating geographically similar HUC8s. The expected effect of agricultural Best Management Practices (BMPs) on agricultural nutrient inputs from 1985 through 2012 was also investigated. Nitrogen (N) and phosphorus (P) inputs from manure increased gradually over time at the scale of the entire watershed. Fertilizer-N inputs showed steeper increases, with greater inter-annual fluctuations. Fertilizer-P inputs were less variable, increasing moderately from 1950 through the mid-1970s, and declining thereafter. Nutrient inputs and farming practices varied geographically within the watershed, with implications for the potential impact of these inputs on downstream water quality and ecosystem health. Temporal and spatial patterns in the intensity of agricultural nutrient inputs were consistent with the magnitude and concentration of livestock populations and the intensity of row crop agriculture. Reported implementation of the animal and land- use change BMPs that were evaluated were expected to have little effect on agricultural N inputs. Animal BMPs were expected to have a more measurable impact on manure-P inputs, particularly in areas with large poultry populations. Understanding these patterns is important for explaining the changes that have been observed in nutrient loads to the rivers and streams of the Chesapeake Bay watershed, and their impacts on the water quality and ecosystem health of Chesapeake Bay itself.

Rhododendron maximum Removal Affects Tree Water Use, Herbaceous-Layer Vegetation and Tree Seedling Recruitment

Author(s): Chelcy F. Miniat, Sandra N. Hawthorne, Tristan M. Cofer

Affiliation(s): USDA Forest Service, Southern Research Station, Center for Forest Watershed Research, Coweeta Hydrologic Laboratory

Abstract: Forest ecosystems dominated by eastern hemlock (*Tsuga canadensis*) are undergoing fundamental changes in function and composition from infestations of hemlock woolly adelgid (*Adelges tsugae*). We proposed that the first step to restoring southern Appalachian riparian forests following hemlock mortality is eliminating the evergreen shrub, *Rhododendron maximum*. We hypothesized that removing the dense rhododendron subcanopy would increase light transmittance, soil moisture and temperature; and subsequently, enhance herbaceous-layer diversity, promote tree seedling recruitment, and increase water use of remaining hardwood trees. Treatments were designed to remove only rhododendron (CR), remove rhododendron and organic soil (CFFR), and untreated, reference (REF). We installed permanent plots across treatments and locations and measured light transmittance, soil water content (SWC), herbaceous-layer cover and diversity (Shannon's index and species richness), tree seedling recruitment, and overstory tree daily transpiration (Et).

As expected, cutting the rhododendron subcanopy (CR and CFFR) immediately increased light transmittance in the spring months across locations, and increased SWC in the CFFR. Cutting without partially removing the organic soil layers (CR) did not significantly alter SWC. Herbaceous-layer cover and diversity increased on CR and CFFR. Herbaceous-layer cover was related to light and SWC, while diversity was only related to light. Tree seedling density was significantly related to SWC ($R = 0.602$, $P < 0.001$), but not to light transmittance ($R = 0.130$, $P = 0.363$). Tree seedling density was low before treatment (1.8±0.2 seedlings/m2) and increased to 24.5±5.8 and 21.8±3.2 seedlings/m^2 two growing seasons after treatment, CR and CFFR, respectively. Tree seedling recruitment ranked *Betula* spp. > *A. rubrum* > *L. tulipifera*. These species likely recruited quickly because they maintain a viable seed bank under a rhododendron subcanopy. The first growing season after treatment (2016), a relatively dry summer/fall, the mean daily transpiration (Et) of hardwood trees was 24% greater in CFFR than REF (t-test, $P < 0.05$). In 2017, a wetter summer/fall, Et was again greater for most tree species in CFFR. These vegetation responses have important implications for potential recovery of riparian forests following hemlock mortality.

Hydrologic and Vegetation Management Influence Oxygen Dynamics, Nitrogen Processing, and Inform Water Management in Agroecosystems

Author(s): Rachel Nifong, Jason M. Taylor, and Lindsey Yasarer

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Abstract: With increasing consumer demand for sustainable agricultural production and continued concern for coastal economies, excess nitrogen (N) runoff from agricultural areas remains a major challenge to reducing the environmental footprint of high intensity agriculture. To address this challenge, producers need simple and innovative approaches that reduce runoff from agricultural fields while maintaining high productivity. Agricultural ditches act as the primary water-soil interface on farms and are a pivotal, but currently underutilized, location to implement low-cost management practices to increase both on-farm and landscape-scale mitigation of excess N runoff. To date, studies evaluating management practices in Lower Mississippi River Basin ditches have relied on small scale mesocosms and core based methods. Yet it is unclear how these studies inform larger scale observations that incorporate diel patterns in light and temperature which can influence primary production, oxygen (O^2) dynamics, and related N processing. To examine larger spatial and temporal scales, we explored how hydrologic and vegetation management practices interact to influence diel N and O^2 dynamics by manipulating hydrologic residence time and the presence of rice cutgrass (*Leersia oryzoides*) in six experimental ditches. We measured plant nutrient uptake, denitrification fluxes, and metabolism using in situ dissolved solute and gas sampling techniques over three 24 hour diel experimental runs. Results indicate that ditches with vegetation promote N retention and have more pronounced O^2 dynamics which can alter expected N removal pathways.

Land-Use-Mediated *Escherichia coli* Regimes in an Appalachian Watershed

Author(s): Fritz Peterson, Jason A. Hubbart, Elliott Kellner, Evan Kutta

Affiliation(s): West Virginia University, Davis College, Division of Plant and Soil Sciences

Abstract: Improved mechanistic understanding of the anthropogenic processes that result in pathogenic contamination of receiving waters is important for improved prediction, mitigation and prevention of water quality impairment due to land use practices. A high resolution experimental watershed sampling regime was implemented in the West Run Watershed, in Morgantown, WV. Daily grab samples were collected from six monitoring sites for six weeks (n=294). Samples were analyzed using Environmental Protection Agency (EPA) certified IDEXX methodology to determine *E. coli* concentration at each sampling location. The forested sub-catchment had the lowest mean value ($\bar{x}$ = 118.22) and the smallest standard deviation (σ = 186.12). The agricultural sub-catchment, had the highest mean value ($\bar{x}$ = 582.41) and highest standard deviation of (σ = 398.52) of all sites. There was a marked difference between the *E. coli* concentrations from different sites related to land use practices. Percent agricultural land cover was significantly ($p < 0.04$) correlated to the study average *E. coli* concentration. Results agree with previous studies that reported un-impacted areas are often associated with good water quality, whereas developed land uses (e.g. agriculture) can have detrimental impacts on water quality. This work advances scientific understanding of anthropogenic *E. coli* loads, thus advancing mitigation strategies and new development practices.

Dissolved Organic Matter Composition in a Small Agricultural Watershed in the Atlantic Coastal Plain, Georgia, USA

Author(s): Oliva Pisani, David D. Bosch, Alisa W. Coffin, Timothy C. Strickland

Affiliation(s): USDA-ARS

Abstract: Carbon cycling is an important process in agricultural systems and its accurate quantification is critical for designing effective 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. To build on an existing water quality monitoring program (ongoing since 1967) and as part of the Long Term Agroecosystem Research (LTAR) Network, bi-weekly water samples are being collected at sites located in the Little River Experimental Watershed (LREW) near Tifton, Georgia. The LREW (334 km^2) is situated in the headwaters of the Suwannee River Basin, in the Coastal Plain region of the southeastern USA. It includes heavily vegetated, slow-moving stream systems with broad flood plains, poorly defined stream channels and gently sloping uplands. The LREW is characterized by forested riparian buffers surrounding the streams and the land-use is primarily commercial forestry and agriculture, including tilled cropland and pasture, where the fields are irregularly shaped and relatively small (mean ~ 6.5 ha). Beginning in October of 2016, DOM characteristics of bi-weekly water samples from the LREW were assessed through the analysis of optical properties using UV-Vis and excitation-emission matrix fluorescence spectroscopy, coupled with parallel factor analysis. Here, we present the first year of optical measurement results obtained to elucidate the impact of different land-use and conservation practices on DOM composition and transport. The aim of this long-term study will be to characterize episodic and base flow relationships between DOM composition and precipitation, nutrient loads, land-use, and dissolved carbon transport in a small agricultural watershed.

Modeling Drivers of Phosphorus Loads in Chesapeake Bay Tributaries and Inferences About Long-Term Change

Author(s): Karen R. Ryberg, Joel D. Blomquist, Lori A. Sprague, Andrew J. Sekellick, Jennifer Keisman

Affiliation(s): U.S. Geological Survey

Abstract: Causal attribution of changes in water quality often consists of correlation, qualitative reasoning, listing references to the work of others, or speculation. To better support statements of attribution for water-quality trends, structural equation modeling was used to model the causal factors of total phosphorus loads in the Chesapeake Bay watershed. By transforming, scaling, and standardizing variables, grouping similar sites, grouping some causal factors into latent variable models, and using methods that correct for assumption violations, we developed a structural equation model to show how causal factors interact to produce total phosphorus loads. Climate (in the form of annual total precipitation and the Palmer Hydrologic Drought Index) and anthropogenic inputs are the major drivers of total phosphorus load in the Chesapeake Bay watershed. Increasing runoff due to natural climate variability is offsetting purposeful management actions that are otherwise decreasing phosphorus loading; consequently, management actions may need to be reexamined to achieve target reductions in the face of climate variability.

Potential to Use Diatom Assemblage Responses to Inform Nutrient Reduction Benchmarks for Improving Water Quality in Mississippi Alluvial Plain Streams

Author(s): Jason Taylor and Matthew Hicks

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Abstract: Anthropogenic alterations to large river floodplains disrupt natural disturbance regimes that maintain the ecological integrity of lowland stream ecosystems. Conversion of forested floodplains to intensive agriculture can also lead to excess nitrogen and phosphorus runoff from farms to stream networks. As a result, streams within large river floodplain regions are generally habitat limited, exposed to alterations of natural temporal and acute geomorphological and hydrologic regimes, and often experience widespread nutrient enrichment, all factors that limit development of field-derived stressor-response relationships for establishing nutrient reduction goals that promote ecological integrity. To address this, we sampled diatom assemblages from 25 streams that were located within the Mississippi Alluvial Plain (MAP) but drained portions of upstream ecoregions with greater variation in land management, and represented a measurable gradient in total phosphorus (TP) and nitrogen (TN). We collected epidendric diatom assemblage samples from instream woody debris, as this was the primary stable habitat for diatom colonization found within our study systems. Our regional nutrient gradient was skewed toward higher concentrations and ranges of previously reported diatom assemblage response thresholds indicative of oligotrophic conditions were not well represented. Despite this, ordination analysis identified a gradient in species composition associated with increasing TP and decreasing dissolved oxygen. Results indicated a significant shift in diatom assemblage structure associated with differences in TP between streams representing moderately and highly enriched conditions in MAP streams. The highly enriched systems were represented by a distinct set of indicator species. While our results do not address potential criteria for identifying high quality, oligotrophic streams, given the current regional context, using diatom assemblage responses has potential for helping set benchmarks to reduce nutrient impacts and monitor effects of agricultural best management practices within MAP streams.

Factors Affecting the Extent of Tidal Freshwater Wetlands and Associated Biogeochemical Functions

Author(s): Carl Trettin, Craig Allan, S. Panda, W. Tang, D. Amatya

Affiliation(s): USDA Forest Service

Abstract: Tidal freshwater wetlands (TFW) exist in low-gradient landscapes where the normal marine tide amplitude functionally dams freshwater discharge during the tidal cycle. The hydrologic effect is that the riparian zone of these tidal freshwater streams are continuously wet, never drying down which is common for many bottomland swamps on lower coastal plain flood plains. As a result, these soils should be wetter and have more reduced conditions than corresponding riparian zones upstream beyond the tidal reach. A major limitation for considering the differences in the ecosystem processes of these wetlands is that there isn't a single data resource to describe their distribution and characteristics. Here we consider the wetlands in the riparian zone of the Cooper River in South Carolina to determine the utility of existing data to identify TFW, consider hydrologic setting for assessing TFW, and synthesize pilot studies on the East Branch of the Cooper River that consider the interactions of TFW hydrologic setting and soil carbon dynamics. Although the National Wetland Inventory contains modifiers to recognize tidal hydrology, that modifier is used inconsistently within a single stream reach. Accordingly, NWI in conjunction with Lidar can be used to identify the upper reach TFW. The next challenge is the identifying the lower limit of saltwater. Again, the reported state-wide saltwater limit for South Carolina significantly underestimates the extent. Finally, soil maps do not provide a basis for distinguishing tidal and non-tidal riparian zones. As a result, the existing data sources underestimate the distribution of TFW in this basin. The TFW have a significantly "wetter" setting with the mean high water table varying between 0.2 and 0.8 m depending on location within the upper tidal reach, as compared to greater than 1.5 m on the non-tidal riparian zone. Measurements of CH_4 and CO_2 confirm the functional linkage of the emissions to micro-topographic features within the tidal riparian zone. Advancing research to address this important part of the landscape is fundamental to addressing issues associated with sea level rise and the interaction of coastal development on estuaries.

Watershed-Scale Effects of Longleaf Pine Restoration on Water Yield and Carbon

Author(s): Carl Trettin, Devendra Amatya, Ben Rau

Affiliation(s): USDA Forest Service

Abstract: Restoration of longleaf pine (LLP) ecosystems is a prominent land management objective throughout the southeastern U.S. While there have been numerous studies regarding the LLP ecology, restoration techniques, and the associated responses of ecosystem services, there is still a major uncertainty in the effects of watershed-scale restoration on the forest water and carbon (C) balance. The linkage between watershed-scale LLP restoration and hydrologic and other biogeochemical processes is particularly important as regional issues on water resources and C sequestration increase along with their uncertainties. In contrast to commercial loblolly pine stands, LLP stands have a much lower stocking with the understory generally dominated by grasses and sedges, potentially influencing on both soil moisture and water uptake as well as above- and below-ground C balance. The principal hypothesis guiding this study is that LLP restoration will result in an increase in water yield from the watershed. Hydrologic responses would be assessed using existing monitoring systems of rainfall, weather, and ground water table, as well as streamflow and water quality at the paired treatment and control watersheds. The pre-treatment monitoring including new soil moisture measurements is currently being initiated and would be continued through post-treatment period after prescribed burning, harvesting, thinning, and stand development. These measurements are being used to construct water budget before and after the restoration, and assess water quality responses at the watershed scale employing both the field experimental and modeling approaches.

Simulations of Hydrology and Water Quality for Irrigated Fields Near Yakima, Washington

Author(s): Rick Webb

Affiliation(s): U.S. Geological Survey

Abstract: Reliable tools are needed by farmers and managers to estimate and mitigate impacts of altered hydrology and degraded water quality downstream from agricultural areas. This talk will present the application of the Water, Energy, and Biogeochemical Model (WEBMOD) to simulate daily variations of hydrology and water quality for five square kilometers of irrigated fields draining to the DR2 Drain, southeast of Yakima Washington. Native vegetation consists of grass and shrubs as the fields lie in the rain shadow of the Cascade Range. Temperature, wind, and humidity are such that the atmosphere has the potential of evaporating 100 centimeters, 80 centimeters more than the annual average precipitation of 20 centimeters. However, in this highly modified system, with peak flows in the summer during the dry season, an average of 100 centimeters per year flow past the gage at the DR2 outlet. WEBMOD simulates the additional inputs (and actual evapotranspiration) to balance the water budget: 80 centimeters of irrigation from the Sunnyside Canal, diverted from the Yakima River; 10 centimeters of leakage through the earthen floor of the canal that is the northern boundary; and 60 centimeters of groundwater flowing south under the canal. Actual evapotranspiration of 70 centimeters closes the budget. This conceptually simple and robust model matches observations of daily discharge and specific conductivity measured at the DR2 gage. Because WEBMOD is based on fundamental principles of hydrology and geochemistry, it should prove useful in simulating how changing land use and climate may alter the hydrology and water quality of managed watersheds in the future.

A Continental-Scale Assessment of Soil Moisture Monitoring of Forest and Grassland Ecosystems in the United States

Author(s): Cynthia West, Liza Jenkins, and Richard Pouyat

Affiliation(s): US Forest Service

Abstract: Soil moisture monitoring in forest and grassland ecosystems is often overlooked by national efforts to coordinate soil moisture monitoring, which have mostly included the agriculture and water resource sectors. A workshop held recently by the U.S. Forest Service and Michigan Technological University with various stakeholders, scientists, and natural resource managers focused on contemporary and emerging research and management issues related to the importance of soil moisture monitoring in forest and grassland ecosystems. The overarching goal of the workshop was to develop a strategic plan to envision a new continental-scale approach of research and monitoring of soil moisture across forest and grassland areas of the United States. Specific objectives were to (1) assess the research and data available to monitor soil moisture for various purposes including the development of indicators, or thresholds, of soil moisture that relate to forest health, draught and water supply; (2) discuss currently available and emerging technology used in measuring soil moisture in situ and by remotely sensed platforms; (3) explore opportunities to expand and integrate existing networks to fill spatial and temporal gaps in data; and (4) determine research needs and needed technological advances for measuring soil moisture. Presentations were given on existing soil moisture monitoring networks such as the Soil Climate Analysis Network (SCAN), existing remote sensing platforms such as the Soil Moisture Active Passive (SMAP) mission, and the current effort to develop a National Soil Moisture Network (NSMN). Presentations were also given on the relationship between soil moisture, at different spatial and temporal scales, to forest health, forest productivity, fire, and watershed function. Next steps include: drafting a roadmap to expand and maintain the soil moisture network into forested landscapes and to engage with key stakeholders to determine what information is most important to address their needs.

Hydrology of a Sugarcane Production System and Associated Ecosystem Services

Author(s): Paul White

Affiliation(s): USDA-ARS

Abstract: Sugarcane (*Saccharum* sp.) is cultivated on over 172,000 ha in Louisiana and generates a projected economic impact of $3 billion dollars annually. Much of the area now under production was once occupied by bald cypress (*Taxodium distichum*) wetlands. The humid, sub-tropical climate receives 1650 mm of precipitation annually, exhibits a shallow water table (<1.5 m), and is periodically flooded. Despite these limitations, sugarcane is widely cultivated due to its adaptability. In addition, certain varieties have shown tolerance to high water conditions. A new management practice was initiated in 2017 that increased plant population by up to 50% by widening rows, with a concomitant reduction in field drains. Supporting ecosystem services, including water quality, photosynthesis, sugar production, and carbon sequestration may be affected by the different management practice. Thus, the research will evaluate water flux and storage at the plot (time domain reflectometry probes), field (run-off collection), or farm-level (eddy covariance) over time under different cropping intensities. The goal of the project is to quantify changes to supporting services and identify linkages to off-site ecosystem services.

Using Endangered Species Act Consultations as a Tool to Improve Water Quality and Monitoring in Coral Reef Ecosystems

Author(s): Lisamarie Currubba

Affiliation(s): NOAA Fisheries Office of Protected Resources

Abstract: The NOAA Coral Reef Conservation Program has been investing in watershed restoration projects in jurisdictions with coral resources for a number of years, often in partnership with the U.S. Environmental Protection Agency (EPA). Two Atlantic/Caribbean coral species, elkhorn and staghorn, were listed as threatened under the Endangered Species Act (ESA) in 2006 and five more, lobed star, boulder star, mountainous star, pillar, and rough cactus corals, were listed in 2014. Fifteen Indo-Pacific corals were also listed as threatened in 2014. Because of this, NOAA Fisheries collaborates with EPA through ESA section 7 consultations for the development of water quality standards and EPA permit requirements that are protective of corals. Here we present two examples of this collaboration through section 7 consultations, one in the U.S. Virgin Islands (USVI) and one in Puerto Rico. The USVI example demonstrates how water quality standards can be developed along with monitoring to track the effectiveness of setting numeric limits on things like turbidity and nutrients on improving coral health. The Puerto Rico example demonstrates how collaboration with EPA and permit applicants under programmatic consultations for general permits can be used to ensure stormwater management is designed in a site specific way to minimize potential impacts of land-based pollutant transport to nearshore waters during construction of projects in the coastal zone.

Water Clarity Criteria for Seagrass Protection in Sarasota Bay, FL: An Optical Model and Assessment Tool

Author(s): L.K. Dixon, Michael R. Wessel, Emily R. Hall

Affiliation(s): Mote Marine Laboratory

Abstract: Seagrass is a key ecological indicator and a cornerstone of the Sarasota Bay Estuary Program's conservation and management plan for Sarasota Bay, Florida. The amount of light reaching the seagrass is an important water quality indicator but the attenuation of photosynthetically active light through the water column (KdPAR)) is difficult to accurately measure in this shallow water estuary. Accordingly, a spectrally explicit optical model was developed and parameterized as a function routinely measured water quality constituents including color, chlorophyll and turbidity and successfully calibrated and validated against known quality observed (KdPAR) data. Segment-specific seagrass depth targets ranging between 1.5 and 3.1 m were identified based on the 95th percentile of the depth distribution during a benchmark period when seagrass acreages (and water clarity) were stable. Quantile regression was used to relate the distribution of modeled KdPAR between biennial aerial seagrass mapping events to the seagrass depth distribution at the closest subsequent event and indicated that the duration of high clarity conditions over two or more successive growing seasons may be the most critical for seagrass depth changes in most segments. A water clarity reporting tool was developed to score the results of annual optical model water clarity predictions relative to benchmarks (i.e. the 20th and 40th percentiles) established for the reference period. A color coded table presented the results as "Stable", "Caution" or "Declining" (Green, Yellow and Red, respectively). Trends in annual scores, averaged over two or three years, were generally consistent with observed changes in seagrass depths and support the utility of the method. The spectrally explicit optical model allows for the reliable estimation of water clarity using routinely collected water quality data and the Water Clarity Reporting Tool provides a straightforward method of disseminating complex light attenuation processes to both managers and the public.

