

ACES

A Community on Ecosystem Services



PROGRAM & ABSTRACTS



December 12-15, 2022
Greater Washington, DC Area

ECOSYSTEM MARKETS
Making Them Work

ESP
Ecosystem Services Partnership



December 12-15, 2022

Crystal Gateway Marriott
Greater Washington, DC Area

conference.ifas.ufl.edu/aces

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WELCOME ATTENDEES!

Thank you for joining us for the ACES 2022 conference!

On behalf of the Executive Planning Committee, we graciously welcome you to the 14th year of A Community on Ecosystem Services (ACES) conference. Since 2008, ACES has been a place for colleagues and friends with expertise and interest across the ecosystem services community to gather and share their science and practice. This year the conference will focus on Leveraging Opportunities for Ecosystem Services Implementation. As we reassemble this week, we encourage you to make a concentrated effort to reach out and interact with everyone but especially those who have a different expertise than your own.

We would like to express much appreciation to our valued partners and sponsors. Without their generosity and financial support, it would be impossible to have a conference of this caliber. Please make time to stop by and visit with each of our sponsor representatives at their displays in the exhibit hall and take a moment to thank them for their support and learn more about what they do.

We also urge you to join us on Tuesday, December 13th at the 5:30pm Pollinator Workshop followed by Conservation and Cocktails at 6:30pm. As we celebrate 50 years of the Clean Water Act, the National Capital Chapter of the Soil and Water Conservation Society will lead a special session featuring Nancy Stoner, President of the Potomac River Keeper Network and one of the nation's most experienced water policy experts who recently served as Acting Assistant Administrator at the U.S. Environmental Protection Agency (EPA).

We are grateful to those who assisted in the planning and delivery of this year's conference. We'd especially like to thank those who coordinated plenaries, organized sessions to develop our program agenda, presided over sessions as moderators, and those who submitted abstracts; your presentations, panel sessions, posters, and willingness to share is critical to the growth and development of the ACES community!

ACES 2022 will provide many opportunities to share science advances and practices within the ecosystem services community. We hope the conference brings you new connections, new tools, and the latest cutting-edge knowledge to advance ecosystem services in the world!

Sincerely,

Shonté Jenkins

ACES 2022 Co-Chair
Science Information Specialist
Science and Decisions Center
U.S. Geological Survey
Reston, VA

Emily Pindilli

ACES 2022 Co-Chair
Economist
Science and Decisions Center
U.S. Geological Survey
Reston, VA

Christopher G. Hartley

Senior Environmental Markets Analyst
Office of Environmental Markets
U.S. Department of Agriculture
Washington, DC

THANK YOU TO OUR SPONSORS

Without their generous support, this symposium would not be possible.

*Sponsors listed below are in **alphabetical order**.*

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(American Society of Agronomy, Crop Science Society of America, Soil Science Society of America)

Environmental Protection Agency (EPA)

MDPI Journal: International Journal of Environmental Research and Public Health

MDPI Journal: Remote Sensing

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National Institute of Food and Agriculture (NIFA)

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U.S. Department of Agriculture (USDA)

U.S. Geological Survey (USGS)



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CONFERENCE ORGANIZERS & PLENARY SPEAKERS

ACES 2022 Executive Planning Committee



Shonté Jenkins

ACES 2022 Co-Chair

Science Information Specialist, U.S. Geological Survey

Shonté Jenkins is the Science Information Specialist at the US Geological Survey (USGS) Science and Decisions Center (SDC) in Reston, VA. While at the center Shonté has been instrumental in producing products, which communicate the many efforts and projects by the SDC scientists within the center through print and digital media. Shonté is passionate about early education outreach and bringing more diversity to science. She pursues these efforts for the center and across the USGS as a member for the Diversity, Equity, Inclusion, & Accessibility (DEIA) Council. Shonté has served an active role in the