Seagrass Ameliorates Coral Physiological Performance Under OA Conditions

Author(s): Emily Hall, Cinzia Alessi, Sean Fitzpatrick, Zhazira Irgebay, and Lindsay Arick

Affiliation(s): Mote Marine Laboratory

Abstract: Coral reefs are the most biologically diverse and economically important ecosystem on the planet; however they are sensitive to impacts from human activities like ocean acidification. Ocean acidification lowers the saturation state of calcium carbonate utilized by calcifying organisms, potentially leading to dissolution of skeletons and reduced ability to form new calcium carbonate structures, as well as impacting general health and physiology. Seagrass meadows, sometimes found adjacent to coral reefs in the Florida Keys, are mostly net autotrophic as a carbon sink and use the excess bicarbonate for growth. This presents the possibility of locally mediating ocean acidification effects on corals downstream of seagrass meadows. We performed a land-based study as well as an in situ study to understand if seagrass could ameliorate coral physiological performance under OA conditions. We tested the impacts of the presence of seagrass (*Halodule wrightii* and *Syringodium filiforme*) on carbonate chemistry and coral health (*Acropora cervicornis*, *Porites porites*, and *Porites astreoides*) in ocean acidification scenarios expected to occur in this century and present day conditions in land-based experimental settings as well as physiological performance of *A. cervicornis* within and outside of a natural seagrass bed. Physiological and functional responses measured include chlorophyll a, total protein, zooxanthellae counts, photosynthesis, respiration, and net calcification. Physiological responses were variable among species; however, growth and rates of photosynthesis were generally higher in the presence of seagrass. Results presented here describe the potential for seagrass to buffer against negative effects from OA.

Ridge to Reef Integrated Terrestrial and Marine Monitoring to Assess the Impact of Watershed Restoration on Marine Sediment Dynamics and Coral Reef Sedimentation in St. John, US Virgin Islands

Author(s): Sarah Gray (Environmental and Ocean Sciences, University of San Diego), Carlos Ramos-Scharrón (Univ. of Texas at Austin), Julia Royster, Lisa Vandiver (NOAA Restoration Center)

Abstract: Terrigenous sediment derived from unpaved roads is a significant stressor to coral reefs in the high-relief island of St. John, US Virgin Islands. The 10.7 km^2 Coral Bay watershed was the focus of a NOAA-ARRA watershed restoration program completed in 2011, which included: sediment retention structures, road drainage improvements, and limited road paving. A seven-year terrestrial-marine monitoring program to assess the effectiveness of this restoration at multiple spatiotemporal scales measured: (a) terrestrial erosion and runoff-sediment yields; (b) time integrated (sediment traps) and high resolution (nephelometers) marine terrigenous sedimentation and turbidity at shoreline and coral reef sites; and (c) sediment “residence time” using short-lived radioisotopes (SLR) in developed/restored and minimally developed sites.

Watershed erosion, sediment yields, terrigenous sedimentation, and coral exposure to sedimentation stress were significantly greater below developed compared to minimally developed watersheds. Restoration program paving reduced road-segment-scale erosion rates to 4-29% of pre-paving rates, but watershed modeling showed that ~90% of the ~110 Mg yr^{-1} reductions were due to sediment retention ponds. In the marine environment, resuspension contributed more to turbidity and deposition than shorter lived (hours) runoff plumes, and limited the ability to resolve changes post-restoration in the potential exposure of corals to sedimentation stress.

Due to resuspension, statistically significant pre- vs. post- restoration reductions in marine sedimentation were not measured. However, significant decreases in % clay and terrigenous sediment were found below the restored watersheds post restoration. These data suggest that % clay (rather than reduced total sedimentation) may be a more sensitive tracer of effective restoration, which targets sediment input from unpaved roads.

Lessons learned from the Coral Bay watershed restoration and monitoring program may serve to inform the development of effective management and monitoring strategies that may be applied to other areas with similar ephemeral hydrologic behavior. Long term (several seasons) integrated terrestrial- marine monitoring is essential to quantify the habitat impact of watershed restoration and must include regular coordination and data sharing between a multidisciplinary team of scientists, community members, and the sponsors.

Diary of a Pacific Island Stream Monitor

Author(s): Kathryn Graziano, Anne Kitchell, Malcolm Johnson, Autumn Poisson, Max Muña, James Manglona, and Michelle West

Affiliation(s): Horsley Witten Group

Abstract: This talk describes the methodology, challenges, and results of multi-year stream monitoring to quantify reductions in soil loss due to extensive badland revegetation efforts in the Talakhaya watershed. The area studied encompassed over 1,000 acres of steep terrain and the only perennial streams on the south western side of Rota, CNMI. A two-phased stream monitoring study between 2012-2017 by the University of Guam, NOAA, and territorial agencies involved measuring flow, suspended sediment, and turbidity at multiples sites in five subwatersheds with varying degrees of vegetative cover. Researchers hypothesized that TSS and turbidity in streams would be higher in subwatersheds with bare soils than in more vegetated areas, and that sediment loads would decrease over time in replanted subwatersheds. It was hoped that linking watershed monitoring with a coastal water quality sampling program would show a direct relationship between watershed restoration and nearshore health.

Day 1: Restarting the sampling protocol after a 15-month hiatus seemed reasonable, until we discovered that the control subwatershed (barren) had been replanted. We added a new control to the study, which required the installation of pressure transducers at two new, questionably-accessible stations.

Day 30: Upon further investigation, it turns out that those anomalies in the precipitation data were caused by shotgun pellets, ants in the tipping bucket, and rain gauge abduction by aliens. On another note, Cape Air successfully delivered water quality samples to Saipan for analysis.

Day 60: Contrary to popular belief, it doesn't have to rain during the rainy season. We are getting baseflow samples at some stations (I didn't know "perennial" streams could dry up), but the sediment concentrations are highest in the forested subwatershed. That might have something to do with the Japanese diversion structure and the cows.

Day 120: Good news, we found the flow meter. Bad news, I'm not sure we have enough measurements to confidently establish stage-discharge relationships. P.S. We have no flow information for the new control subwatershed.

Day 160: Despite all the blood, sweat, and tears contributed to this effort, results are inconclusive. It's clear we need more data. Perhaps an alternative monitoring approach is warranted.

A Brief History of the Chesapeake Bay Program and How It's Facilitating the Recovery of One of the Bay's Most Important Habitats: Submerged Aquatic Vegetation

Author(s): Brooke Landry, Jennifer Keisman, Bill Dennison, Bob Orth, and Jonathon Lefcheck

Affiliation(s): Maryland Department of Natural Resources

Abstract: In the 1970's, a period ripe with environmentalism, U.S. Senator Charles Mathias (R-Md.) called for and appropriated Congressional funding for a study to analyze the degradation of the Chesapeake Bay ecosystem. The study determined that excess nutrient pollution from the Bay's watershed was the primary culprit for the Bay's degrading water quality and loss of aquatic life, including a catastrophic loss of submerged aquatic vegetation (SAV) – one of the Bay's most important habitats. Soon thereafter, in 1983, the Chesapeake Bay Program was formed and charged with the ambitious task of restoring the iconic estuary. Fast forward thirty-five years and the Bay Program has evolved into one of the most successful models of federal, state, and local partnership in the world. Through a series of landmark agreements, the Program and its partners have successfully implemented adaptive management strategies and actions, including the Chesapeake Bay Total Maximum Daily Load (TMDL), that have reduced water column nitrogen concentrations in the Bay by 23% and phosphorus concentrations by 8%, on average. Though seemingly modest, the reductions have been directly linked to a resurgence of SAV over the same time period. In 1984, results of the baywide SAV aerial survey indicated that there were less than 39,000 acres of SAV remaining in the Bay's shallow waters. In 2016, 97,668 acres were mapped, exceeding the Bay Program's 2017 SAV restoration goal of 90,000 acres for the second year in a row. This achievement validates the Chesapeake Bay Program's sustained efforts to restore the Bay and shows that the 2025 SAV restoration target of 130,000 acres is within reach.

Understanding and Measuring Changes in Coastal Resilience: Lessons from the DOI Hurricane Sandy Response Program

Author(s): Peter Murdoch, Richard O. Bennett, Susan M. Taylor, Kim M. Penn, Bhaskar Subramanian

Affiliation(s): U.S. Geological Survey

Abstract: Hurricane Sandy made landfall in the Northeastern US on October 29, 2012, wreaking havoc on communities in 12 states and the District of Columbia. In the aftermath of that destruction, the Department of the Interior (DOI) funded 162 restoration, mitigation, and research projects to develop and implement best practices for enhancing coastal resilience of communities, ecosystems, and infrastructure to sea level rise, storm surge, and wave erosion. Since then, Federal, State, and NGO partners have been developing recommendations for a small set of core environmental and socio-economic measurements to assess project performance and overall coastal resilience at multiple temporal and spatial scales. These measurements are being assessed for their ability to identify vulnerability, detect disturbance, and track recovery. Leveraging of existing data and measurement capabilities, and nesting research watersheds and coastlines within baseline surveys of regional environmental condition, will be essential to enable cost-effective resilience management of coastal regions and help define best-resilience practices before more costly mitigation or restoration efforts are required. The conceptual model, science updates, lessons learned from the DOI Sandy program, and opportunities for collaboration in building a research and monitoring program in the Northeast coastal regions and beyond will be presented.

Making our Science Accessible: Engaging Stakeholders to Participate in Coastal Wetland Restoration Decisions Using Web Mapping Applications

Author(s): Justin Saarinen, Kurt Kowalski, Blake Draper

Affiliation(s): New College of Florida

Abstract: With multiple benefits served to aquatic ecosystems, wide spread restoration of the services provided by coastal wetlands is one of the highest priorities of the congressionally supported Great Lakes Restoration Initiative (GLRI). This is a complex challenge, as some former functional Great Lakes coastal wetland areas are more conducive to restoration than others given their relative locations on the landscape, the specific services they provide and the land-use history. Furthermore, stakeholders find the data and decision tools necessary to remotely identify and evaluate those areas are disparate, while also technically inaccessible for their optimal use by stakeholders. Therefore, we developed a suite of web-based mapping applications designed to foster participation by regional stakeholders engaging in restoration decisions. These applications provide ready access to a spatially explicit and scalable (parcel to region) composite index model for restoration to support the identification and prioritization of potentially restorable coastal wetlands (i.e., areas that could return to coastal wetland status if hydrologically reconnected to the Great Lakes). This model was created using a geodesign framework that included expert formulation of 6 primary geospatial data layers (water surface/land elevation, hydric soils, flow lines, conservation and recreation lands, impervious surfaces, undeveloped lands). Users can query the data set to summarize model results and produce outputs that support prioritization and selection of restoration sites. A geonarrative application (https://glcwra.wim.usgs.gov/) was developed to link the individual restoration assessments through a larger story and streamline access to the mapping applications. This work 1) promotes multi-scale (site to landscape) assessment of the restoration potential, function, and ecosystem services of coastal wetlands, and 2) encourages regional participation in the process, and 3) leverages GLRI restoration investments.

Pollutant Inputs to Coastal Environments and their Regulation from an Endangered Species Act Perspective

Author(s): Pat Shaw-Allen

Affiliation(s): NOAA Fisheries, Office of Protected Resources

Abstract: The Endangered Species Act (ESA) requires Federal agencies to consult with the National Marine Fisheries Service (NMFS) to ensure that the activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat under NMFS' jurisdiction. This includes implementation of specific sections of the Clean Water Act by the U.S. Environmental Protection Agency (EPA). While EPA must approve water quality criteria proposed by the states for use in regulating point and non-point source discharges, permitting authority has been delegated to most states, territories, and tribes. This presentation summarizes the EPA authorizations NMFS has consulted on under section 7 of the ESA and places these ESA consultations in the context of current permitted discharges to coastal waters and their constituent pollutants.

The Tampa Bay Story: Fostering Collaborative Partnerships to Restore an Urban Estuary

Author(s): Ed Sherwood, Anthony Janicki, Holly Greening, Maya Burke and Gary Raulerson

Affiliation(s): Tampa Bay Estuary Program

Abstract: A proactive and adaptive nutrient management plan for the Tampa Bay watershed has evolved over the past quarter century largely through local efforts implemented by the Tampa Bay Nitrogen Management Consortium (NMC) which has been coordinated by the Tampa Bay Estuary Program (TBEP) since 1998. The NMC, an ad-hoc public-private partnership, now consists of more than 50 local governments, industries, utilities and agricultural stakeholders that have worked cooperatively to help support the TBEP's efforts to recover seagrass in Tampa Bay through implementation of total nitrogen (TN) load reduction projects within the watershed. To date, and of those projects that have reported costs, the NMC has invested over $710M in various nutrient load reduction projects in Tampa Bay, which has led to the preclusion of approximately 530 tons of TN from entering the bay each year. When taking into account additional educational and land preservation activities, the amount invested is >$2.47B. These investments have resulted in vast reductions in nitrogen loadings to Tampa Bay as compared to levels in the 1970's, and as a result, has contributed to Tampa Bay's ecosystem recovery. Presently, the Tampa Bay seagrass recovery goal to restore acreages to 1950's levels has been achieved. However, future challenges still exist. The Tampa Bay region continues to expand in population and potential expansion and introduction of new sources of TN loads to the bay is a possibility. Therefore, the NMC continues to implement new load reduction projects in a collaborative and consensus-driven process. This presentation will discuss the formation of the local partnerships, their role in contributing to Tampa Bay's ecosystem recovery, and planned future work to maintain a "healthy" Tampa Bay.

Benthic Habitat Metrics as Indicators for Linking Watershed Restoration to Coral Reef Habitats

Author(s): Lisa Vandiver

Affiliation(s): NOAA

Abstract: NOAA's Coral Reef Conservation Program and NOAA's Restoration Center utilize watershed restoration as a technique to reduce the threat of land-based sources of pollution (LBSP) to benefit coral reef habitats. However, there has been little success in translating watershed restoration into a quantifiable impact to coral reef habitats. Here we propose and evaluate a simplified monitoring protocol that would use benthic habitat metrics (i.e., seagrass and macroalgal cover) as a means of quantifying the coastal habitat impact of watershed restoration in NOAA's Caribbean coral reef jurisdictions. Preliminary results suggest that monthly measurements of water clarity, turbidity, and total chlorophyll a are strongly correlated to the degree of LBSP threats. Specific habitat metrics (e.g., *Thalassia testudinum* Density, Percent macroalgal cover, Epiphyte index, and maximum depth of seagrass growth) are also strongly correlated to LBSP threats. Furthermore, these habitat metrics can be used to inform the development of initial water quality thresholds to identify nearshore water quality targets for restoration. Although this is certainly a simplified approach to evaluating a very complicated problem, it is potentially a way to develop meaningful water quality thresholds and coastal habitat restoration targets for watershed restoration.

Exploring Drivers of Regional Water-Quality Trends Using Differential Spatially Referenced Regression – A Pilot Study in the Chesapeake Bay Watershed

Author(s): Jeffrey Chanat, Guoxiang Yang

Affiliation(s): U.S. Geological Survey

Abstract: An understanding of riverine water-quality dynamics in regional mixed-land-use watersheds is the foundation for advances in landscape biogeochemistry and informed land management. A “differential” implementation of a well-established statistical/process-based model is proposed to empirically relate a regional pattern of changes in constituent flux, over a multi-year period, to spatially referenced changes in explanatory variables over the same period. Interpretation is based on conceptualizing change in flow-normalized flux, traceable to a shift in the concentration-discharge relation, as a transition between “quasi-steady-state” conditions. A pilot implementation explores factors influencing changes in flow-normalized flux of total nitrogen over the period 1990-2010 at 43 sites in the non-tidal Chesapeake Bay watershed. A cross-validated 7-parameter model explains 80 percent of the transformed variability in flux changes, estimated independently using monitoring data. Combined, 5 time-varying sources, point, agricultural fertilizer, manure, atmospheric, and urban land, contribute between one-quarter to one-half of the model’s explanatory power. The remainder is accounted for by localized changes in 2 variables governing land-to-water transport: air temperature and precipitation. Although qualified by constraints on explanatory data availability at the time of formulation, the pilot suggests limits on allowable model complexity, places practical bounds on the efficacy of management actions targeting nitrogen, and indicates that climatic variability should be taken into account when interpreting any outcome at this time scale. Overall, the study suggests that differential spatially referenced regression is a promising approach for broadening scientific understanding of factors driving regional water-quality trends, and for supporting evidence-based land-management decisions.

Pooled Monitoring – A Novel Approach that Pools Funding to Support Research to Answer Key Restoration Questions vs. Site/Project Specific Monitoring in the Chesapeake Bay

Author(s): Sadie Drescher, Jana Davis

Affiliation(s): Chesapeake Bay Trust

Abstract: Efforts to restore the Chesapeake Bay and its tributaries call for a significant increase in the number of watershed restoration projects intended to improve both water quality and habitat. Questions about the performance and function of some of these practices persist in the regulatory and practitioner community that prevent more rapid implementation. As a result, a new initiative called the Pooled Monitoring Program has been designed to connect key stormwater and stream restoration questions posed by the regulatory and practitioner communities with researchers in the scientific community.

Pressing questions about the practices have been articulated over the last several years with input from the regulators and practitioners. Examples include questions about cumulative impacts of restoration practices at a watershed scale, differences in efficacy of different stream restoration techniques, trade-offs among different resources impacted positively and negatively by restoration activities (e.g., trees removed during stream restoration), how and if iron flocculate is associated with stream restoration techniques and whether it is “bad,” and how to predict or model structural stability of stream restoration. The Initiative articulates the “burning” restoration questions that regulators and practitioners need to make decisions. The novelty of the initiative is derived from identifying funds used for other types of monitoring that have more power in a pool.

Results of the research are communicated back to the regulators and practitioners in a way that maximizes their ability to inform work in those realms. The Pooled Monitoring Program aims to answer these questions to ultimately increase confidence in proposed restoration project outcomes, clarify the optimal site conditions in which to apply particular restoration techniques, provide information useful to regulatory agencies in project permitting, and provide information that will help guide monitoring programs. Finally, new key restoration questions are added each year ensuring that the top restoration questions continue to be answered with robust research using the Pooled Monitoring Program. For more information see our website at https://cbtrust.org/restoration-research/.

Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales I (Tuesday) and II (Thursday)

The Conservation Effects Assessment Project (CEAP) Watershed Assessments: A synthesis of measuring and understanding the effects of conservation practices within watersheds

Author(s): Lisa Duriancik (USDA NRCS), Daniel Moriasi (USDA ARS), John Sadler (USDA ARS), Teferi Tsegaye (USDA ARS), Jean L. Steiner (USDA ARS), Martin A. Locke (USDA ARS), Tim C. Strickland (USDA ARS), and Deanna L. Osmond (NC State University)

Abstract: Under the Farm Bill, the USDA spends about $5 billion per year on agricultural conservation programs supporting technical and financial assistance for implementation of conservation practices (CPs) and systems on private agricultural lands. In 2003, the USDA Natural Resources Conservation Service entered into partnership with USDA Agricultural Research Service and many other partners to create the Conservation Effects Assessment Project (CEAP). The objective of CEAP is to quantify the environmental effects of CPs and develop the science base for managing the agricultural landscape for environmental quality. Over the last 15 years, research and assessment has been conducted to test the effectiveness of CPs at various spatial scales using combined monitoring and modeling approaches in a national coordinated network of small CEAP Watershed Assessment Studies. Documenting conservation effects in watersheds on water quality, availability and soils is a substantial technical challenge, yet remains an area of significant interest to stakeholders, policy makers, agricultural land managers and agencies alike. Major findings of 15 years of work in the ARS CEAP Benchmark Watershed Assessment Studies and other CEAP watersheds is being synthesized. Findings will focus on highlighting the measured effects of conservation at different scales, with a particular interest in watershed or sub-watershed effects, but to include Edge-of-Field (EOF) effects. Where measured effects are challenging to document because of the influence of numerous complex drivers, particularly at larger scales, modeled results will also be reviewed. Application of data and findings from CEAP to inform development and delivery of USDA conservation programs and initiatives such as the National Water Quality Initiative, Mississippi River Basin Initiative, Great Lakes Restoration Initiative, Chesapeake Bay Watershed and Regional Conservation Partnership Program, will be discussed in the context of adaptive management. Lastly, potential future directions will be presented.

Tracking Flows of Water Through a Complex Urban System: Chicago

Author(s): Laura Erban, Stephen Balogh, Henry Walker, Daniel Campbell

Affiliation(s): U.S. EPA

Abstract: Urban water systems are complex and tightly coupled. In Chicago, the third largest US city, wastewater treatment plant (WWTP) effluent comprises up to 70% of streamflow, more than half of which is withdrawn for thermoelectric power generation (PG). Despite the interdependence of users and mass conservative behavior of water flows, monitoring and management efforts are highly fragmented. Here we comprehensively analyze the urban water system in greater Chicago during water years 2001-2010 and examine longer trends in coupled flows. Our study area is defined by the seven counties that are served by the Chicago Metropolitan Agency for Planning (CMAP). We use a reproducible workflow codified in our newly developed R package CityWaterBalance to automate data retrieval and quantify the relative magnitudes of measured and unmeasured flows through the CMAP region. Among other insights, our system-level assessment reveals the comparable long-term (10-yr) average magnitudes between a) Lake Michigan withdrawals and river inflow, b) total effluent (WWTP and PG) and river outflow, c) sewer infiltration and combined sewer overflow. Finer scale examination of temporal trends reveals significant reductions in potable water use and sewer overflows, and steady wastewater effluent volumes despite increased precipitation in recent years. Although a wealth of open data is available to study this region, discrepancies in spatial and temporal resolution preclude finer analysis of all system components at a scale relevant to CMAP. However, the increasing availability of web-served data will improve our ability to assess and compare urban water flows and to inform management decisions.

Drivers of Orthophosphate Trends in Tributaries to Chesapeake Bay

Author(s): Rosemary Fanelli, Joel Blomquist, Robert Hirsch

Affiliation(s): U.S. Geological Survey

Abstract: Orthophosphate (PO_4) is the most bioavailable form of phosphorus (P) in aqueous systems, and excess PO_4 may cause harmful algal blooms in lake and estuary ecosystems. A major restoration effort is underway for Chesapeake Bay (CB), with the goal of reducing P, nitrogen, and sediment loading from the watershed. However, spatial patterns in PO_4 fluxes and trends in those fluxes over time remain poorly understood, because most of the scientific attention has been focused on total phosphorus to date. To address this research gap, we analyzed PO_4 fluxes and trends over a 9-year period at 53 monitoring stations across the CB watershed to: 1) characterize the importance of PO_4 to TP fluxes and trends; 2) describe spatial and temporal patterns of PO_4 concentrations across seasons and stream flow; and 3) explore factors that may explain these patterns across time and space. Agricultural watersheds exported the most TP in the CB watershed, with PO_4 comprising up to 50% of those exports. Although PO_4 exports are declining at many sites, some agricultural regions are experiencing increasing trends at a rate sufficient to drive increases in TP. Regression modeling suggests that point source declines are likely responsible for the decreases observed in many of the watersheds, and that declining point sources may reduce concentrations at both low and high flows. Watersheds with higher enrollment in the Conservation Reserve Program had lower summer PO_4 concentrations, highlighting the potential of that practice for mitigating the effects of agriculture on PO_4 in streams. Manure inputs were a strong predictor of PO_4 concentrations at high flows, and increasing manure applications may be contributing to increasing PO_4 concentrations. Conservation tillage was also correlated with changes in PO_4 concentrations at high flow, suggesting that this practice could contribute to increasing PO_4 concentrations as well. Overall, this study highlights the success of point source reductions for reducing PO_4 exports in many CB tributaries. These results also underscore the need for phosphorus management strategies to target dissolved PO_4 and sediment-associated phosphorus in soils and biomass, particularly in regions with high manure inputs.

Looking for Solutions to Water Quality Problems in the Chesapeake Bay Watershed: What Does Water Quality Trading Have to Offer

Author(s): Patricia Gleason

Affiliation(s): US EPA Region 3

Abstract: Water quality trading is an approach that offers greater efficiency in achieving water quality goals on a watershed basis. it allows one source to meet its regulatory obligations by using pollutant reductions created by another source that has lower pollution control costs. Trading capitalizes on economics of scale and the control cost differentials among and between sources. The United States Environmental Protection Agency (EPA) believes that market-based approaches such as water quality trading provide greater flexibility and have the potential to achieve water quality and environmental benefits greater than would otherwise be achieved under more traditional regulatory approaches. Three or four case studies will be discussed that highlight this approach.

Scaling Green Infrastructure to Watersheds: Current Insights and Future Directions

Author(s): Heather Golden, Nahal Hoghooghi, Brian Bledsoe

Affiliation(s): U.S. EPA Office of Research and Development, University of Georgia

Abstract: Urbanization modifies watershed hydrological processes, such as evapotranspiration, soil water storage, and runoff, and therefore requires deliberate, targeted stormwater management. Green infrastructure (GI) is a decentralized approach to stormwater management that uses plants, soils, and landscape design, and is promoted as a sustainable method for attenuating the adverse water quality and quantity (e.g., flooding) effects from urbanizing systems. However, evidence on the efficacy of GI is primarily based on local-scale studies, such as plots and small homogeneous patches of landscapes – not watersheds, the widely established scale of water resources management. Here we present considerations and approaches for scaling local-scale water quantity and quality responses to GI to watersheds. We discuss important concepts emerging from GI research at the local scale, methods for scaling this research to watersheds, recent advances in scaling the effects of GI practices on water quality and quantity at watershed scales, and the use of combined novel measurements and models for these scaling efforts. We highlight these ideas with a case study that uses model simulations to assess how various types and configurations of GI practices affect watershed hydrology in a mixed land cover watershed. Our synthesis of recent research suggests that advances are being made to scale results from GI studies to watersheds, but we are still at the vanguard of what may become an expansive area of research.

The Urban Waters Program: A Platform for Actionable Science to Improve Cities and Their Waterways

Author(s): Morgan Grove, Bob Shedlock, Mike Galvin, Sarah Hines, Steve Terracciano

Affiliation(s): USDA Forest Service, U.S. Geological Survey

Abstract: The Urban Waters program involves 14 federal agencies working together and with state and local partners to improve cities and their waterways in 19 locations across the United States. While a major focus of Urban Waters is on specific projects and their implementation, many of the agencies have the capacity to conduct research and provide technical assistance. Thus, Urban Waters offers a novel forum for coordination, collaboration, and synthesis of federal research assets for local decision makers to use.

In this presentation, we use the Baltimore, Maryland Urban Waters project to discuss the structure, topics, and lessons learned for interactions among federal agencies and local decision makers and some of the novel outcomes of this partnership. Some of the key federal "research" agencies involved include USDA, USGS, EPA, NSF, and NASA. Baltimore Urban Waters' structures facilitate the co-design and co-production of research, as well as sharing of data, findings, and research products. Topics range from vary specific issues, such as PCBs in aquatic systems to the social, economic, and ecological benefits or urban land reclamation in disadvantaged neighborhoods. Lesson are diverse, including how to engage and retain interest of scientists and decision makers over the long term, to how to leverage and integrate existing data with new data needs. While not an initial focus of the Urban Waters program, the capacity for actionable science has played an increasing role in the success of the program.

Assessing the Impact of Wildland Fire on Runoff and Erosion using the Automated Geospatial Watershed Assessment Tool

Author(s): D. Phillip Guertin (UA), David C. Goodrich (USDA-ARS), B. Scott Sheppard (USFS), Jane Barlow (Tucson Water), Thomas Clifford (BLM), Carl Unkrich (USDA-ARS), I. Shea Burns (UA), and William G. Kepner (U.S. EPA)

Abstract: Functionality has been incorporated into the Automated Geospatial Watershed Assessment Tool (AGWA) to assess the impacts of wildland fire on runoff and erosion. AGWA (see: https://www.epa.gov/water-research/automated-geospatial-watershed-assessment-agwa-tool-hydrologic-modeling-and-watershed or www.tucson.ars.ag.gov/agwa) is a GIS interface jointly developed by the USDA-Agricultural Research Service, the U.S. Environmental Protection Agency, the University of Arizona, and the University of Wyoming to automate the parameterization and execution of a suite of hydrologic and erosion models (RHEM, WEPP, KINEROS2 and SWAT). Through an intuitive interface the user selects an outlet from which AGWA delineates and discretizes the watershed using a Digital Elevation Model (DEM). The watershed model elements are then intersected with terrain, soils, and land cover data layers to derive the requisite model input parameters. Based on a small sample of pre- and post-fire rainfall-runoff data a method was developed to adjust model parameters as a function of the pre-fire vegetation cover and fire severity maps. To date AGWA was been used on over 50 wildland fires by the Department of Interior Interagency Burn Area Emergency Response teams to assess the fire impacts on runoff and erosion and support the development of Burned Area Assessment Reports. AGWA has also been used to assess the runoff and erosion impacts of wildland fire before and after forest health treatments. The presentation will review AGWA and its application for post fire assessment in several cases studies.

Quantifying Floodplain Ecosystem Services

Author(s): Kristina Hopkins, Gregory Noe, Samuel Lamont, Peter Claggett, Dianna Hogan, Emily Pindilli

Affiliation(s): U.S. Geological Survey

Abstract: Retention of sediments and nutrients in floodplain areas provides critical ecosystem services to downstream communities. Lidar mapping, field data collection, and modeling were integrated to quantify the ecosystem service of sediment and nutrient retention that floodplains provide in the Delaware River watershed. The mapping component of this project resulted in the development of the Floodplain and Channel Evaluation Toolkit (FACET) to identify features and calculate key metrics describing channel and floodplain geometry from high-resolution bare-earth elevation data in the Delaware River watershed. Field data collection employed dendrogeomorphic techniques to estimate rates of stream bank erosion and floodplain sediment deposition at fifteen sites in the watershed. These two datasets were combined to develop predictive models estimating sediment trapping and export for each stream reach within the non-tidal portion of Delaware River watershed. This assessment of floodplain net sediment flux and associated ecosystem services will help identify areas for targeted management to maintain areas with high ecosystem service values, and to restore areas that could provide the most ecosystem service benefits.

Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales I (Tuesday) and II (Thursday)

Strengthening Resiliency in Coastal Watersheds: A Web-Based GIS Map Viewer Decision Support System

Author(s): Anne Kuhn, Jane Copeland

Affiliation(s): US EPA

Abstract: To promote and strengthen the resiliency of coastal watersheds in the face of climate change and development, ecological outcomes as well as socioeconomic issues need to be considered. An integrated assessment framework is being developed to help watershed managers, coastal communities, and other stakeholders strengthen coastal resiliency by identifying and prioritizing conservation and restoration efforts within coastal watersheds. This framework is linked to a desktop and web-based decision support system (DSS) incorporating ecological integrity principles with ecosystem services (ES). The DSS tools operate within a geospatial platform, allowing for spatially-explicit analysis of individual ecological units and their associated ESs at multiple scales, and provides web-based and mobile applications (tablets and smart phones) developed for a range of users from technical users/stakeholders to the general public. The DSS tools allow for the evaluation of both ecological integrity and ESs of key functional processes, components and elements of watershed integrity relative to the location within the watershed (e.g. headwater streams, flood plains, riparian condition, coastal wetlands, etc.). The web-based map viewer DSS enables stakeholders to integrate a watershed perspective into their decision making at multiple scales. This coastal watershed resiliency DSS can be used to make decisions for: 1) prioritizing protection and restoration of upland and riparian habitat for water quality and mitigating non-point source stressors; 2) reducing flooding risks by identifying opportunities to restore flood plains and riparian zones increasing aquatic connectivity for habitat and flood resilience; 3) planning for sea level rise adaptation, marsh migration and marsh hydrology restoration; and 4) optimizing green infrastructure to reduce nutrients and non-point source pollutants. These DSS tools are unique in that they integrate ecosystem services and ecological integrity with science-based decision making, allowing managers to consider ecological outcomes as well as economic and social issues when making important decisions within their watershed.

Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales I (Tuesday) and II (Thursday)

Landscape Features and Processes Affect Aquatic Nutrient Dynamics in a Regional-Scale River Basin

Author(s): Samson Mengistu, Heather E. Golden, Charles R. Lane, Scott G. Leibowitz, Jay R. Christensen, Jana E. Compton, Ellen D'Amico, Amy Prues, Marc H. Weber, Ryan A. Hill

Affiliation(s): National Research Council, US Environmental Protection Agency (EPA) Office of Research and Development, Pegasus Technical Services

Abstract: Surface depressions on landscapes create "hotspots" for biogeochemical processing, which play a role in a watershed's surface water quality. However, despite recent expansions in the availability of high resolution spatial datasets and capabilities to analyze them, limited progress has been made in using these data to investigate the extent to which surface depressions have water quality consequences, particularly in large regional river basins. This study investigates the link between surface depressions and nitrogen and phosphorus dynamics across the 490,000 km^2 Upper Mississippi River Basin (UMRB). An initial 10-yr dataset from nearly 330 federal, state, and local gages throughout the UMRB with total nitrogen (TN) and total phosphorus (TP) records were acquired and summarized for seasonal and annual analyses. We used nationally available high resolution spatial data to delineate the UMRB sub-watersheds draining to the selected gages and build new datasets to help explain surficial hydrologic transport. We delineated the sub-watersheds using the National Hydrography Dataset (1:24K) and a 10-m digital elevation model obtained from USGS's 3D elevation program. We calculated spatial predictors describing depressional areas and other landscape characteristics using a crop data layer, point-source data, and ancillary nationally available datasets. Preliminary analyses between the response variables (i.e., seasonal and annual TN and TP concentrations) and spatial predictors suggest depressional areas in the landscape have a statistically significant relationship with downstream TN and TP concentrations. However, these preliminary results also indicate that predictor-response variable relationships may be seasonal. Outcomes from this study will improve our understanding of landscape-scale controls on in-stream nutrient concentrations across the UMRB and subsequent receiving waters such as the Gulf of Mexico.

Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales I (Tuesday) and II (Thursday)

EPA's ENVIROATLAS: Indicators for Working Watersheds

Author(s): Anne Neale

Affiliation(s): U.S. EPA

Abstract: Over recent decades the government has made a wealth of information publicly available as part of the Federal Open Data Policy. The EnviroAtlas provides a wealth of geospatial data and other resources to decision makers, educators, and researchers. EnviroAtlas resources are organized according to the benefits we receive from ecosystems (i.e., ecosystem goods and services) with one of the major categories being Clean and Plentiful Water. Much of the information contained within EnviroAtlas may be of particular interest to stakeholders engaged in the research, maintenance, protection, and improvement of aquatic condition and functional integrity within watersheds. This presentation will provide a brief overview of EnviroAtlas resources and will include data related to water use, potential wetland restoration, potential evapotranspiration now and in the future, floodplain delineation, water quality trading, aquatic invasiveness, overland flow, and pollutant loads.

EPA's EcoService Models Library (ESML): A New Tool for Quantifying and Valuing Ecosystem Services

Author(s): Tammy Newcomer-Johnson, Randy Bruins, Gregg Lomnicky, John Wilson, Ted DeWitt

Affiliation(s): US EPA

Abstract: A challenge in quantifying and valuing ecosystem services is finding ecological models with endpoints that align with ecosystem services. U.S. EPA's EcoService Models Library (ESML) is a readily available tool that addresses this challenge. ESML is a website and database for finding, examining and comparing ecological models that may be useful for estimating ecosystem goods and services. This new EPA tool released in 2018, describes >125 ecological models. ESML shows how ecological models align with ecosystem services under two classification systems: U.S. EPA's National Ecosystem Services Classification System and the European Environment Agency's Common International Classification of Ecosystem Services. This presentation discusses which classes of ecosystem services are covered by this population of ecological models, and the implications for quantifying and valuing ecosystem services.

Delineation of Wetland Hydrologic Hot-Spots Using Large-Scale Models

Author(s): Adnan Rajib, Heather Golden, Charles Lane, Ellen D'Amico

Affiliation(s): ORISE Post-Doctoral Research Program, US EPA Office of Research and Development, Pegasus Technical Services

Abstract: Wetlands are hot spots of hydrological activity in watersheds. However, most hydrological models do not produce fine-resolution spatial characterizations of watershed locations where wetlands have the greatest impact on downstream hydrology. This is particularly true for large river basins. In response to this limitation, we initiated a large-scale modeling study to enable wetland hydrological hot spot delineation across the ~0.45 million km^2 Upper Mississippi River Basin (UMRB). Using the Soil and Water Assessment Tool (SWAT), we developed a high-spatial resolution hydrologic model for UMRB with ~20,000 National Hydrography Dataset (NHD) stream segments. We included a spatially explicit 100-year floodplain in SWAT, and further modified the model to incorporate floodplain hydraulic geometry and roughness parameters that vary both spatially and temporally with normal and flood conditions. The areal extent and water-storage capacity of ~0.9 million wetlands in the UMRB were determined from the National Wetland Inventory and 10-m National Elevation Dataset and incorporated into the SWAT model as Hydrologically Equivalent Wetlands (HEWs). With aggregated wetland storage-discharge functions at sub-basin level, the use of HEWs allows quantification of wetland hydrologic contributions to downstream flow over the ~0.45 million km^2 domain. A 5-year hydrologic simulation using the modified UMRB SWAT model enabled spatially explicit delineation of wetland hydrologic hot spots across the basin. The results highlight specific zones of wetland influence, identifying areas for targeted wetland management and restoration.

Where the Map Meets the Mud: Watershed Assessment

Author(s): Matt Royer, Kristen Kyler, Jenn Fetter, Sarah Xenophon

Affiliation(s): Penn State Agriculture and Environment Center

Abstract: As limited resources continue to curb regional pollution reductions, a great need has emerged to prioritize project implementation across watershed regions. To overcome this challenge, Penn State's Agriculture and Environment Center has developed a comprehensive watershed assessment method supporting municipalities, landowners, and scientists in prioritizing implementation of best management practices. This assessment can be replicated in a variety of regions at varying scales and for a broad range of uses. Additionally, it requires minimal training and low capital investment, making this strategic method widely accessible and cost effective. By integrating commonly available tools and models, while approaching assessment with scientific accuracy and practical application, the Center has created a process to prioritize projects for long-term planning, implementation, and monitoring.
This presentation outlines the methods and explores the detailed steps of our watershed assessment process, while providing the audience with the tools to apply this systematic approach to their own regions. We will also discuss our "lessons learned" from method development and how completed assessments are currently being used to support implementation. The tools that are presented in our discussion can be adapted, mastered, and replicated by a wide range of audience members, not only for use in this assessment method, but also for use in additional professional capacities.

Our discussion begins with the methods of our assessment process, prefaced by setting goals and objectives while facilitating local partnerships. The process transitions into an innovative watershed assessment using aerial imagery, followed by windshield surveys conducted to confirm current conditions. Once projects are confirmed, a quantitative analysis takes place after which, projects are run through commonly available watershed models. Throughout our presentation, we will also demonstrate how our staff completed each step and what resources were required for successful assessments.

This cost-effective, yet thorough assessment method ultimately aids land managers, large or small, in reducing non-point source pollution in the pursuit of clean water and effective watershed management. By streamlining the decision-making process for community leaders, we can effectively prioritize the use of limited resources and produce the most pollution reduction for the least cost during implementation.

Strategies to Address Endocrine Disruption in Fish and Wildlife in the Chesapeake Bay Watershed

Author(s): Kelly Smalling

Affiliation(s): U.S. Geological Survey

Abstract: U.S. Geological Survey (USGS) scientists have established a national framework to evaluate endocrine disrupting chemicals (EDCs) and their effects on fish and wildlife. The four strategic goals for EDCs outlined by the framework were to 1) identify and quantify sources, fate, transport, distribution and exposure; 2) evaluate their effects on fish and wildlife; 3) determine their mechanism(s) and thresholds for adverse effects and 4) develop appropriate assessment tools and models to evaluate risk. The framework and strategic goals were applied directly to ongoing research in the Chesapeake Bay watershed to assess the exposure and potential effects of EDCs on fish and wildlife. The Chesapeake Bay is the largest estuary in the United States, and provides critical resources to fish, wildlife and people that use the 64,000 square mile watershed. For more than a decade, adverse effects associated with exposure to EDCs have been observed including intersex (testicular oocytes) in bass and plasma vitellogenin in male fishes (bass and sucker species). Skin lesions and mortalities of both adult and young-of-year bass have also been observed in fish from the same locations where the prevalence of intersex was high. Currently, emphasis is being placed on aquatic ecosystems with a focus on the identification of relevant EDCs, how they enter waterbodies, and how they affect aquatic organisms. Studies are investigating key pathways of EDC transport and exposure including the mechanisms and chemical thresholds associated with observed effects. Controlled laboratory and environmental field sampling approaches are being applied in tandem at six integrator sites that are dominated by agricultural land use. EDC research in the Chesapeake Bay Watershed was designed as a coordinated and collaborative effort between Federal, State and academic research partners to fill data gaps and synthesize findings. This study will provide a scientific basis for resource managers to consider strategies to reduce the occurrence of EDCs and their effects on fish and wildlife in this, and other, valuable ecosystems.

Quantifying the Benefits of Land Conservation on Water Supply in the Catawba-Wateree Watershed

Author(s): Michele Eddy, Katie van Werkhoven, Ben Lord, Jake Serago, Samuel Kovach

Affiliation(s): RTI International

Abstract: The Catawba-Wateree watershed in North Carolina and South Carolina is faced with a number of pressing water resource management challenges. Key among these challenges are the needs of 18 drinking water utilities to (1) meet long-term and often competing water demands from a growing population and (2) protect water quality in their rivers, streams, and reservoirs from the effects of continuing growth and development. Changes in land use and land cover that will accompany population growth could impact water availability within the watershed in multiple ways, including reduced reliability of baseflow, increased sediment load, and changes in evapotranspiration. The impacts of land use change may be exacerbated by increased water withdrawals and a warming climate. In combination, these changes could generate a situation in which there is a steadily growing imbalance between water demand and available water supply within the watershed. This study aimed to determine if deterioration in water availability and water quality due to land use change can be cost-effectively mitigated by focusing conservation efforts on identified geographic “hot spots” within a watershed. A spatially explicit hydrologic model was used to simulate streamflow under current and likely future land use, climate, and water use conditions for NHDPlus catchments across the watershed. Changes in flow characteristics and sediment load were compared to baseline/current conditions for each catchment under each future scenario. Catchments (or groups of hydrologically connected catchments) were ranked by the magnitude of the predicted changes in these variables in each scenario to reveal defined geographic areas (i.e., hot spots) that contribute disproportionately to the deterioration of water availability and quality within the watershed under the assessed conditions. The identified hot spots are locations where concentrated management options, such as land conservation, could be instituted to prevent losses to drinking water utilities in terms of availability and quality of supplies. In combination with an economic cost-benefit analysis, the study results offer guidance for the set-up of a “water fund” for the watershed, which could be used to pay for economically beneficial upstream land conservation activities.

How Best to Address the Challenge of Geology Along an Agricultural Reach of the Arkansas River in Colorado?

Author(s): Carleton Bern, Michael Holmberg, Zachery Kisfalusi

Affiliation(s): U.S. Geological Survey, Colorado Water Science Center

Abstract: The Arkansas River and the irrigation water it provides are the foundation for rural economies and communities in southeast Colorado. Water quality for agriculture, wildlife, and drinking water supplies in the region face complex but interrelated challenges from high concentrations of uranium, selenium, and salinity. Uranium concentrations in the river and groundwater sometimes exceed drinking water standards and uranium accumulates in downstream irrigated soils. Selenium concentrations in the river and some tributaries exceed the chronic exposure threshold for aquatic life in much of the region. Salinity accumulates in soils and decreases irrigated crop yields. The ultimate sources of these constituents are Cretaceous marine rocks present throughout the region, but canal diversions, reservoir storage, and irrigation are among the many anthropogenic influences that also affect their concentrations.

A wicked problem can be so named because of contradictory requirements, and the water quality challenges in the Arkansas River qualify. Deep percolation and subsequent return flow to the river from irrigation and water management structures contribute to greater mobilization of uranium, selenium, and salinity, but irrigators and other water users struggle with resulting poor water quality. Further, efforts to reduce deep percolation through increased irrigation efficiency can be at odds with requirements that return flows be maintained in line with the Kansas-Colorado Arkansas River Compact. Finally, some amount of irrigation-induced, deep percolation is required to prevent salinity buildup in irrigated fields.

Strategies to improve water quality in the Arkansas River in southeast Colorado have been suggested through previous reach-scale modeling efforts. The work presented here seeks to test assumptions about the drivers of uranium, selenium, and salinity concentrations, which include evaporation, transpiration, mobilization from geologic sources, and biogeochemical sequestration. Each driver imparts a fingerprint on the chemistry or isotopic composition of water they influence. Using chemistry and isotopes as tracers, the relative magnitude of each driver’s influence can potentially be traced, as well as how it varies spatially and seasonally. The resulting understanding can point towards management strategies likely to have the greatest positive influence on water quality, while not impacting water usage from the Arkansas River.

Using Nitrogen Isotopes of Chironomidae as an Index of Nitrogen Sources and Processing within Watersheds as Part of EPA's National Aquatic Resource Surveys

Author(s): J. Renée Brooks, Jana Compton, Alan Herlihy, Dan Sobota, Amanda Nahlik, and Marc Weber

Affiliation(s): US EPA

Abstract: Nitrogen (N) removal in watersheds is an important regulating ecosystem service that can help reduce N pollution in the nation's waterways. However, processes that remove N such as denitrification occur at defined points in space and time. Measures that integrate N processing within watersheds over time would be particularly useful for assessing the degree of this vital service. Because most N removal processes isotopically enrich the remaining N, $\delta^{15}N$ from basal food-chain organisms in aquatic ecosystems can provide information on watershed N processing. As part of EPA's National Aquatic Resource Surveys (NARS), we measured $\delta^{15}N$ of Chironomidae collected from thousands of lotic and lentic ecosystems across the continental U.S.; these larval aquatic insects were found in abundance in almost every lake, river, and stream surveyed. Using information on N loading to the watershed and summer total N concentrations in the water column, we assessed where elevated chironomid $\delta^{15}N$ would indicate N removal rather than possible enriched sources of N. Chironomid $\delta^{15}N$ values ranged from -4 to +20 ‰, and were higher in rivers and streams than in lakes (median = 7.6 ‰ vs. 4.8 ‰, respectively), indicating that lotic chironomids acquired N that was processed to a greater degree than lentic chironomids. For both lotic and lentic chironomids, $\delta^{15}N$ increased with watershed-level agricultural land cover and N loading, and decreased as precipitation increased. In rivers and streams with high synthetic fertilizer N loading, we found lower N concentrations in streams with higher chironomid $\delta^{15}N$ values, suggesting high rates of N removal. At low levels of synthetic fertilizer N loading, the pattern reversed; streams with enriched chironomid $\delta^{15}N$ had higher N concentrations, suggesting enriched sources such as manure or sewage. Our results indicate that chironomid $\delta^{15}N$ values can integrate watershed-level N sources, input rates, and processing for water quality monitoring and assessment at large scales.

Monitoring Aquatic Systems from Daily to Decadal Scales: Advances and Applications

The National Ecological Observatory Network Aquatic Sampling: Dissolved Gas Concentrations, Stratification Conditions in Lakes, and Reaeration Rates in Streams

Author(s): Kaelin Cawley, Keli Goodman

Affiliation(s): National Ecological Observatory Network (NEON)

Abstract: The National Ecological Observatory Network (NEON) is deploying instrumentation and collecting samples on a continental scale for 30 years, beginning in 2018. There are five components of NEON: Airborne Observation Platform (AOP), Terrestrial Instrument System (TIS), Terrestrial Observation System (TOS), Aquatic Instrument System (AIS), and Aquatic Observation System (AOS). Collocation of measurements associated with each of these components will allow for linkage and comparison of data related to physical, chemical, and biological parameters. The NEON Aquatic subsystem, comprised of AOS and AIS, will quantify the impacts of climate change, land use, and biological invasions on freshwater populations and processes. NEON will collect observational samples to evaluate stream geomorphology and lake bathymetry, organismal community composition, surface and groundwater chemistry, and habitat structure, in addition to deploying instrumentation in and around water bodies. Additionally, data processing of NEON measurements is standardized, and these quality-controlled data products are freely available through a publicly accessible online data portal (data.neonscience.org).

Some of the data that will be collected, processed, and published by NEON are particularly relevant to discovering connections between air, land and associated freshwaters, which drive the dynamics of carbon in inland waters. As part of the AOS sub-system, samples are being collected bi-weekly from 24 streams and 3 rives, and samples are collected monthly from 7 lakes for analysis of greenhouse gas (GHG) concentrations (CO_2, N_2O, and CH_4). At the same time, depth profiles for temperature, conductivity, and dissolved oxygen will be collected in the lake and river sites. From these depth profiles, stratification conditions can be discerned. At stream sites, reaeration tracer experiments (simultaneous conservative and gas tracer injection) are performed about 6 times per year. The stream reaeration rates will be related to stream discharge values to develop a rating curve from which temporally interpolated reaeration rates can be derived from high frequency discharge data. Dissolved gas concentrations and physical parameters derived from the NEON dataset will make up a component of GHG flux estimates at these sites, which will be useful for elucidating the relationship between GHG fluxes and physical characteristics of inland waters.

Seasonal Disconnect Between Hydrology and Retention Drives Riverine N Export in Western Oregon

Author(s): Jana E. Compton, Kara E. Goodwin, Daniel J. Sobota, and Jiajia Lin

Affiliation(s): U.S. EPA Office of Research and Development

Abstract: Watershed nutrient balance studies traditionally focus on annual timescales to examine factors controlling landscape level nutrient inputs, processing, and export. In areas with strongly seasonal precipitation, leaching losses may be greater during wet seasons when hydrologic forcing overwhelms retention and removal mechanisms. Information describing seasonal nitrogen (N) fluxes can provide insights on how N supply, landscape retention mechanisms, and hydrologic processes interact to shape the amount and timing of riverine N export, and can provide guidance for nutrient management. In Oregon's Willamette River Basin (WRB), a large watershed with pronounced dry summers and wet winters, we examined how the spatial distribution of farmland, cities, and forests influence N inputs and interact with hydrology to affect riverine N export. Nitrogen loads affect surface water functions and also groundwater quality in this area. Locally-derived data on N inputs coupled with streamflow and chemistry were compiled to calculate N balances for 25 WRB sub-watersheds for the mid-2000s. For the entire WRB, 80% of the nitrogen inputs came from agricultural activities, largely from synthetic N fertilizer (71%). The second largest input to the WRB was atmospheric N deposition (10%). Fractional riverine N export (annual riverine N export / annual watershed N input) averaged 20% of total N inputs; but ranged widely from 8-66% across the watersheds. Watersheds with the highest fractional export had very high rates of N input, or contained large proportions of urban land. Fall and winter seasons together accounted for 60-90% of the riverine N export across all watersheds. Summer export was generally quite low, but was highest in the watersheds that receive summer snowmelt. Fractional N export in the WRB watersheds is relatively high relative to other areas of the US. The fate of N, whether it is retained in the soils and groundwater or exported downstream or to the coast, is important for considering the net effects of N. Our analysis indicates that the wet winter season drives the high proportion of N inputs exported to rivers during winter in this strongly seasonal climate.

Assessing Physiochemical and Biological Condition of Rivers and Streams within the Mississippi River Basin and Sub-Basins

Author(s): Richard Mitchell, Susan Holdsworth, Michelle Maier

Affiliation(s): U.S. EPA

Abstract: The National Rivers and Streams Assessment (NRSA) is a partnership between US EPA, States and Tribes, with the purpose of providing estimates of river and stream condition at national and large regional scales. NRSA uses a randomized, unequally weighted probability survey design that provides an unbiased assessment of condition for these core indicators. Due to the geographic scale of the Mississippi River basin, NRSA is able provide an adequate sample size to report on the condition of rivers and stream for the entire Mississippi River basin, as well as major sub-basins such as the Ohio River basin. For this study the Mississippi River basin was divided into six sub-basins to ensure sufficient sampled sized for condition estimate (Upper Missouri, Lower Missouri, Arkansas-White-Red river basin, Ohio-Tennessee). To ensure comparability of results, NRSA utilizes standard sampling protocols across all sites. NRSA utilizes regionally developed thresholds for assigning condition classification (good, fair, poor) based regional reference condition. NRSA started in 2008/2009, with the second survey occurring in 2013/2014. Approximately 900 sites were sampled within the Mississippi River basin during each survey, with approximately 50% of sites re-sampled between surveys. Results from NRSA 2013/2014 showed substantial nutrient degradation throughout the Mississippi basin, with five out of the six sub-basins having at least 50% of river and stream miles in poor condition for phosphorus. Biological condition (benthic macroinvertebrates) was much more variable throughout the basin, with the percentage of river and stream miles in poor condition ranging from a low of 32% in the Upper Missouri to a high of 80% in the Lower Mississippi. Changes in phosphorus condition occurred between 2008/2009 and 2013/2014, with five of the six sub-basins showing a significant decrease in river and stream miles from 2008/2009 to 2013/2014. The basin wide increases of river and stream miles in poor condition for phosphorus were not seen for either nitrogen or biological condition, but there were some significant changes for a few of the sub-basins for both nitrogen and biological condition. As NRSA continues, future results will provide important data for assessing both nutrient and biological trends within the Mississippi basin.

Relating Watershed Land Use to Benthic Invertebrate Condition in the Virginian Biogeographic Province, USA

Author(s): Marguerite C. Pelletier, Arthur J. Gold, Jane Copeland, Liliana Gonzalez, Peter V. August

Affiliation(s): U.S. EPA

Abstract: Estuaries are dynamic transition zones linking freshwater and oceanic habitats. These productive ecosystems are threatened by a variety of stressors including human modification of coastal watersheds. Despite this, there are few studies conducted to demonstrate the importance of the watershed to coastal systems. In this study we examined potential linkages between estuarine condition and the watershed by developing regression models between landscape condition indicators and benthic invertebrate communities. To determine if the spatial arrangement was important in predicting benthic invertebrate condition, we examined variables at the watershed and riparian scale. We also developed models weighting landscape variables by distance as we expected proximity to the estuary to be important. Modeling estuarine condition indicated that inherent landscape structure (estuarine area, watershed area) is important to predicting benthic invertebrate condition. Estuarine area was positively related to invertebrate condition while the watershed area was negatively related. As shown in other studies, more natural land cover features (evergreen forest, wetland) help improve estuarine condition while anthropogenic impacts (development, agriculture) can have adverse impacts. Our results emphasize the importance of considering the underlying, unchanging components of the system that can influence resilience or vulnerability of the system. Considering the value of natural land as well as the minimization of the effects of development through best management practices will also be important.

Monitoring Aquatic Systems from Daily to Decadal Scales: Advances and Applications

Temporal Disturbance at the Micro Scale: Natural and Anthropogenic Impacts on Seepage Across the Sediment-Water Interface

Author(s): Don Rosenberry

Affiliation(s): U.S. Geological Survey

Abstract: The volume within several cm of the sediment-water interface is a dynamic ecotone where large gradients in physical, chemical, and biological processes and concentrations exist. Disturbances can disrupt flows of water, chemicals, and organisms across the interface and alter conditions both within and beyond this transitional volume. Simple and common anthropogenic influences can greatly disrupt this interface and may have unintended or unanticipated consequences. Boat wakes, for example, can create orders-of-magnitude increases in rates of flow across the sediment-water interface. Seepage at an estuary in New York City changed from upward flow at 1 cm/d to downward flow at more than 200 cm/d as a barge approached and then back to upward seepage but at more than 100 cm/d as the barge moved away from the measurement location. One-minute averages of seepage in 10 m water depth at a lake in central Minnesota increased from 0.2 to 0.6 cm/d as a large boat wake passed the measurement location. The standard deviation for that 1-minute interval increased from 1 to 9 cm/d, indicating the seconds-long disruption at 10-m depth was much larger during actual passage of the wave. Upward seepage at the shoreline of a large lake in California reversed and became downward when calm conditions transitioned to 15-cm-amplitude small waves, potentially flushing nutrients into the lake from the near-shore margin. These processes, although short in duration, represent large disturbances that have rarely been considered in studies of processes at and near the sediment-water interface. Biological and geochemical consequences of these disturbances thus far are largely unknown and may warrant additional investigation.

Hydrogeochemical Changes and Watershed Degradation Induced by Hemlock Loss in Northeastern Riparian Forests

Author(s): Kanishka Singh, Todd Walter, Mark Whitmore

Affiliation(s): Cornell University

Abstract: Eastern hemlock (*Tsuga canadensis*) is a keystone coniferous tree species found across eastern North America that performs a variety of crucial ecosystem functions.

Riparian forests and aquatic habitats dependent on hemlock-induced conditions are threatened by the hemlock woolly adelgid, an invasive species of insect that infests and precludes the tree from producing new foliage, causing rapid mortality. Hemlock decline is expected to initiate a cascade of ecosystem dynamics and attendant biogeochemical fluxes with the potential to precipitate severe water quality degradation through elevated nitrate loading into neighboring watersheds. Further, as climate change facilitates adelgid range expansion and increases the frequency of large precipitation and soil runoff events, the negative repercussions of hemlock loss pose greater future complications for watershed management.

Extant literature investigating such dynamics illuminates a number of relevant terrestrial factors, such as forest succession, temperature, the frequency of freeze-thaw events, soil frost, snow-bank depth, antecedent moisture, and soil profile, but remains divided on their ultimate consequences for water quality.

This present research project, based in Catskill State Park (NY), examines some of these factors and their relationship with hydrogeochemical changes and water quality, in the context of hemlock decline and deciduous succession in northeastern riparian forests.

Plots with critical infestation neighboring streams are identified with red and near- infrared spectrum imaging characterized as normalized difference vegetation index data. Satellite information is verified through in-situ light measurements of photosynthetically active radiation. Fluxes in nitrogen pools, nitrification and mineralization rates in soil, as well dissolved oxygen and aqueous nitrate concentrations in streams are measured and analyzed, and if significant changes are recorded, hydrologic modeling will be carried out to determine downstream effects. Findings may help natural resource managers understand what levels of hemlock decline contribute to critical changes in riparian stream chemistry and water resource quality.

Advancing Continuous Streamflow and Water Quality Monitoring Networks in the Coastal Plain, Waccamaw River Watershed, South Carolina

Author(s): Benjamin Thepaut

Affiliation(s): U.S. Geological Survey, South Atlantic Water Science Center

Abstract: The U.S. Geological Survey (USGS), South Atlantic Water Science Center, Conway Field Office is located in Horry County near the northeastern coast of South Carolina and maintains 29 stations at various waterbodies in the Santee and Pee Dee River basins. The stations are located in diverse hydrologic environments unique to the southeastern Coastal Plain such as fresh, black water rivers that are also tidally affected. These stations are equipped with instrumentation which records various parameters, including water level, velocity, precipitation, water temperature, specific conductance, pH, dissolved oxygen, and turbidity . Data are typically recorded at 15-minute intervals and transmitted hourly, via satellite, to the USGS NWISWeb, publicly accessible webpage (http://waterdata.usgs.gov/sc/nwis/rt). NWISWeb users also have the ability to query conditions in real-time and establish thresholds for automatic data delivery via email or text message using the USGS WaterAlert and WaterNow applications.

In addition to routine parameters, USGS stations have the ability to incorporate a suite of other monitoring instrumentation at any time. This ability to incorporate additional parameters is timely and beneficial as the South Carolina Department of Health and Environmental Control is currently developing nutrient concentration criteria for estuaries, rivers, and streams. In June, 2016, equipment was added to monitor nitrate (as NO_3^-) at an existing streamgage on the Waccamaw River near Longs, SC (USGS station 02110500). Data collected is post-processed using discrete samples to calibrate the equipment and develop a relationship between the recorded values and sample data. Project objectives include the validation of equipment and deployment strategies, determining baseline nitrate concentrations, and assess sources and sinks of nitrate. This presentation will focus on the advancement of monitoring stations in South Carolina, collection of continuous streamflow and water quality data, and highlight provisional nitrate data.

Nutrient Export from Highly Managed Coastal Watersheds: Lessons Learned from Long-Term Monitoring Data

Author(s): Yongshan Wan

Affiliation(s): U.S. EPA Office of Research and Development, National Health and Environmental Effects Research Laboratory

Abstract: The health of estuarine ecosystems is often influenced by hydraulic and nutrient loading from upstream watersheds. This study analyzed a long-term (1979~2014) water quality and discharge data set collected from four adjacent coastal watersheds in south Florida where land and water resources are highly managed through an intricate canal network. The objective was to determine the temporal and spatial changes in nutrient concentrations and export behavior in relation to watershed hydrology and resources management. While close associations of nutrient concentrations with land management and storm-water retention were identified across watersheds, long-term trends in nutrient concentrations were intervened by short-term highs driven by high discharges and lows associated with regional droughts. Nutrient export exhibited a chemostatic behavior for total nitrogen for all the watersheds, largely due to the biogenic nature of organic nitrogen associated with the ubiquity of organic materials in the managed canal network. Varying degrees of chemodynamic export was present for total phosphorus, reflecting complex biogeochemical responses to the legacy of long-term fertilization, low soil phosphorus sorption, and intensive stormwater management. The anthropogenic and hydro-climatic influences on nutrient concentrations and export behavior had great implications in nutrient management programs for restoration of the downstream estuarine ecosystem.

Regression-Based Rainfall-Runoff Modeling of Semi-Arid Ephemeral Watersheds: Analysis of High Resolution Long-Term Rainfall and Nested Watershed Properties in Walnut Gulch

Author(s): Menberu M. Bitew, David Goodrich, Eleonora Demaria, Philip Heilman, Lainie Levick, Carl Unkrich, Mark Kautz, and Mary Nichols

Affiliation(s): ARS-USDA Southwest Watershed Research Center

Abstract: Walnut Gulch is a semi-arid experimental watershed and Long Term Agro-ecosystem Research (LTAR) site managed by the USDA-ARS Southwest Watershed Research Center for which high-resolution, long-term hydro-climatic data are available across its 149 km^2 drainage area. In this study, we present the analysis of 50 years of hourly rainfall data to evaluate runoff control and generation processes. Multiple regression models were developed to relate rainfall and watershed properties to runoff characteristics in 12 sub-watersheds of area ranging from 0.002 – 100 km^2. The rainfall properties were event depth, maximum intensity, duration, location of the storm center with respect to the outlet, and storm size. The interaction between rainfall and runoff was evaluated through antecedent moisture condition (AMC), antecedent runoff condition (ARC) and runoff depth and duration for each rainfall event. The watershed properties include parameters such as contributing area, slope, shape, channel length, stream density, channel flow area, and percent area behind stock ponds for each of the nested catchments. Evaluation of the model using basic and categorical statistics showed good predictive skill throughout the sub-watersheds. The model produced correlation coefficients ranging from 0.4-0.94, Nash efficiency coefficients up to 0.77, and Kling-Gupta coefficients ranging from 0.4 to 0.98. The model predicted 92% of runoff events and 98% of no-runoff events across all the sub-watersheds considered in the study. The regression predictions were used to assess the effectiveness of QAQC procedures for the Walnut Gulch dataset and showed good potential in identifying inconsistent observations or processing of observations. The model also has the potential for making runoff predictions in similar hydro-climatic environments where high-resolution ground-based radar-rainfall estimates are available.

Novel Approaches and Applications in Hydrologic Modeling for Watershed Research

Characterizing Depressional Wetland Storage in a Watershed: Linking Remote Sensing and Hydrologic Modeling Approaches

Author(s): J. Christensen, G. Evenson, M. Vanderhoof, Q. Wu, H. Golden, C. Lane, L. Alexander

Affiliation(s): U.S. EPA Office of Research and Development, U.S. Geological Survey, Virginia Tech, Binghamton University

Abstract: Wetlands in the 700,000 km^2 Prairie Pothole Region of North America (PPR) can store large amounts of water on the landscape. Some wetlands fill and spill to other aquatic systems while others fill and merge within larger wetland depressions. Wetland storage and spillage varies both spatially and temporally in PPR watersheds and these variable dynamics influence hydrologic and biogeochemical landscape processes. To explore how to best characterize spatial and temporal variability of this wetland storage, we compared three approaches, 1) hydrological modeling alone, 2) remotely-sensed data alone, and 3) integrating remotely-sensed data into a hydrological model. These approaches were tested in the Pipestem Creek Watershed, North Dakota across a drought to deluge cycle (1990-2011). A Soil and Water Assessment Tool (SWAT) model was modified to include the water storage capacity of individual wetlands on the landscape identified in the National Wetland Inventory (NWI) dataset. The SWAT-NWI model simulated the water balance, storage and spillage of each wetland during the 21-year study period. However, SWAT-NWI only accounted for fill-spill, and did not allow for the expansion and merging of wetlands situated within larger depressions. The SWAT-NWI model was then modified to use LiDAR-derived depressions that account for the potential maximum depression extent, including the merging of smaller wetlands. Alternatively, we assessed the occurrence of fill-merge mechanisms using Landsat-derived inundation maps on 19 cloud-free days during the 21 years. During deluge, fill-merge mechanisms were prevalent across the Pipestem watershed and storage volume was dominated by large merging depressions. The inundation maps were used to evaluate the ability of the SWAT-depression model to simulate fill-merge dynamics in addition to fill-spill dynamics. Ultimately, using remote sensing to inform and validate process-based modeling allows us to assess both the spatial and temporal continuum of storage across a watershed, identify approach limitations, and improve efforts to study and map wetland storage dynamics in the PPR and beyond.

Modeling Impacts of Inter-Basin Transfers on Water Supply Distribution for National Forest Lands and the Conterminous United States

Author(s): Kai Duan, Peter V. Caldwell, Chelcy F. Miniat, Ge Sun, Paul V. Bolstad

Affiliation(s): University of Minnesota

Abstract: The 170 National Forests and Grasslands (NFs) in the conterminous United States occupy 8.8% of the land area yet provide 14% of the freshwater supply. Regional availability of water supply from these NFs, as well as state and private forests and non-forested areas, varies spatially depending on local water yield and streamflow accumulated from upstream watersheds. Several previous studies have addressed water yield from NF lands under natural conditions without human impacts. However, redistribution of water from NF lands through human water management such as inter-basin water transfers (IBTs) is largely unstudied due to the lack of data. Using monthly outputs from the Water Supply Stress Index model for the time period of 1961-2015, geospatial attributes of streams from the National Hydrography Dataset, and a modified dataset of 228 IBTs from US Geological Survey reports, we established an inventory of sources of renewable freshwater for the 82,773 12-digit Hydrologic Unit Code (HUC-12) watersheds. Specifically, the footprint of water originating from NFs was tracked and compared under two scenarios with or without the impact of IBTs. Results suggest that these IBTs have played a notable role in re-distributing water from the NFs to densely populated areas. For example, the 8.1 billion m^3 water transferred through five IBTs from the Sierra Nevada and the Colorado River to southern California has been a major source of freshwater for cities including Los Angeles, and water originated from NF lands accounts for 66% (5.3 out of 8.1 billion) of the water transferred. Across the HUC-12 watersheds, IBTs caused changes in the contribution of NF lands to regional streamflow in 2,249 watersheds, varying between a decrease of 11% in the proportion of water from NFs to an increase of 60%. Over a thousand watersheds, mostly located in the drainage basins of South Atlantic-Gulf, Missouri, Arkansas-White-Red, and Rio Grande, have benefited from additional water from NFs delivered by the IBTs. These results provide insights into the natural and anthropogenic water nexus among watersheds, and can support water management at various levels when linked to national water use census data.

Contrasting SWAT Predictions of Watershed-Level Streamflow and Nutrient Loss Resulting from Static Versus Dynamic Atmospheric CO_2 Inputs

Author(s): Kpoti Gunn, Tamie Veith, Anthony Buda

Affiliation(s): USDA-ARS

Abstract: Past climate observations have indicated a rapid increase in global atmospheric CO_2 concentration during late 20th century (13 ppm/decade), and models project further rise throughout the 21st century (24 ppm/decade and 69 ppm/decade in the best and worst case scenario, respectively). We modified SWAT2012, a watershed-level, semi-distributed hydrologic and water quality simulation model, to incorporate dynamic atmospheric CO_2 concentrations and account for the mechanistic effects of CO_2 concentrations on vegetative transpiration by plant species. Using downscaled predictions from nine climate models for 1960-2100, we investigated the effects of static versus dynamic CO_2 inputs on simulated streamflow and nutrient concentrations in an agricultural watershed that drains to the Chesapeake Bay. Preliminary results under current agricultural management indicated that rising CO_2 levels through the 1900s were minimal enough to not impact streamflow and water quality, but that additional increases in CO_2 will have an impact and must be considered as we move further into the 21st century. In particular, predicted streamflow levels decrease, presumably in response to increased plant evapotranspiration as CO_2 concentrations continue to rise. We will compare the predicted streamflow and evapotranspiration between the static and the dynamic CO_2 status, and explore the implications of these changes on nutrient concentrations and fluxes.

Novel Approaches and Applications in Hydrologic Modeling for Watershed Research

Rangeland Watershed Research for the West

Author(s): Philip Heilman, G. Ponce, F. B. Pierson, and D. C. Goodrich

Affiliation(s): USDA-ARS Southwest Watershed Research Center

Abstract: We reclassified the 2011 USGS National Land Cover Dataset (NLCD) in Google Earth Engine to include only open space and low intensity developed, evergreen forest, grassland, shrub- and barren-land classes west of the 100th meridian to define the extent of the area to which western headwater rangeland watershed research needs to be applied. The resulting upland area is on the order of 3.6 million km^2 and the length of intermittent and ephemeral flows based on the National Hydrography Dataset (NHD) is substantial. Two research units with the mission of improving the science used to manage rangeland watersheds, the USDA-Agricultural Research Service's Northwest and Southwest Watershed Research Centers, operate long term experimental watersheds in Idaho and Arizona respectively. In addition to the Reynolds Creek and Walnut Gulch Experimental Watersheds, there are three other experimental watersheds, 13 experimental forests and four experimental ranges with long-term measurements of streamflow in the West. Unfortunately, many of these sites no longer collect streamflow data, and it is unclear how much concurrent precipitation, soil, topography, and watershed cover data are available to model streamflow. Rainfall simulation experiments have also been widely used to better quantify the effect of soil and vegetation on runoff and erosion at the plot scale. The US Geological Survey monitors streamflow, primarily on larger, perennial reaches. Typically, the understanding of physical processes that determine the hydrologic cycle and erosion at the hillslope and small watershed scale is incorporated into and applied to improve management through simulation models. There is a significant national interest in land management in the West, with 47% of the 11 western states federally owned. As the western population grows, groundwater tables often decline, and climate change increases sublimation and evapotranspiration, so surface water supplies are under increasing pressure. A concerted and more systematic effort to quantify watershed processes across the West is needed to help public land management agencies and grassroots groups improve watershed management for the sustainable provision of a range of ecosystem services.

Comparison of the Critical-Depth Method with Conventional Indirect Methods of Computing Peak Discharge in Mountain Streams: Evaluation of the 2013 Flood in the Colorado Front Range

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Abstract: A critical component of flood science, watershed restoration, and watershed management is rapid and reliable data collection for subsequent water-resources investigations. In 2013, Colorado experienced one of its worst flood seasons in history. During July and August, the foothills west of Colorado Springs experienced three moderate thunderstorms that typically would not have produced any flooding in forested watersheds. However, the rain fell on terrain that had been severely burned in 2012 by the Waldo Canyon wildfire. Intense runoff from the burn area produced a true “wall of water” from several rainstorms, which resulted in the loss of one life and extensive property damage. In mid-September, up to 500 mm of rainfall over several days produced record flooding over much of the Front Range, extending from Colorado Springs north to Wyoming; the rainfall recurrence interval was greater than 1,000 years. The storm produced widespread flooding (recurrence interval of up to about 700 years) that resulted in ten deaths and over 2 billion dollars in damages. Man-made dam failures, landslides (and associated landslide-dam failures), and debris flows all served to exacerbate flooding in many mountain streams, and in some cases tripling the natural flood discharges.

Estimating the magnitude and frequency of regional flooding requires substantial peak-discharge documentation. Using cost effective methodologies, over 150 indirect measurements were obtained using the critical-depth method at a cost of approximately 250 dollars per measurement (vs greater than 15,000 dollars for standard indirect-flood methods). Some of these measurements were made where more comprehensive indirect methods of computing peak discharge were made by other flood specialists. Scientists, engineers, and planners were provided peak-discharge data and technical assistance to better understand the nature of the floods to help the region recover more effectively from flooding, as well as to help mitigate the effects of future flooding. This presentation provides a brief overview of the 2013 flooding, and a comparison of peak discharges computed with the critical-depth method and standard, indirect-measurement methods (slope-area, bridge contractions, 2-D hydraulic models, etc.). Improvements in rainfall-runoff modeling and flood-frequency estimates will help mitigate future loss of life and property from flooding.

Modeling Urban Hydrology and Green Infrastructure using the AGWA Urban Tool and the KINEROS2 Model

Author(s): Yoganand Korgaonkar (UA), D. Phillip Guertin (UA), David C. Goodrich (USDA-ARS), Carl Unkrich (USDA-ARS), William Kepner (U.S. EPA), I. Shea Burns (UA)

Abstract: In arid and semi-arid regions, green infrastructure (GI) can address several issues facing urban environments, including augmenting water supply, mitigating flooding, decreasing pollutant loads, and promoting greenness in the built environment. An optimum design captures stormwater, addressing flooding and water quality issues, in a way that increases water availability to support natural vegetation communities and landscaping in the built environment. A module was developed for the Automated Geospatial Watershed Assessment (AGWA) tool (https://www.epa.gov/water-research/automated-geospatial-watershed-assessment-agwa-tool-hydrologic-modeling-and-watershed or https://www.tucson.ars.ag.gov/agwa/) which supports the design and placement of a suite of GI practices, singularly or in combination, in order to simulate urban hydrology with and without GI features at the household and neighborhood scale. The GI tool takes advantage of the advanced, physically-based infiltration algorithms and geometric flexibility of the Kinematic Runoff and Erosion (KINEROS2) watershed model. The resulting software provides an up-to-date GIS GI assessment framework that automatically derives model parameters from widely available spatial data. It is also capable of manipulating GI features within a graphical interface to conveniently view and compare simulation results with and without GI features at a lot, neighborhood or small catchment scale. The new tool was used to assess a variety of GI designs across a subdivision in Sierra Vista, Arizona for design objectives to: 1) maximize stormwater capture; 2) maximize water augmentation; and, 3) maximize ecosystem services.

Mapping Stream and Floodplain Geomorphic Characteristics with the Floodplain and Channel Evaluation Toolkit (FACET)

Author(s): Marina Metes, Kristina Hopkins, Gregory Noe, Samuel Lamont

Affiliation(s): U.S. Geological Survey

Abstract: The Floodplain and Channel Evaluation Toolkit (FACET) was developed as an open source tool to calculate a suite of geomorphic metrics describing channel and floodplain geometry from high-resolution digital elevation models (DEMs), providing estimates of channel width, bank height, cross-sectional area, and active floodplain extent. Field data from sites in the Chesapeake Bay and Delaware River watersheds were used to calibrate and validate FACET within four physiographic provinces: 1) Coastal Plain, 2) Piedmont, 3) Valley and Ridge, and 4) Appalachian Plateau. FACET has built-in pre-processing steps to hydrologically condition DEMs using open-source tools (Whitebox GAT, TauDEM) and the stream network is delineated using the initiation points of an existing stream layer such as the High Resolution National Hydrography Dataset. Stream banks are identified using two methods: 1) by applying a slope-threshold method at cross-sections which are automatically generated at a user-defined interval along the delineated stream network and 2) by applying a curvature-threshold method for grid cells within a buffered distance from the stream network. The active floodplain is identified using a height above nearest drainage (HAND) grid and empirical regression models built for each physiographic province relating the HAND threshold to drainage area. Channel and floodplain metrics are extracted from each method. Other user-defined input parameters control the sensitivity of calculations to sinuosity, relief, and channel/floodplain width, allowing for the ability to optimize FACET at multiple scales and/or regions if field survey data are available for calibration. The increasing availability of high-resolution elevation data provides the ability to scale up field-based measurements to the watershed scale. Geomorphic metrics derived from FACET can be related to field measurements of bank erosion and floodplain deposition rates to predict fluxes at unmeasured reaches and improve the development of watershed sediment and pollutant budgets. Geomorphic metrics also can improve regional-to-national scale hydrologic and water quality models and support land and water resource management decision making.

Modeling Violations of the Nitrate Standard for Public Drinking Water Across the Conterminous United States

Author(s): Michael Pennino, Scott G. Leibowitz, Jana E. Compton

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Abstract: Excess nitrate in drinking water is a human health concern, especially for young children. As a result, when a public drinking water system exceeds the 10 mg nitrate-N L^{-1} maximum contaminant level standard, that system is reported as having a violation in the US Environmental Protection Agency's (EPA) Safe Drinking Water Information System. We used random forest classification (RFC) and RF regression (RFR) modeling to predict nitrate violations across the conterminous United States, to determine where systems are most likely to exceed the nitrate MCL. For RFC, we assigned stream catchments in the national hydrography dataset that have had a violation any time between 2013 and 2017 as a one and catchments without violations as a zero. For RFR, we calculated the mean annual percent of public drinking water systems in violation for each catchment. As explanatory variables, we used EPA's StreamCat variables, including land cover, nitrogen inputs from fertilizer, precipitation, and soil characteristics. We also calculated other metrics: agricultural drainage, nitrogen surplus, aquifer type, water inputs and withdrawals, density of septic systems and wastewater treatment plants for each catchment. For groundwater systems, the RFC model was able to correctly classify 79.9% of catchments with or without systems, whereas the RFR model explained 26.6% of the variation. The variables consistently most important in both models for predicting groundwater system violations were percent cropland, temperature, soil permeability, fertilizer inputs, water table depth, and precipitation. For surface water systems, the RFC model was able to correctly classify 83% of catchments with or without systems, however, the RFR model explained <0% of the variation. The variables most important for both models were percent cropland, runoff, baseflow, percent forest, and organic matter content. Regions predicted to have highest probability of violations were central California, areas in Texas, Oklahoma, and Kansas that are above the Ogallala aquifer, the Upper Midwest (Minnesota, Wisconsin, and Michigan), and southeast Pennsylvania and Delaware. Understanding where violations are most prevalent and the causes of violations will help inform future management decisions on how treatment, source water protection, and other management options could best protect drinking water from nitrate contamination.

Integrating LiDAR Data and Google Earth Engine for Mapping Watershed-Scale Wetland Hydrological Dynamics

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Abstract: 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. The National Wetlands Inventory (NWI) for this region was developed decades ago through manual interpretation of black-and-white aerial photographs acquired in the 1980s, which is static and out of date. Traditional medium-resolution satellite imagery (e.g., Landsat, MODIS) do not effectively delineate these small depressional wetlands. By integrating high-resolution Light Detection and Ranging (LiDAR) data, time-series aerial photographs from the National Agriculture Imagery Program (NAIP), and Google Earth Engine, we developed a workflow for mapping wetlands and analyzing their hydrological dynamics at watershed scales. Machine learning algorithms were used to classify aerial imagery with additional spectral indices to extract wetland inundation areas, which were further refined using LiDAR-derived landform depressions. The wetland delineation results were then compared to the NWI dataset to evaluate the performance of the proposed method. We tested the workflow on the 2270-km^2 Pipestem Creek subbasin in North Dakota (2009 - 2015). 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 the fill-spill hydrological processes. Our workflow provides a scalable framework readily available to be adapted to delineate wetlands at regional and national scales.

Sierra Nevada Streamflow Response to Forest Fuels Treatments During the California Drought

Author(s): Ryan Bart, Mohammad Safeeq, Joseph Wagenbrenner, Carolyn Hunsaker

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Abstract: Forest fuel treatments (e.g. thinning, prescribed fire) are used in the Sierra Nevada to minimize forest fire risks and in some cases have been shown to affect the amount and timing of water contributing to streamflow. This effect, however, is variable, with the amount of post-treatment streamflow change affected by differences in treatment locations and post-treatment meteorological conditions. In this study, we examined the effect of fuel treatments on Sierra streamflow in two sets of paired-watershed experiments. The first set of watersheds, Providence, was located at the rain-snow transition zone and consisted of treatments that included thinning, prescribed fire, and thinning followed by prescribed fire. The second set of watersheds, Bull, was located above the rain-snow transition zone and had an identical treatment design. The treatment events happen to coincide with one of the most severe droughts in California history (2012-2016). As such, the overarching research question for this analysis was how do fuel treatments affect streamflow during drought conditions. Results from the paired-watershed experiments showed no discernible change in post-treatment annual streamflow, seasonal streamflow or low flows at either of the study locations. To explore the physical mechanisms for why no streamflow change was observed during the drought, we used an ecohydrology model, The Regional Hydro-Ecologic Simulation System (RHESSys), to model the effect of fuel treatments on streamflow under different levels of post-treatment precipitation. The modeling results indicated that streamflow change during drought conditions should be minimal at the levels of basal area removed that occurred with the treatments, confirming the paired-watershed results. This study contributes to the growing body of knowledge demonstrating when and where forest fuel treatments may affect streamflow.

Hydrologic Impacts of Extreme Precipitation Events on a Low Gradient Coastal Plain Watershed

Author(s): David Bosch

Affiliation(s): USDA-ARS

Abstract: Extreme climatic events, particularly those involving extreme precipitation, can have dramatic effects on the landscape. These effects can be buffered or enhanced by the characteristics of the landscape. The Little River Watershed (LRW) at the headwaters of the Suwannee Basin in south central Georgia of the United States has been studied by the Southeast Watershed Research Lab of the USDA Agricultural Research Service since 1968. Data are collected on the LRW to quantify the long-term relationships between precipitation and streamflow. Watersheds in this region are characterized by low-gradient stream channels with wide and heavily vegetated floodplains. The long-term nature of the data set provide an opportunity to characterize the impact of extreme precipitation events in particular on this unique landscape. The characteristics of these coastal plain watersheds can buffer the impacts of extreme events during dry seasons of the year but offer less buffering during wet seasons. Observed precipitation and streamflow were analyzed to develop probability distribution curves for each. Extreme rainfall and streamflow events were then related back to seasonal patterns to separate the effects of large springtime events from summer hurricane related events. Lastly, a comparison was made between the impacts of the extreme events on a primarily agricultural watershed to those observed in an urban watershed.

Using Long-term Data on Assessing Extreme Climatic Events Effects on Watershed Processes, Functions and Management Practices

Warming Temperature Homogenizes Landscape Vegetation Patterns at the Catchment Scale

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Affiliation(s): Indiana University Bloomington

Abstract: Hydroclimate change is expected to bring warmer temperatures and increased hydrologic extremes, including more intense precipitation and longer inter-storm periods. In mountainous headwater catchments, downslope flow could mitigate the impact of dry periods in convergent topographic areas, buffering vegetation species from soil moisture stress during drought. Here we investigate changes in catchment-scale vegetation patterns in six forested headwater catchments in the Coweeta Hydrologic Laboratory in the southern Appalachian Mountains. We use a 30-year Landsat Thematic Mapper (TM) image record, spanning a period of recorded warming from the mid-1980s to present, and relate these long-term vegetation dynamics to seasonal water balance and low flow dynamics. Contrary to expectation, upslope vegetation showed a greater response to warming, compared downslope, also supported by long-term tree and litterfall data in one of the reference watersheds (20 years). This indicates that vegetation density (leaf area) patterns paths have been homogenized along hydrologic flow over time. In contrast to our expectations, the vegetation downslope may be experiencing lower growth with increased drought conditions than upslope vegetation, due to their strong dependency on upslope water subsidy. This suggests that vegetation downslope may experience more dramatic changes in hydroclimate condition with more frequent droughts due to their strong dependency on upslope subsidies. This study also highlights need to understand underlying hydrologic balance along hillslope gradient and topographic redistribution of soil moisture to predict forested ecosystem response to climate change.

The Role of Drought in the Post-Harvest Hydrologic Recovery of a Rain-Dominated Forested Watershed

Author(s): Elizabeth Keppeler, Joe Wagenbrenner, Paul Richardson

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Abstract: Managers face a myriad of complexities in maintaining healthy, productive watersheds. The effects of land use on ecohydrologic processes must be addressed and distinguished from those of climatic variation. Long-term data from forested watersheds are critical to parsing out treatment effects from cycles of precipitation deficit and surplus. Incorporating climate data into streamflow analyses from paired-watershed studies can lead to new insights into hydrologic responses to watershed treatments. Here, a 55-year record of precipitation and streamflow is used to explore the transformation of meteorologic drought into hydrologic drought in the Caspar Creek Experimental Watersheds in coastal northern California. The standardized precipitation index (SPI) and the standardized runoff index (SRI) time series are calculated for two forested catchments using accumulation periods of 1–24 months. Two “extremely dry” events (1976-77 and 2013-14) are evident in the 12-month SPI time series. The earlier event follows the 1971-73 harvest of the 424 ha South Fork watershed and the second follows the 1989-92 harvest of the 473 ha North Fork watershed. The relationship between meteorologic and hydrologic drought is examined by correlating the two indices using a range of accumulation periods. In the absence of harvest treatments, differences between the two indices suggest a multi-year delay in recovery of subsurface water storage following the cessation of meteorological drought. Post-harvest differences suggest larger changes in the magnitude and timing of runoff. When overlain by the treatment cycles in the paired watersheds, these results provide new insights into the annual and seasonal streamflow trends following timber harvest and how recovery may be altered by climatic variation.

Automated Geospatial Model Based Assessment of Erosion Vulnerability at Forest Road/Stream Crossings under Extreme Precipitation Intensities Scenario

Author(s): Sudhanshu Panda, Devendra M. Amatya, Johnny Grace, Pete Caldwell, and Dan Marion

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Abstract: Forest road/stream crossing drainage structures (culverts/bridges) are vulnerable to erosion due to high gradient topography and climate change related extreme precipitation events. Therefore, goal of this study is to develop automated geospatial models to identify erosion hazards and vulnerability risks to these structures through amounting the sediment erosion passing through them during extreme precipitation events. This study is completed in three environmentally differing watersheds – 1) Coastal Turkey Creek watershed in South Carolina, 2) Mountainous Coweeta watershed in North Carolina, and 3) Alum Creek watershed in central Arkansas. Two modeling approaches were used in this study- 1) a streambank erosion spatial vulnerability assessment (SBEVA) model and 2) Revised Universal Soil Loss Equation (RUSLE) model for erosion potential estimation. SBEVA model was developed in ArcGIS ModelBuilder using geospatial data like landuse, digital elevation models (DEM), various soil characteristics, and design flood discharges calculated using 100-year recurrence interval 24-hour partial duration series storm data obtained from National Oceanic & Atmospheric Administration (NOAA). All these spatial environmental variable rasters were reclassified with their vulnerability probability scale developed through Delphi method of weighted scale determination. The combined parameters overlayed model provided the qualitative scale vulnerability results of all the forest streams. RUSLE model was developed in ArcGIs ModelBuilder to estimate pixel based erosion amount and a cumulative erosion at each road/stream crossings. The model uses the proven empirical equations using factors: rainfall erosivity, soil erodibility, slope length and gradient, crop/vegetation management, and support practice for erosion prediction. NOAA 100-year, 30-minute partial duration series storm intensity raster was used to develop the latest Isoerodent map (R-factor). The K, L, and S-factor rasters were developed from gSSURGO data. OBIA-based classified ultra-high resolution orthoimageries provided accurate and timely C-factor and P-factor rasters. Both SBEVA and RUSLE model resultant rasters were spatially combined to establish the most vulnerable culverts/bridges in the three forested watersheds. In addition, to confirm and identify through our study, GNSS instruments were used to groundtruth the culverts for erosion vulnerability in extreme weather condition. Moreover, this study would provide proactive decision support to USDA Forest Service or any other agencies responsible for safeguarding these structures

Using Long-term Data on Assessing Extreme Climatic Events Effects on Watershed Processes, Functions and Management Practices

"The Storm Was Downright Weird": Understanding the December 2007 Storm in Southwest Washington Using Short- and Long-term Hydro-Climatic Data

Author(s): Maryanne Reiter, Jami Nettles

Affiliation(s): Weyerhaeuser Company

Abstract: From December 1-4, 2007 an unusual and powerful storm struck Northwest Oregon and Southwest Washington with hurricane-force winds and extreme magnitude precipitation. The windstorm, dubbed "the Great Coastal Gale" had high wind speeds (>50-knots) for two days, far exceeding the duration of other historic regional windstorms. The duration of high winds led to extensive damage to coastal structures and surrounding forests. The intense rainfall most heavily affected areas on the eastside of the north Oregon Coast Range, the Willapa Hills of southwest Washington and the eastern Olympic Peninsula. The greatest recorded storm rainfall was 499 mm (19.6 in) with a 24-hour rainfall maximum of 364 mm (14.35 in) for a station in the Willapa Hills. Snowmelt generally contributed only a small amount of runoff compared to rainfall. Ten rivers in Washington exceeded their flood of record. In the Chehalis River basin, 5 all-time high records were broken. In the upper Chehalis River, flood peaks were twice the previous flood of record and estimated to have a recurrence interval of 500-years. The extreme magnitude precipitation in that area also resulted in a large number of landslides, but where rainfall totals were closer to the 100-year storm, very few landslides occurred. The greatest impact of rainfall, flooding and landslides occurred in an area of the state that is sparsely populated and where, until recently, there was no weather radar and few climate stations. Because of the more localized nature of the storm and the lack of publicly available climate data, the storm was initially classified as a moderate event. Accessing all available stream gage and climate station data were critical in interpreting the magnitude of this event in order to put the damage in context. Equally as important for interpreting the storm were our company climate stations that we had previously located in areas where no public stations existed. This storm and its aftermath illustrated the importance of access to long-term public data as well as maintaining a robust monitoring network in areas where public data is lacking.

Potential Impacts of Extreme Precipitation Events on Peak Discharges at USDA Forest Service Long-term Experimental Watersheds

Author(s): S. Tian, D.M. Amatya, D.A. Marion, P. Caldwell, S. Panda, S. Laseter, G.M. Chescheir, J.M. Grace, C. Roghair, M.A. Youssef, G. Sun, J.M. Vose, Y. Ouyang, and A. Dolloff

Affiliation(s): North Carolina State University

Abstract: Increased peak-flow magnitudes resulting from growing extreme precipitation events might have adverse effects on the existing stormwater management, drainage, culverts, bridges, and other applications. Engineers and hydrologists often use precipitation intensity-duration-frequency (PIDF) curves published by NOAA for design of such infrastructure. However, it is unknown how the PIDF has changed over time for specific sites and applications. In this paper we derived PIDF curves using a Generalized Extreme Value Distribution (GEV) approach with 1976-2015 hourly precipitation data from rain gauges at two USDA Forest Service research sites instead of using corresponding NOAA estimates. Coweeta Hydrologic Laboratory (CHL), NC, and Santee Experimental forest (SEF), SC representing a mountain and a coastal type site, respectively. The study objectives were to 1) examine the trend of annual maximum rainfall intensity and 2) compare the derived design PIDFs for 2-, 5-, 10-, 25, -50-, 100-, and 200-yr return periods for durations ranging from 1-hr to 72-hr to NOAA estimates. Preliminary results showed no trend in rainfall intensities at the coastal SEF site. However, increasing trends were found at the mountainous CHL site for all durations especially since after 2000, although significant trends were only detected for durations of 24-hr ($p=0.04$) and 2-day ($p=0.03$). Compared to our results using on-site data, published NOAA predictions underestimate rainfall intensities for durations of 1-hr and 2-hr for frequencies > 25-yr and overestimated for longer durations with frequencies >50-yr. This finding may be significant as shorter duration intensities are critical for infrastructure design on flashy high-gradient sites with shorter time of concentration (Tc), especially if a design frequency of > 25 years is used for road infrastructure. However, at the coastal SEF site with longer Tc, both the NOAA and our results yielded similar results for 1-hr duration for up to 50-yr frequency after which NOAA slightly exceeded our value. For all other durations, our results were higher than those from the NOAA estimates for all frequencies > 5-yr, indicating NOAA-based estimates may lead to underestimating design rainfall intensities for sizing road infrastructure at the coastal SEF site

USEPA’s OpenTERRAworks Software System - An Open-Source 2D/3D Landscape Design GIS Tool

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Abstract: Human activities involving significant terrain alteration (e.g. earthworks operations associated with mines, urban development, landslides) can lead to wide-ranging changes in the surrounding terrestrial and aquatic environments. Potential aesthetic impacts can be associated with modified relief, soils, or change in land cover. Additionally, changes can be seen in spatiotemporal rates of surface runoff and erosion; rerouted flow paths; impacts to water quantity and quality; and species and ecosystem composition. Readily-accessible GIS-based landscape design tools available to the environmental community are lacking. Often modelers lack tools to create the detailed views of the land needed to model environmental changes before they happen. The OpenTERRAworks Software System (OTW) is an open-source Geographical Information System (GIS) that expands the capacity of USEPA to predict hillslope- to watershed-scale effects of proposed, alternative, and legacy landscape designs involving significant terrain modification terrain (3D) and/or surface (2D) modification. Users can readily access web-served landscape datasets and modify acquired data to represent changes in terrain elevations, soils, land use/land cover, and hydrography. OTW represents a "substitution" pattern for consuming landscape data that capture many key features of the environment needed to understand and predict future watershed conditions at multiple scales. OTW is not a model, but instead helps generate modified data in formats that many hydrology models and other analytical frameworks already consume. OTW provides a set of site-level, value-added “design operations” (e.g. cut, fill) for defining landscape change within the conterminous US. OTW tracks design branches and phases at and across sites. OTW’s geologic erosion routine and a companion dataset of coal seam data (West Virginia only) allows users to construct resource layers they can employ for design cuts. Typical intended consumers of OTW output files are analytical tools or models that already consume HUC8-scale geospatial datasets in standard formats. Typical uses include producing modified datasets, allowing users to analyze “futures” and/or conduct comparative analysis of baseline vs. future landscapes. OTW’s newest Model Mode facilitates customized extensions that let model developers and users automate production of input data that can be consumed directly by their modeling system (e.g. add new map layers and web-services as needed).

Cumulative Effects of Unconventional Oil and Gas Development on the Chemistry of Headwaters Within West Virginia

Author(s): Kevin Eliason, Todd Petty, Eric Merriam

Affiliation(s): West Virginia University

Abstract: We assessed the effects of unconventional oil and gas (UOG) development on headwater stream chemistry and biological condition within the Monongahela River watershed, WV. We selected 53 study sites differing with respect to their individual and combined influence from UOG, conventional oil and gas (COG), coal mining, and residential development. Principal components analysis identified 3 dominant (~60% cumulative variance explained) dimensions of variation in water chemistry. Principal component (PC) 1 (~31% variance explained) was associated with dominant ions (Ca, Mg, K, Na, and SO_4^{-2}), as well as Sr and Br. Multiple regression analysis suggested mining and residential development were the dominant contributors to altered chemistry as characterized by PC 1. Using elevated Br/Cl as a tracer of oil and gas impact suggested greater chemical degradation with increased oil and gas intensity in impacted sites; however only 15 sites had elevated Br/Cl. Our results suggest UOG development is having a significant but inconsistent effect on surface water chemistry, with overall chemical degradation being dominated by mining and development. Additional sampling is needed to improve our ability to characterize and predict chemical degradation associated with UOG, as well as consider potential combined effects of UOG and other pre-existing land use stressors on aquatic communities.

The Experimental Watershed Study Approach to Monitoring and Managing Contemporary Mixed-Land-Use Watersheds

Author(s): Jason Hubbart, Elliott Kellner

Affiliation(s): West Virginia University

Abstract: Advancements in contemporary watershed management are both a major challenge, and urgent need of this century. The experimental watershed study (EWS) approach was used in forested wildland watersheds over a century ago to quantitatively characterize basic landscape alterations (e.g. forest harvest, road building) on water quality and various ecosystem responses. In recent years, EWS is being repurposed for contemporary multiple-land-use watershed monitoring and management practices. Contemporary watersheds comprise a mosaic of land use practices including (but not limited to) urbanizing centers, industry, agriculture, and rural development. The EWS method provides scalable and transferrable results that address the uncertainties of development, and outcomes of mitigation practices, while providing a scientific basis for total maximum daily load (TMDL) targets. This is critical considering increasing numbers of Clean Water Act 303(d) listed waters nation-wide. Collaborative adaptive management (CAM) programs, designed to consider the needs of many stakeholders, can also benefit from EWS-generated information, which can be used for best decision making, and serve as a guidance tool throughout the CAM program duration. Of similar importance, long-term EWS monitoring programs create a model system to show stakeholders how investing in rigorous scientific research initiatives improves decision-making and reduces long-term costs, thereby improving management decisions, increasing management efficiencies, and sustaining natural resources through more focused investments. The evolution from classic wildland EWS designs to contemporary EWS designs in multiple-land-use watersheds will be presented while illustrating how such an approach can encourage innovation, cooperation, and trust among watershed stakeholders working towards a common goal of improving and sustaining hydrologic regimes and water quality.

Characterization of Sub-Watershed-Scale Stream Chemistry Regimes in an Appalachian Mixed-Land-Use Watershed

Author(s): Elliott Kellner, Jason Hubbart, Kirsten Stephan, Ember Morrissey, Zachary Freedman, Evan Kutta, Charlene Kelly

Affiliation(s): West Virginia University, IWSS

Abstract: An exploratory study was conducted in an urbanizing, mixed-land-use Appalachian watershed. Six study sites, characterized by contrasting land use/land cover, were instrumented to continuously monitor stream stage. Weekly grab samples were collected from each site and analyzed for elemental composition via spectrometric and spectrophotometric methods. Additional physico-chemical parameters were measured in situ. Data were analyzed using a suite of statistical methods, including hypothesis testing, correlation analysis, and Principle Components Analysis (PCA). Significant differences ($p < 0.05$) between study sites were identified for every measured parameter except Cu concentration. However, different parameters showed significant differences ($p < 0.05$) between site pairings. PCA results highlight consistent 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, with certain elements (e.g. Ca, Sr) and physico-chemical parameters (e.g. specific conductance) displaying greater sensitivity to hydroclimate at sites mixed-land-use sites, as compared to predominately urban, agricultural, or forest sites. Given the geological, topographical, and climatological similarities between the sites, and their close proximity, it was concluded that land use characteristics and associated hydrologic regime contrasts were the primary factors contributing to the observed results. Results comprise valuable information for land and water managers seeking to mitigate the impacts of land use practices on water resources and aquatic ecosystem health. The applied methodology can be used to more effectively target sub-watershed-scale remediation/restoration efforts within mixed-use watersheds, thereby improving the ultimate efficacy of management practices.

Human Dimensions of Water Quality: A West Virginian Case Study

Author(s): Jonas Levêque, Robert C. Burns

Affiliation(s): West Virginia University

Abstract: Water quality issues in the Appalachia region are great and require further understanding of the chemical, biological, physical aspects of water quality and the human dimensions associated with it. With past and current human activities that have influenced water quality, and different sectors of activity competing for natural resources in the Appalachia, research on water quality is essential for this region. This study aims at understanding the social aspects related to water quality in Appalachia and more precisely on West Virginia, as a case study. While water provides different ecosystem services to the general public, this study has aimed at understanding the public perceptions of water quality, for drinking purposes but also from a recreational standpoint. For instance, one of the goals of this study was to understand how water quality perceptions affect intentions to recreate in West Virginia. Another goal was to understand how drinking behaviors (using bottled water, using a filter, treating the tap water) are related to the health risks perceptions when drinking from the tap. Other factors were also considered to explain these behaviors and intention. Specifically, variables such as trust in governments and agencies, concern for the environment and demographics variables. This study was operationalized during the Spring 2017, using an online survey. A total of 724 randomly selected rural West Virginia residents and 4188 West Virginia University students received an invitation via e-mail and completed the survey. As data is currently analyzed, we hypothesized several relationships among the diverse variables. Particularly, we hypothesized that higher risk perceptions of water quality would decrease recreation intention in West Virginia and increase the use of bottled water instead of tap water. Multiple linear regression using IBM SPSS software is used to test these hypotheses. The implications of these results in terms of management will be discussed for the case of West Virginia and the Appalachia region.

The Effects of Off-Highway Vehicles on Stream Water Quality in the North Fork of the Broad River

Author(s): Chelcy Miniat, P.P. Clinton, S.H. Laseter, and L.K. Everage

Affiliation(s): USDA Forest Service, Southern Research Station, Coweeta Hydrologic Lab

Abstract: Managing forests for recreational benefits, such as off-highway vehicle (OHV) use, as well as other ecosystem services such as clean and abundant water, can often present challenges for land managers when one ecosystem service conflicts with another. We conducted research in the Chattahoochee National Forest to assess whether the presence of OHV trails, and trail use, were associated with higher total suspended solid (TSS) concentration, TSS export, and turbidity in streams during 25 individual storms in 2015–2016. We used a paired watershed approach, with a treatment watershed containing the Locust Stake OHV trail system on the North Fork of the Broad River, paired with a reference watershed similar in all respects except for the trail system. Prior to the trails being re-opened following a period of closure, the OHV treatment watershed had TSS concentration 4.4 times greater for any given flow than the reference watershed (14.2 vs. 3.2 mg/L/cfs). After trail opening, the OHV treatment watershed had TSS concentration 7.3 fold greater for any give flow than the reference (63.7 vs. 8.7 mg/L/cfs). TSS concentration in the OHV treatment watershed 4.5 times higher when trails were open compared to when trails were closed, 14.2 vs. 63.6 mg/L/cfs; and while TSS concentration also increased in the reference watershed for these storm events, it was not significant. Our results suggest that the Locust Stake OHV trail system is associated with poorer water quality, but that water quality is improved with trail closure. Future management actions could focus on a spectrum of reducing hotspots of erosion to permanent trail closure and remediation.

P-Optimal Wetlands: Assessing the Capacity of Wetlands to Improve Water Quality in Great Lakes Agricultural Watersheds

Author(s): Scott Bell (LimnoTech), Jacob Berkowitz (USACE-ERDC), Derek Schlea (LimnoTech), Anthony Friona (USACE-ERDC), Michael Voorhees (USACE-Buffalo)

Abstract: The reduction of harmful algal blooms (HABs) linked with nonpoint source phosphorus runoff remains a key priority of the Great Lakes Restoration Initiative (GLRI). In response, innovative solutions to watershed scale nutrient management are needed in both US and Canadian watersheds. Numerous studies evaluate nutrient dynamics and removal in wetlands, indicating a wide range of phosphorus reduction capacity based on various factors including location, design and edaphic conditions. While many wetlands function as effective nutrient sinks (providing improved water quality), others operate as net nutrient sources (impairing downstream waters). Current work, supported by USEPA with GLRI funds and implemented through the USACE Environmental Research and Development Center (ERDC) and USACE Buffalo District, seeks to optimize phosphorus removal in wetlands through appropriate siting, design, and management. Such wetlands are herein referred to as P-optimal wetlands. The development of P-optimal wetland demonstration projects provides a template to employ nature-based nutrient pollution solutions across watersheds of concern, thus addressing regional (and international) excess nutrient loading and associated HAB scenarios. The optimization approach focuses on three main objectives: 1) restoring/creating wetlands in locations contributing to excess phosphorus loads; 2) designing wetlands to achieve maximum phosphorus removal through soil sorption and plant uptake and 3) insuring that wetlands exhibit sufficient soil phosphorus sorption capacity (SPSC). Measured SPSC, a characteristic related to soil composition and landuse history, will help determine the end-state (i.e., nutrient sink or source) and sustainability of wetland features on the landscape. In total, the optimization process promotes the most effective application of limited resources across a watershed or region. The presentation will discuss how potential P-optimal wetland locations are being identified, report preliminary SPSC results from constructed wetlands in agricultural watersheds, and identify challenges to the development of regional nutrient reduction strategies utilizing natural and nature based features including P-optimized wetlands.

Using Multi-media Modeling to Investigate Conditions Leading to Harmful Algal Blooms

Author(s): Valerie Garcia, Catherine Nowakowski, Marina Astitha, Penny Vlahos, Ellen Cooter, Chunling Tang

Affiliation(s): US EPA

Abstract: Lake Erie is the twelfth largest lake in the world and provides drinking water to over 11 million people in the United States. 22,720 square miles of varying landcover (e.g., urban, agriculture) drain directly into Lake Erie. Harmful algal blooms (HABs) have historically been an issue in Lake Erie, with events peaking in the late 1960's to early 1970's. Several studies have shown that these events were the result of excess phosphorus draining predominantly into the western portion of the lake from agricultural practices occurring in the surrounding watersheds. Phosphorus controls led to recovery of the lake by 1990, but since the mid-1990's, there has been a resurgence of HAB events, with the largest event on record occurring in 2015. We used linked and coupled physical models to examine relationships among environmental variables across multiple sources and pathways. Because these models link emission sources with meteorology and the pollutant concentrations found in the environment, they shed new light on the complex interactions of these chemicals and chemical mixtures. We used the broad range of variables available from these models, representing meteorology, hydrology, atmospheric processes, landscape characteristics, and agriculture management practices, to examine relationships with available dissolved oxygen and chlorophyll α concentrations measured in Lake Erie. We found that inorganic nitrogen (N) fertilizer applied to crops and atmospheric N deposition were the strongest nutrient loading predictors of dissolved oxygen and chlorophyll α concentrations measured in Lake Erie. Further, we were able to examine the relationships of oxidized and reduced forms of N deposition, and dry and wet N deposition. The results of this analysis will be presented at the conference.

Nitrogen Inventories in the Nooksack-Fraser Transboundary Watershed: North American Demonstration for the International Nitrogen Management System

Author(s): Jiajia Lin, Jana Compton, Jill Baron, Donna Schwede, Shabtai Bittman, David Hooper, Chris Clark, Peter Kiffney, Nichole Embertson, Barb Carey, Heather MacKay, Robert Black, Gary Bahr

Affiliation(s): US EPA/National Research Council

Abstract: Excessive nitrogen (N) loading can lead to eutrophication in coastal and fresh waters, air quality issues, and nitrate contamination of groundwater. The Nooksack-Fraser Transboundary-Nitrogen (NFT-N) project was developed to explore ways to work with a community to balance the beneficial and harmful aspects of nitrogen management. The NFT area (2639 km^2) is home to communities dependent on farming, fisheries and outdoor recreation. Our first goal was to determine sources and fates of N in the watershed in 2014 using data on energy use, transportation, fertilization, wastewater treatment plants, livestock operations, wildlife and more. This project brings together stakeholders, agencies, tribes, and scientists from the U.S. and Canada to characterize this transboundary N inventory.
A comprehensive N assessment can benefit decision-making by providing key information on sources, transformations and effects. This effort builds upon an existing Canadian N inventory for the Lower Fraser Valley, and currently is focusing on N sources on the US side. The N needed for crops was estimated using local-specific data collected in 2014, while evaluating different fertilizer and manure application rates with various management intensities. Preliminary result found that to meet crop N demand on the U.S. side, about 2947-3526 metric tons (MT) of N had to be applied. Because only about 50% of applied manure N is available to crops after denitrification, mineralization, and volatilization loss, substituting manure for inorganic fertilizer would require 5937-7103 MT manure N. The combined septic and sewage input of N ranged between 71 and 84 MT per year, while atmospheric deposition contributed 527 MT N per year. Preliminary results demonstrate the importance of N inputs from agriculture. Future efforts will include updating agricultural data and Canadian budget information, and improving understanding of N fate and transport in ground and surface water in order to examine the impacts of N policy and management across the boundary (US-Canada), and to support the development of sustainable N management plans in the region.

Eutrophication Management in the Baltic Sea – A Partial Success?

Author(s): Michelle McCracken

Affiliation(s): Stockholm University

Abstract: Eutrophication is a major stressor in the Baltic Sea, which is home to the world's largest anthropogenic "dead zone". Environmental management is politically complicated because there are 14 countries in the drainage basin. The causes and consequences of eutrophication are well documented and a number of national and international policies have been implemented to address external nutrient loads. Nutrient reduction targets have been established through close collaboration between scientists and the Helsinki Commission (intergovernmental organization established in 1974 to protect the sea's environment). Since the 1980s, nutrient loads have nearly halved due largely to improved sewage treatment capabilities. Meeting environmental targets will require addressing diffuse agricultural sources. More recently, the long response time of the sea has led to "fatigue" and further nutrient reductions are seen as burdening the agricultural sector. Concern that slow recovery from eutrophication will weaken political support has led to discussions of geo-engineering measures to remove accumulated nutrients from the sea. To better disseminate scientific knowledge to policy- and decision-makers, Stockholm University partnered with a private foundation in 2014 to create Baltic Eye, a boundary organization composed of scientists, professional communicators, and policy analysts. I will share Baltic Eye's progress in engaging with eutrophication-related policies in the Baltic Sea region.

Is Potential Evapotranspiration Increasing? A Comparison of Estimation Methods to Long-Term Measurements

Author(s): Peter Caldwell, K. Duan, C.F. Miniat

Affiliation(s): USDA Forest Service, Southern Research Station, Coweeta Hydrologic Laboratory

Abstract: Potential evapotranspiration (PET), a measure of evapotranspiration (ET) when water is not limiting, is often used in hydrologic models to examine potential changes in watershed yield (Q) under climate change scenarios. These studies estimate PET using microclimatic variables and one of a number of equations ranging from complex (e.g., Penman-Monteith) to simple (e.g., Hamon) depending on climate data availability. PET can also be estimated from direct measurements with open evaporation pans, or in energy-limited regions, annual watershed ET (precipitation – Q) can approximate annual PET. Many studies have examined biases in PET estimates using prediction equations relative to direct measurements over short time periods but few evaluate predictions of how PET has changed over the long-term in response to climate change. In this study, we examined differences in the magnitude and timing of changes in predicted PET from 1961-2015 at the USDA Forest Service Coweeta Hydrologic Laboratory using the Penman, Priestley-Taylor, and Hamon methods. We then compared these predictions of changes in PET over time to pan evaporation measurements and reference watershed ET. Preliminary results indicate that mean PET predicted with all equations using standard adjustments was consistent with pan evaporation and watershed ET, highlighting the fact that over the long-term ET is energy rather than water limited at this site. All PET estimation methods, pan evaporation, and watershed ET showed that annual PET has increased over time, however the magnitude and timing of change over the period of record varied across methods. The magnitude of predicted increases in PET over the period of record ranged from 10% (Hamon method) to 17% (Priestley-Taylor method) while pan evaporation and watershed ET increased 8% and 13%, respectively. The timing of changes in PET ranged from increases from 1961 to 1988 and constant since that time (Priestley-Taylor), to constant from 1961 to 1977 then increasing to the present (Hamon). These results suggest that predictions of the magnitude and timing of changes in PET can vary widely among estimation methods and in relation to direct measures, thus projections of future changes in Q under climate change scenarios could be highly dependent on PET estimation method used.

Evaporative Demand and Drought: Dynamics and Opportunities in Early Warning and Monitoring

Author(s): Mike Hobbins, Daniel McEvoy, Candida Dewes, Shraddhanand Shukla, Justin Huntington, Imtiaz Rangwala

Affiliation(s): NOAA-Physical Sciences Division and University of Colorado-Cooperative Institute for Research in Environmental Sciences

Abstract: Despite not being an actual land-atmosphere flux and generally being poorly understood, modeled, and appreciated, atmospheric evaporative demand (Eo) plays an important role in determining and signaling watershed-scale hydroclimatic states. For those with an interest in changing hydroclimatic regimes and their extreme anomalies (notably drought), I will aim to answer the question, "What is evaporative demand and why should I care?"

I will summarize the basic principles behind Eo and the surface assumptions that complicate its interpretation, with an emphasis on understanding the interactions between Eo and actual evapotranspiration (ET)--both complementary and parallel--under drought conditions. While Eo is easier to estimate than ET over the time and space scales most relevant to drought monitoring and decision-making, it is also notoriously easy to estimate Eo badly, and doing so has bedeviled the drought community for decades, as I will demonstrate.

Work at NOAA's Physical Sciences Division is exploiting the opportunities presented by Eo as they relate to the development of a new, demand-side understanding and approach to drought at operational, secular, and climate time scales. Thus far, this work has primarily revolved around the new Evaporative Demand Drought Index (EDDI). EDDI has been shown to provide early warning of agricultural and hydrologic drought (as well as incipient wildfire risk), and it does particularly well in spotting early the conditions that may lead to flash drought. The Eo used in EDDI further provides the opportunity for explicit attribution of the demand side of drought into its meteorological and radiative drivers. I will demonstrate the power of EDDI and its ancillary products across CONUS and, extending this work for the Famine Early Warning System Network (FEWS NET), discuss early results relating to EDDI and the variability and attribution of Eo over the globe.

Moving beyond secular and monitoring timescales, I will discuss the opportunities presented by Eo in short-term operational forecasting and seasonal-to-subseasonal forecasting. At longer-again timescales, I will raise some conceptual and biophysical issues that must be addressed before we can successfully implement climate-scale Eo projections in drought and climate vulnerability assessments.

Effects of Forest Composition on Components of Evapotranspiration in a Mature, Southern Appalachian Forest

Author(s): A. Christopher Oishi, Chelcy Miniat, Steven Brantley, Kimberly Novick, Paul Bolstad, James Vose, Peter Caldwell, Kai Duan

Affiliation(s): USDA Forest Service

Abstract: Mature, temperate forests have often demonstrated relatively low interannual variability in evapotranspiration (ET), compared to variability in precipitation. However, warming temperatures have the potential to increase forest ET by increasing the atmospheric demand for water (i.e., vapor pressure deficit) and extending the growing season length. Whether increases in potential ET translate to actual ET will depend on local conditions, including seasonal soil water availability and stand characteristics. The effect of warmer temperatures on actual ET is particularly uncertain in forests with a diversity of leaf habits (e.g., evergreen and deciduous), plant hydraulic strategies (e.g., isohydric and anisohydric), and drought tolerance characteristics (e.g., rooting depth) since interactions among species may amplify or mute the overall response. We examine seven years of data (2011-2017) from the Coweeta Hydrologic Laboratory in the southern Appalachian mountains of North Carolina, including meteorological, eddy covariance, sap flux and streamflow measurements. Despite high interannual variability in precipitation (1315 to 2384 mm y^{-1}; coefficient of variation (CV) = 20%) and in pan evaporation (701 to 1071 mm y^{-1}; CV = 15%), eddy covariance-based ET was much less variable (813 to 905 mm y^{-1}; CV = 4%). Variation in the timing of leaf expansion in the deciduous canopy did not affect springtime transpiration, due to the contribution of transpiration from the evergreen understory. Although no growing season drought conditions occurred during the study period, we found some evidence that moderately low soil moisture may affect ET when it occurs late in the growing season. These results will improve our understanding of how predicted changes in species composition through management practices, changing disturbance regimes, or successional change (e.g. mesophication) are likely to affect forest water use and water yield.

Response of Evapotranspiration to Drought and Management in Loblolly Pine Forests on the Lower Coastal Plain in North Carolina

Author(s): Ge Sun, Xiaodong Liu, Bhaskar Mitra, J-C. Domec, M.J. Gavazzi, David Zietlow, S.G. McNulty, J.S. King, and A. Noormets

Affiliation(s): USDA Forest Service

Abstract: Since 2004, we have monitored energy, water, and carbon fluxes in a chronosequence of three drained loblolly pine (*Pinus taeda*) plantations using integrated methods that include eddy covariance, sap flux, watershed hydrometeorology, remote sensing, and process-based simulation modeling. Study sites were located on the eastern North Carolina coastal plain, representing highly productive ecosystems with high groundwater table, and designated in the Ameriflux network as NC1 (0-10 year old), NC2 (12-25 year old) and NC3 (0-3 years old). The 13-year study spanned a wide range of annual precipitation (900-1600 mm/yr) including two exceptionally dry years during 2007-2008. We found that the mature stand (NC2) had higher net radiation (Rn) flux due to its lower albedo (α =0.11-12), compared with the young stands (NC1, NC3) (α=0.15-0.18). Annually about 75%-80% of net radiation was converted to latent heat in the pine plantations. In general, the mature stand had higher latent heat flux (i.e. evapotranspiration, ET) rates than the young stands, but ET rates were similar during wet years when the groundwater table was at or near the soil surface. During a historic drought period (i.e., 2007-2008) when precipitation was reduced by 40% from a norm of 1300 mm/year, the total stand annual ET exceeded precipitation, but only resulted in a moderate decrease (~10%) in annual ET. Over a full stand rotation, approximately 70% (young stand) to 90% (mature stand) of precipitation was returned to the atmosphere through ET. A 50% thinning caused a large reduction of Leaf Area Index of above ground forest canopy, annual ET estimates were similar, 1055 mm prior to vs 1104 mm post thinning in late 2009. The results suggest that the hydrologic effects of prescribed thinning may be masked by climatic variability and/or total forest ET recovers quickly in the coastal plain pine forest. We conclude that both climatic variability and canopy structure controlled the partitioning of precipitation and solar energy in pine forests. In addition, we conclude that accessible groundwater was an important factor for stabilizing forest water and energy balances during a drought in the lower coastal ecosystems.

Investigating Impacts of Drought and Disturbance on Landscape Evapotranspiration Using High Spatiotemporal Resolution Data

Author(s): Yun Yang, Martha Anderson, Feng Gao, Christopher Hain, Asko Noormets, Ge Sun, Randolph Wynne and Valerie Thomas

Affiliation(s): USDA-ARS

Abstract: Forest ecosystem services such as clean water and timber supplies are increasingly threatened by drought and disturbances (e.g., harvesting, fires, and conversion to other uses) that can have great impacts on the hydrologic cycle of forests. Hence, improved understanding of the hydrologic response to drought and disturbance at a high spatiotemporal resolution is important for effective forest management at landscape scale to maximize forest ecosystem services. As a key variable in assessing forest ecosystem functions and services, Evapotranspiration (ET) still remains a challenge to be accurately quantified at landscape scale. To investigate the response of forest ET to drought and disturbance, we estimated ET using a surface energy balance model based on thermal infrared (TIR) imagery and generated a multi-year daily ET datacube at 30 m resolution using a data fusion technique. We estimated ET for an area (~900 km^2) on the humid lower coastal plains in North Carolina, USA, including natural and managed forest as well as croplands. The study period was from 2006 to 2012, with 2007 and 2008 as severe drought years. We evaluated our model using data collected at two AmeriFlux sites (US-NC2 and US-NC1) dominated by a mature and a recently clearcut pine plantation, respectively. We examined plant ET, transpiration (T) and actual-to-reference ET ratio (fRET) to investigate changes in water use patterns in response to land cover type, forest stand age, climatic forcing and disturbance. We show differential response to drought events from different land cover types, with young plantations showing larger impacts than mature pine plantations with significantly deeper rooting systems. Anomalies of fRET, that well capture the signal of drought and disturbance and the subsequent recovery after clearcut, is an effective indicator for water use change detection and monitor. This study provides new insights about detecting and monitoring the water dynamic under drought and disturbance at landscape scale.

Can Mountainous Terrain within Puerto Rico Buffer the Projected Subtropical Precipitation Decline?

Author(s): Jared Bowden (North Carolina State University), Adam J. Terando (Southeast Climate Science Center, USGS), Tanya L. Spero (National Exposure Research Lab, US EPA)

Abstract: A robust response of global climate models (GCMs) in the coming decades to increasing greenhouse gases is a global decline in subtropical precipitation, particularly over the oceans. This is a concerning result for small island nations, especially those within the Caribbean, as the exposure to long-term drying will likely create significant stresses to already vulnerable ecosystems and water resources. However, climate change projections from GCMs cannot resolve the terrain and land use/land cover that interact with the prevailing trade winds to create sharp precipitation gradients over short distances (< 10km), which promote a rich mosaic of habitats in this 'Ridge-to-Reef' system. High resolution regional climate models (RCMs) can better resolve the mountainous terrain and associated microclimates, such as those within Puerto Rico which sits in the heart of the large-scale precipitation decline in the Atlantic Ocean.

To illustrate the effects of the terrain on the climate and precipitation regime of Puerto Rico, two different GCMs are dynamically downscaled using a RCM to a 2-km horizontal resolution centered on mid-century, 2040-2060, for a business as usual (RCP 8.5) greenhouse gas scenario. Results from these climate change realizations suggest that higher elevations within Puerto Rico may buffer the large projected subtropical precipitation decline. This presentation will discuss the robustness of these results and compare them to a statistical downscaling method that depicts more drying at higher elevations in the future. We highlight the implications for both water resource and natural resource management in Puerto Rico and similar areas around the world.

Implications of Climate and Emissions Changes on Atmospheric Nitrogen Deposition to the Chesapeake Bay Watershed

Author(s): Patrick Campbell, Jesse O. Bash, Chris Nolte, Tanya Spero, Ellen J. Cooter, Kyle Hinson, Lewis Linker

Affiliation(s): US EPA

Abstract: Atmospheric deposition remains one of the largest loadings of nutrients to the Chesapeake Bay Watershed (CBW). The interplay between future climate and emission changes, however, will cause shifts in the future nutrient deposition abundance and regime (e.g., oxidized vs. reduced nitrogen (N)). In this work we use a Representative Concentration Pathway 4.5 W m^{-2} (RCP4.5) scenario-driven Community Earth System Model version 1.0, and dynamically downscale an offline WRF version 3.8.1 and CMAQ version 5.2 model system coupled to the agro-economic Environmental Policy Integrated Climate (EPIC) model. We use the model system to explore the relative impacts of emission and climate changes on atmospheric nutrient deposition to the CBW for a current (CURR: 1995 – 2004) and a future period (FUT: 2045 – 2054). The regional emission projections in CMAQ are based on federal and state regulations promulgated in 2015, which use baseline and projected emission years 2011 and 2040, respectively. Evaluation of the downscaled WRF/CMAQ CURR simulations in the CBW show a good agreement in average 2-meter temperature (CBW avg. mean bias ~ +1.5 K) and precipitation (CBW avg. mean bias ~ +12.4 mm) compared to reanalysis data sets, with a warmer (CBW relative change ~ +14%) and wetter (CBW relative change ~ +4%) FUT period under RCP4.5. An approximate WRF/CMAQ CURR comparison against surface observations of wet deposition (WDEP) of inorganic PM2.5 species also shows good agreement, except for larger underpredictions in WDEP of PM2.5 nitrate. Climate and deposition changes impact the EPIC agroecosystem changes, leading to increases in FUT ammonia (NH_3) fertilizer application and crop soil content, which in turn affects the CMAQ bi-directional NH_3 surface exchange in the CBW. These changes along with widespread decreases anthropogenic nitrogen oxides (NO_x) emissions (U.S. avg. ~ -51%), but increases in agricultural NH_3 emissions (U.S. avg. ~ + 2%) projected in the FUT period leads to a shift towards relative decreases in total oxidized N deposition (CBW seasonal avg. ~ -40 to -50%), along with increases in total reduced N deposition (CBW seasonal avg. up to ~ +20%) that are dominated by NH_3 dry deposition changes.

Soil Moisture Scaling Function Development for the Little River Experimental Watershed

Author(s): M. H. Cosh, D. D. Bosch, A. Coffin, T. J. Jackson, A. Colliander, S. Chan, R. Bindlish, W. Crow, and S. Yueh

Affiliation(s): USDA ARS

Abstract: Soil moisture remote sensing scales are on the order of 3-36 km with the advent of the Soil Moisture Active Passive Mission (SMAP). In situ networks that are used to calibrate and validate these remote sensing products also exist in this range of scales, but there are challenges to be met in estimating the soil moisture across an entire region with a network of sensors. Scaling functions have been developed to estimate large scale soil moisture from these sensor networks in the most accurate means possible. For example, the Little River Experimental Watershed near Tifton, Georgia is a SMAP Core Validation Site and while it had a low error (< 0.03 m^3/m^3) when compared to the SMAP data product for the region, there was a considerable bias (~0.10 m^3/m^3) present. A field experiment was developed to update the scaling function used for the Little River region by deploying a temporary network across a greater selection of land covers than were previously covered by the permanent soil moisture network. After six months of deployment it was possible to create a new function which decreased the bias of the network to approximately 0.045 m^3/m^3, a significant improvement.

Impacts of Potential Changes of Land Use, Climate, and Water Use for Water Availability, Coastal Carolinas

Author(s): Ana Maria Garcia, Laura Gurley

Affiliation(s): U.S. Geological Survey

Abstract: Sustainable growth in coastal areas with rapidly increasing populations, such as the coastal regions of North and South Carolina, relies on an understanding of the current state of coastal natural resources coupled with modeling future impacts of changing coastal communities and resources. Changes in climate, water use, population, and further urbanization will place additional stress on societal and ecological systems that are already competing for water resources. The potential effects of these stressors on water availability are not fully known and future management of water resources and planning efforts to meet societal and ecological needs requires estimates of likely changes in population growth, land-use, and climate.

Two Soil and Water Assessment (SWAT) models were built to help address the challenges that water managers face in the Carolinas: the (1) Cape Fear and (2) Pee Dee drainage basins. SWAT is a basin-scale, process-based watershed model with the capability of simulating water-management scenarios. Model areas were divided into two square mile subbasins to evaluate ecological response at headwater streams. Subbasins were subsequently divided into smaller, discrete hydrologic response units based on land use, slope, and soil type. Data compiled on water-use from 2000-2014 were included. These water-users included public water supply, industrial water use, irrigation needs and golf courses. Potential future streamflow values were also estimated based on a suite of scenarios that coupled land use change projections, climate projections and water use forecasts. The approaches and new techniques developed as part of this project can be transferred to other growing coastal areas that face similar water availability conflicts.

Developing Intensity-Duration-Frequency (IDF) Curves from Modeled Meteorological Fields to Inform Storm Water Management under Future Scenarios

Author(s): Anna M. Jalowska, Tanya L. Spero

Affiliation(s): US EPA/ORISE and US EPA

Abstract: Extreme precipitation has important implications for watershed management, agriculture, urban and rural development, public infrastructure, and human health. Based on 30-year flood loss averages, flooding associated with extreme precipitation causes 82 casualties and about 7.96 billion dollars in damages across the United States each year. Intensity-Duration-Frequency (IDF) curves are a common tool used to account for extreme precipitation events in urban and environmental planning. The IDF curves estimate a frequency of occurrence of extreme rain events (rainfall amount within a given period of time) based on frequency analyses of the available historical observational data. Often the data for frequency analyses are not available. This study develops a methodology to produce IDF curves for 3 cities in the Southeastern U.S. for a 23-year historical period (1988–2010), using a 36-km dynamically downscaled Weather Research and Forecasting (WRF) model simulation. The results are verified against historical observational data. This study applies the IDF curve methodology to project future extreme precipitation probabilities for 75 years (2025-2100) by dynamically downscaling future climate projected by the Community Earth System Model (CESM) under Representative Concentration Pathway 8.5 (RCP 8.5) to 36 km. U.S. historical climate records since 1950s indicate an increase in frequency and intensity of extreme precipitation in Eastern U.S. Recent climate research suggests that the frequency and magnitude of extreme precipitation in the U.S. will continue to increase throughout the twenty-first century. Preliminary data from the CESM-WRF RCP 8.5 future scenario, indicate ~30% increase in annual precipitation from 2025 to 2100. The one-hundred-year recurrence interval precipitation amounts exhibit a median increase of ~6% with the highest change in the 1-h (~11% increase) and 24-h (~16% increase) return periods. The two-year recurrence interval precipitation amounts demonstrated highest median increase of 12%, with most significant change in the 12-h (~17% increase) and 24-h (~16% increase) return periods. The methodology presented in this study will be used to develop a database for the EPA's National Risk Management Research Laboratory (NRMRL) Storm Water Management Model (SWMM).

Climate Change in West Virginia and Implications for Appalachian Food Deserts

Author(s): Evan Kutta, Jason Hubbart, Elliot Kellner

Affiliation(s): West Virginia University Institute of Water Security and Science

Abstract: Increasing variability in temperature and precipitation patterns are reducing the security of natural resources including food, water, and energy in many locations globally. These climate changes are particularly relevant to the agricultural sector, particularly given increasing demand for food, less predictable water supplies, and more expensive energy. Among these challenges however, opportunities may be emerging in previously less productive areas such as West Virginia with implications for the entire Appalachian region often typified by food deserts. To focus the current work, observed datasets of daily maximum temperature, minimum temperature, and precipitation for 18 individual observation sites in West Virginia dating back to at least 1930 were used. Daily data were averaged annually and spatially (all 18 sites) and the Mann-Kendall trend test and Sen's slope estimator were used to assess statistically significant ($\alpha = 0.05$) trends in temperature and precipitation. Maximum temperatures were shown to decrease significantly over the entire period of record (1900-2016), minimum temperatures were found to increase significantly during all three periods of record, and precipitation was found to increase significantly over the second half (1959-2016). Observed climate trends indicate that West Virginia may be becoming wetter and more temperate and thus potentially more supportive of a broader range of crops and a longer and more productive growing season. Therefore, this work suggests the food desert crisis impacting the Appalachian region could be alleviated by restoring the regions' agricultural sector, which could simultaneously improve human health and socioeconomic well-being.

Trends in Water Yield Under Climate Change and Urbanization in the U.S. Mid-Atlantic Region

Author(s): Glenn Moglen, S. Kumar, A. Godrej, H. Post, T. Grizzard

Affiliation(s): USDA-ARS

Abstract: Changes in climate and land use are two primary drivers of hydrologic adjustment. This study analyzes forty years of water resources data for ten watersheds in the Washington, DC, metropolitan area to quantify the impact of climate change and urbanization on water yield. The watersheds investigated have experienced varying degrees of land use change, from relatively little change to rapid and extensive urbanization. Comparing the data trends for different watersheds allows the separation of effects due largely to climate from those due to land use change. Predominantly rural watersheds show a steady decline in annual water yield while predominantly urban watersheds do not show any similar trend with time. Separating the year into growing versus non-growing seasons reveals that limited evapotranspiration from urban surfaces during the growing season or the general effects of a leaking water distribution network may mask the reductions in water yield in urban watersheds from changing climate. These analyses provide hydrological evidence for generally enhanced evapotranspiration and complex interactions between concurrent climate change and urbanization within the study area.

QSWAT Modeling for Forecasting Hydrologic Behavior in a Coastal Forested Watershed in the Global Climate Change Setup

Author(s): Sudhanshu Panda, Devendra M Amatya and Ge Sun

Affiliation(s): University of North Georgia, US Forest Service

Abstract: Understanding the potential impacts of climate change and associated stresses on water resources is key to develop overall adaptation responses to minimize negative consequences at the local level. Streamflow and depth to water table within the forest landscape of the lower coastal plain along the Southeastern Atlantic Ocean is heavily dependent on precipitation and evapotranspiration. The main goal of this study is to set up and apply a distributed watershed-scale model for Turkey Creek water, a typical forest watershed within the USDA Forest Service Francis Marion National Forest in coastal South Carolina to forecast hydrologic effects of future climate change. We used the QSWAT (QGIS based Soil and Water Assessment Tool) model to assess the impacts of climate change on the water balance, water yield, flooding and droughts on the low-gradient, coastal forested watershed. High-resolution LiDAR data was used to develop the DEM for delineating watershed boundary and hydrologic modeling along with classified landuse data using 1m resolution NAIP imagery, SSURGO and the National Forest soils database. Precipitation and weather data from stations within the site were used as model input along with other default QSWAT database as primary model inputs. Model calibration and validation for the baseline watershed condition was conducted using the 10-year (2005-14) stream flow data. The validated SWAT model is further applied to analyze the hydrologic effects of potential climate change using two contrasting scenarios of future climate from the regional climate models for 2015 to 2050. The QSWAT simulation model used multivariate Adaptive Constructed Analogs (MACA) daily weather data (precipitation, air temperature, humidity, wind speed, and solar radiation) obtained from five CMIP models. They are: Beijing Climate Center Climate System Model (BCC_CSM1.1), Canadian Centre for Climate Modeling and Analysis (CanESM2) model, National Center of Atmospheric Research, USA (CCSM4) model, NOAA Geophysical Fluid Dynamics Laboratory, USA (GFDL-ESM2G) model, and the Met Office Hadley Center, UK (HadGEM2-CC) model. Simulation results of water yield and evapotranspiration for these scenarios are analyzed for understanding the hydrologic response to climate change. Information gained from this study should serve for management decision support in the low-gradient forested watersheds in the region.

Thirty Years of Phosphorus Dynamics in Nine Watersheds Contributing to the Chesapeake Bay

Author(s): Karen Rice, Aaron L. Mills

Affiliation(s): U.S. Geological Survey

Abstract: Dissolved inorganic phosphorus (OP) and total phosphorus (TP) concentrations and loads, along with a large number of variables representing climate and land use over a 30-year period were examined for nine major watersheds that drain to the Chesapeake Bay. The watersheds are those designated as River Input Monitoring (RIM) watersheds, and include the Choptank, Susquehanna, Patuxent, Potomac, Rappahannock, Pamunkey, Mattaponi, James, and Appomattox Rivers. OP and TP concentrations and loads varied among the watersheds with respect to their response to the various climate and land-use factors, however, all of the watersheds accumulated TP over the period of record. That is, more P was applied to the watershed than was exported from the watershed at the RIM streamgage. Some phosphorus is exported as harvested crop and animal product; however, the fate of the majority of the P is that it is attached to soil particles in the upland regions or attached to sediment particles that have accumulated in river and reservoir beds. Notably, cumulative fluxes of OP out of the watersheds was greater in the cooler part of the year (presumably due to increased discharge) in seven of the nine RIM watersheds; only the Patuxent River lost more OP during the warm season, and the Choptank River exported OP equally during the two seasons. The accumulation of TP in the adsorbed pool begs the question of the maximum holding capacity for P within the watersheds, and whether saturation might someday be reached such that the watersheds would pass P in excess of the sorption capacity directly to the rivers, as has been observed in some locations for sulfate. Because the responses to environmental change differ among the watersheds, management strategies need to reflect the dominant factors accounting for changes in P over time, so that P may be managed more effectively in the different watersheds going into the future.

Why Is There So Much Mercury in Permafrost? When and Where Will It Go If It Thaws?

Author(s): Paul Schuster, Kevin Schaefer, Ron Antweiler, Rob Striegl, Kim Wickland, Dave Krabbenhoft, John Dewild, Nicole Herman-Mercer, Gustaf Hugelius

Affiliation(s): U.S. Geological Survey

Abstract: Warming of northern regions is causing permafrost to thaw with major implications for the global mercury (Hg) cycle. Mercury was estimated in permafrost regions based on in situ measurements of sediment total mercury (STHg), soil organic carbon (SOC), and the Hg to carbon ratio (RHgC) combined with maps of soil carbon. We measured a median STHg of 43 ± 30 nanograms of Hg per gram of soil and a median RHgC of 1.6 ± 0.9 nanograms of Hg per gram of carbon, consistent with published results of STHg for tundra soils and 11,000 measurements from 4,926 temperate, non-permafrost sites in North America and Eurasia. We estimate that the Northern Hemisphere permafrost regions contain 1,656 ± 962 gigagrams of Hg, of which 793 ± 461 gigagrams is frozen in permafrost. This store is nearly twice as much Hg as all other soils, the ocean, and the atmosphere combined. As warming continues over the next century, this Hg may be released to streams and groundwater. Existing estimates greatly underestimate Hg in permafrost soils, indicating a need to reevaluate the role of Arctic regions in the global Hg cycle. Further research is under way to expand the current data set through the inclusion of soils from several other circumpolar permafrost regions (Norway, Russia, Siberia, Canada, and Antarctica). This additional data will create a more robust data set and greatly improve the performance of models used to predict the rate of potential Hg release on a time frame up to the next century.

The Value of Long-Term Research at USGS Research Watersheds

Author(s): James Shanley, Mike McHale, Pete Murdoch

Affiliation(s): U.S. Geological Survey

Abstract: Long-term research catchments are sentinel sites for detecting, documenting, and understanding environmental change. The small watershed approach fosters advances in understanding fundamental hydrological, biogeochemical, and ecological processes, while a collective network of catchment observatories offers a broader context to synthesize understanding across a range of climates and landscapes. We report here on the value and successes of small watershed programs of the US Geological Survey, with examples from the Water, Energy, and Biogeochemical Budgets (WEBB) program, and small watershed studies in the Catskill and Adirondack Mountains in New York. We also nest those watersheds in the context of regional small watershed networks such as the National Network of Reference Watersheds. Long-term datasets are vital to understanding trends and effects of changing climate and atmospheric deposition. Institutional support for long-term monitoring provides infrastructure and context that foster academic partnerships for focused shorter-term grants. Research watersheds are test sites for new methods and technologies, allow iterative hypothesis testing, and are training grounds for the next generation of scientists. In the current era of de-emphasis of field observations and declining budgets for science, it is especially important to sustain research watershed programs for their scientific value and societal benefits.

Projecting Regional Climate Change for Air Quality and Water Quality Applications

Author(s): Tanya Spero, Jared Bowden, Megan Mallard, Chris Nolte

Affiliation(s): US EPA

Abstract: This presentation will provide an overview of methods to downscale future global climate projections to characterize climate change at regional and local scales. Changes in weather patterns and extreme events have implications for air quality, water quantity, and water quality that can inform decisions related to watershed management. Although both statistical and dynamical downscaling techniques will be discussed, the focus will be on the more resource intensive dynamical downscaling. Examples will be shown from dynamical downscaling fields developed by the U.S. EPA and their research partners. In addition, several of the nuances and limitations of each approach will be presented.

Effects of Climate Change on Coastal Wetlands: Adaptive Management Case Studies from the National Wildlife Refuge System

Author(s): Scott Covington and Kurt Johnson

Affiliation(s): U.S. Fish and Wildlife Service

Abstract: The US Fish and Wildlife Service (FWS) has more than 185 coastal National Wildlife Refuges (NWR or refuge), most of which are being impacted by relative sea level rise (RSLR) and associated impacts of storms and the surges they produce. Habitat loss and infrastructure damage and/or loss are the key impacts. For example, surveys by the National Wetlands Inventory report that the U.S. lost over 34,000 hectares of salt marsh habitats from 2004-09, the most recent statistic available. Although not all these losses are on refuges, the statistic illustrates the profound changes occurring in coastal habitat primarily as a result of RSLR coupled with storm surges. In addition, the costs associated with hurricane damage to coastal infrastructure alone exceeds $28 billion a year, according to the Congressional Budget Office (2016). We evaluated RSLR and storm surge impacts for seven coastal refuges, each of which faces unique challenges and has developed a management program tailored to respond to these threats. We surveyed climate change related impacts from the past decade at these coastal refuges, and summarized how the refuges are addressing those impacts, as well as how they are monitoring their management progress. At Alligator River NWR in North Carolina, wind fetch from Pamlico Sound causes more damage than RSLR, because it batters the eastern refuge shore causing massive erosion of the peat soils and forces salt water from the bay upstream into low lying tributaries, killing salt-intolerant vegetation. When "Superstorm Sandy" hit Prime Hook NWR in Delaware, it ripped huge inlets in the coastal barrier island, spilling saltwater into a freshwater marsh, killing that vegetation. RSLR is causing inundation of the low-lying salt marsh at Blackwater NWR in Maryland, and is also impacting submerged aquatic vegetation along the refuge's shore. Shoreline erosion of up to 10 feet per year in some places within Anahuac NWR in Texas resulted in extreme losses of valuable land and habitat. RSLR and limited sediment accretion contribute to the complete inundation of the Pacific cordgrass at Seal Beach NWR in California. Tidal marsh restorations in Bandon Marsh NWR in Oregon and Billy Frank Jr. Nisqually NWR in Washington have returned tidal flows to drained and diked areas with the intention of restoring habitat and building greater system resilience to SLR and climate change.

Quantifying Wetland Inundation Dynamics in Coastal Watersheds Using Virtual Constellations of Optical and Radar Earth Observation Satellites

Author(s): Ben DeVries, Chengquan Huang, Wenli Huang, Megan W. Lang, John W. Jones, Irena F. Creed, Mark L. Carroll

Affiliation(s): Department of Geographical Sciences, University of Maryland, College Park, MD, USA

Abstract: Inundation dynamics in wetlands constitute a key variable in the study of the hydrologic cycle in coastal watersheds. While hydrologic models are indispensable in the study of coastal watershed hydrology, satellite data play an increasingly important role in these studies. The opening of many satellite data records and advances in cloud computing technologies have combined to allow the production of continental to global scale land cover change products, including products aimed at quantifying surface water changes at high spatial and temporal resolution. Despite these advances, wetland inundation dynamics are particularly difficult to monitor, given the ephemeral nature of many water bodies, especially among coastal watersheds. Data products based on optical satellite data, such as those from the Landsat constellation, often fail to capture dynamics in surface water extent due to frequent cloud cover and resulting gaps in the time series, a limitation that can be overcome through the use of radar observations. The Sentinel-1 constellation of Synthetic Aperture Radar (SAR) satellites, managed by the European Space Agency's (ESA) Copernicus program, is the first global, open-access SAR data source, and represents an important step forward in the ability to comprehensively map inundation dynamics from space. Importantly, the fusion of Sentinel-1 SAR data with optical data from Landsat and ESA's Sentinel-2 constellation of optical sensors will enable monitoring of inundation dynamics at nearly daily temporal resolution. Here we present first results of a very high temporal resolution surface water product for the Atlantic Coastal Plain physiographic region based on Sentinel-1 SAR and Landsat and Sentinel-2 optical data. We show that both optical and radar satellite data sources are required to adequately track changes in wetland inundation in these dynamic regions, especially in response to extreme hydrologic events like floods. These results represent a step forward in the fusion of data from virtual constellations of optical and SAR Earth observation satellites to characterize wetland inundation dynamics in coastal watersheds. Leveraging "next-generation" satellite constellations like the follow-on Landsat and NASA-ISRO SAR (NISAR) missions to better understand wetland hydrologic dynamics will require improved data fusion approaches such as those described in this study.

Dynamic Surface Water Extent (DSWE): An Operational Satellite-Based Product for the Synoptic Assessment of More Than 30 years of Intra-Annual Variations in Watershed and Wetland Inundation

Author(s): John Jones

Affiliation(s): U.S. Geological Survey

Abstract: The U.S. Geological Survey (USGS) is generating a new data product named Dynamic Surface Water Extent (DSWE) that can contribute to our understanding of variations in the areal extent of inundation through time and enable synoptic watershed and wetland monitoring. DSWE uses the extensive Landsat Archive for the United States (U.S.) as well as data from on-going, moderate resolution satellite systems such as Landsat Enhanced Thematic Mapper and the Operational Land Imager as input, yielding intra-annual records on inland and coastal wetland inundation for more than a 30-year period. A collaborative, multi-tiered evaluation strategy documents DSWE uncertainty and demonstrates its utility for water and wetland resource management. Vegetated wetland environments are particularly challenging for both DSWE inundation detection and DSWE uncertainty assessment. Analyses of in situ data on inundation and water stage collected by the USGS and other DSWE project collaborators at key U.S. wetland areas have identified DSWE strengths and weaknesses as well as facilitate DSWE use in science and resource management. Examples drawn from this experience illustrate DSWE uses for watershed hydrologic modeling and coastal wetland monitoring.

Wetland Trends in Coastal Watersheds: Drivers, Effects, and Adaptive Management

Coastal Wetland Resource Change and Drivers as Quantified by the National Wetlands Inventory Wetlands Status and Trends Project

Author(s): Megan Lang, Susan-Marie Stedman, and Rusty Griffin

Affiliation(s): U.S. Fish and Wildlife Service

Abstract: The U.S. Fish and Wildlife Service (USFWS) is congressionally mandated to produce decadal reports on the status and trends of wetlands within the United States. To date, the USFWS National Wetlands Inventory (NWI) program has produced six national and eight regional Wetlands Status and Trends reports. Regional reports often provide a more in-depth exploration of areas experiencing heightened wetland alteration. A recent regional Wetlands Status and Trends report, co-authored by the USFWS and the National Oceanic and Atmospheric Administration, focused on wetland trends within U.S. coastal watersheds (8 digit hydrologic unit code watersheds that contain tidal water bodies or drain to the Great Lakes) between 2004 and 2009. This region contains a diversity of wetland types, including both fresh and saltwater wetlands. Wetlands in this low-lying region have historically been abundant and provide a wealth of ecosystem services that support human health, safety, and livelihoods, as well as critical habitat for migratory birds and other wildlife. These same areas have experienced land cover conversion, as well as degradation, due to their suitability for commercial industry, including agriculture, and are under increasing pressure due to population growth. The report found that nearly 40% of wetlands in the conterminous U.S. are found in coastal watersheds, but that they are being lost at a greater rate relative to other areas of the U.S. Wetlands in coastal watersheds were lost at an average rate of 324.4 km^2 per year, an increase of 25% in loss rate between the periods of 1998 through 2004 and 2004 through 2009. Emergent and forested/shrub wetland losses were highest for salt water wetlands, while forested wetland losses were greatest for freshwater wetlands. A marked gain was observed in pond habitats. Wetland change was highest in the Atlantic and Gulf of Mexico coastal watersheds, when compared to other coastal regions. Drivers of wetland change (loss and state conversion) within this region are complex, and include development, intensive forest management, and coastal processes. This presentation will provide a brief description of Status and Trends protocols and historic findings for coastal watersheds with an emphasis on policy and management relevant trends.

The Interagency Coastal Wetlands Workgroup: Exploring Challenges and Opportunities in Coastal Wetland Management

Author(s): Jennifer Linn and Dominic MacCormack

Affiliation(s): U.S. EPA

Abstract: In response to concerns about the rate of wetlands loss in coastal watersheds, the Interagency Coastal Wetlands Workgroup (ICWWG) was formed to help identify the causes of these losses as well as identify strategies to address them. The ICWWG consists of representatives from the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, U.S. Geological Survey, Natural Resources Conservation Service, and Federal Highway Administration.

The ICWWG held seven regional workshops involving local, state and federal stakeholders to gather input about factors driving wetland loss in coastal watersheds, successful approaches for addressing this loss, and remaining information needs. Findings were released in 2013. The ICWWG subsequently completed a series of four coastal wetland loss pilot studies to assess watershed-specific data to help identify actions federal agencies can take in coordination with state, tribal, regional, and local agencies to improve management of coastal wetlands and reduce losses nationwide. A Summary Findings of these four pilot studies was released in July, 2017.

This session will detail trends observed in the pilot studies and discuss opportunities for coastal wetland resource management. Emphasis will be placed on the strategies available to federal, state, and local agencies in cooperative contexts.

Assessment of Wetland Conservation Program Effectiveness in the Mid-Atlantic Lower Coastal Plain Region of the U.S.

Author(s): Greg McCarty, Megan Lang, Sangchul Lee, Amir Sharifi, Ali Sadeghi and William R. Effland

Affiliation(s): USDA ARS Hydrology & Remote Sensing Laboratory

Abstract: The U.S. Department of Agriculture (USDA) Mid-Atlantic Regional (MIAR) Wetland Conservation Effects Assessment Project (CEAP-Wetland) study covers an area of ~58,000 km2 in the eastern United States, including areas of the Atlantic Coastal Plain physiographic province located in five states (North Carolina, Virginia, Maryland, Delaware, and New Jersey). To support assessment of current wetland restoration practices, 48 primary study sites were selected (18 restored, 16 prior converted cropland, and 14 natural) and ecosystem service provision was evaluated using both remote sensing and in situ measurements. The services evaluated include: climate regulation, pollution mitigation, water storage and biodiversity. Study results support the following recommendations: 1) Longer easement/contract periods should be promoted to allow time for slower environmental processes to occur; 2) Soil compaction should be minimized to encourage root growth and enhance movement of nitrate rich groundwater into wetland soils capable of nutrient removal; 3) Either a greater number of restored wetland cells and/or larger wetland cells can better support the regulation of hydrologic flows and groundwater levels, and the mitigation of natural hazards, such as flooding; 4) Natural wetlands should be conserved, not only due to the high level of ecosystem services they provide, but also because they directly enhance provision of ecosystem services from restored wetlands and prior converted croplands; 5) Greater effort should be made to restore wetlands in locations that are low elevation relative to broader-scale topographic gradients which are more likely to intercept up gradient groundwater containing agricultural contaminants and sediments; 6) Wetland basins should be shallow with gentle slopes, such that they support hydroperiods and water depths characteristic of natural wetlands to encourage colonization and growth of vegetation? that are representative of more natural conditions; 7) Intra-regional variations in physical and biological parameters should be considered when targeting, implementing, and managing wetland conservation practices; and 8) Increased applications of geospatial datasets and techniques within precision conservation practice strategies can enhance not only ecosystem service provision but also the determination of derived benefits at landscape and watershed scales. Findings are being used to support enhanced implementation of wetland conservation practices.

Increased Hydrologic Connectivity: Consequences of Reduced Water Storage Capacity in the Delmarva Peninsula (U.S.)

Author(s): Daniel McLaughlin, C. Nathan Jones, Grey Evenson, and Megan Lang

Affiliation(s): Virginia Tech

Abstract: Across the Delmarva Peninsula, depressional wetlands (i.e., Delmarva bays) are common features that store water and provide associated landscape functions (e.g., floodwater attenuation, nutrient retention, and habitat). However, pervasive ditching has increased surface water connectivity and thus decreased wetland water storage capacity at local to landscape scales. Here, we utilized both geospatial analysis and hydrologic modeling to explore drivers and consequences of this modified surface water connectivity. Our geospatial analysis quantified both historical and contemporary wetland storage capacity across the region, and suggests that over 70% of historical storage capacity has been lost due to ditching. Building upon this analysis, we applied a catchment-scale model to simulate implications of reduced storage capacity on catchment-scale hydrology. In short, increased connectivity (and concomitantly reduced wetland water storage capacity) decreases catchment inundation extent and spatial heterogeneity, shortens cumulative residence times, and increases downstream flow variation with evident effects on peak and baseflow dynamics. As such, alterations in connectivity have implications for hydrologically mediated functions in catchments (e.g., nutrient removal) and downstream systems (e.g., maintenance of flow for aquatic habitat). Our work elucidates such consequences in Delmarva Peninsula while also providing new tools for broad application to target wetland restoration and conservation. Views expressed are those of the authors and do not necessarily reflect policies of the US EPA or US FWS.

Wetland Trends in Coastal Watersheds: Drivers, Effects, and Adaptive Management

Calculating the Economic Benefits of Coastal Wetlands

Author(s): Susan-Marie Stedman

Affiliation(s): NOAA National Marine Fisheries Service

Abstract: Coastal wetlands (wetlands in coastal watersheds) provide a wide range of economic benefits. They include use values, both direct (fish, timber) and indirect (shoreline stabilization, flood control) as well as non-use values (biodiversity). Use values are the easiest to quantify, especially direct use values tied to human markets. For example, the value of timber from pine plantations in wetlands can be calculated based on market prices and typical timber yield. The value of commercial fish associated with wetlands can be estimated using data on the use of wetlands by various life stages of commercial fish and the typical dockside prices for those fish. Indirect use values require more creative economic analyses. For example, a recent study of the effects of Superstorm Sandy on the northeast United States used high-resolution flood and loss models to calculate the averted losses associated with wetlands. This presentation will review methods used to calculate the economic value of coastal wetlands, the results of those calculations, and considerations for incorporating economic analyses into decision-making.

Evaluating Recent Landsat-Based Map Products for Surface Water and Wetland Information

Author(s): Zhiliang Zhu

Affiliation(s): U.S. Geological Survey

Abstract: Recently, continuous research and data refinements have led to at least three independently developed, continental-scale map products that are based on Landsat and are highly relevant to information needs for surface water and wetlands. The three map products are: the European Union Joint Research Center (JRC) Global Surface Water Explorer (GSWE), the U.S. Geological Survey (USGS) Dynamic Surface Water Extent (DSWE) product, and the USGS Land Cover Monitoring, Analysis, and Projection (LCMAP) system. All three products have 30-meter resolution, cover a common time-window from mid-1980 to present, are temporally resolved annually and seasonally, and are developed using time-series remote sensing methods. The JRC's GSWE and USGS DSWE products are aimed at water-specific policy and science applications, whereas LCMAP is developed as a general-purpose, multi-category product meeting needs for a variety of applications. With the National Hydrological Dataset (NHD) as a standard, we conducted a preliminary comparison of surface water extent from the three map products plus the traditional National Land Cover Database (NLCD). We also compared wetland extent from LCMAP and NLCD with the National Wetland Inventory data. The comparisons were conducted for Chesapeake Bay Watershed. This presentation will show results of the two comparison exercises for their accuracy, extent, and abilities to capture seasonal and inter-annual variabilities.

Index to Presenters

Index to Presenters

Coastal Habitats and Resources: Management, Protection, and Restoration

Managing and Characterizing Complex Aquatic Systems across Different Land Uses and Spatial Scales

Index to Presenters

Monitoring Aquatic Systems from Daily to Decadal Scales: Advances and Applications

Novel Approaches and Applications in Hydrologic Modeling for Watershed Research

Index to Presenters

Plenary Speakers

Posters

Index to Presenters

Using Long-term Data on Assessing Extreme Climatic Events Effects on Watershed Processes, Functions and Management Practices

Water Quality Research in the Appalachia Region

Index to Presenters

Waters at the Border – Science, Management, and Policy Challenges for Transboundary Watersheds

Watershed Evapotranspiration in a Changing Environment

Watershed Research and Management in a Changing Climate

Index to Presenters

Wetland Trends in Coastal Watersheds: Drivers, Effects, and Adaptive Management

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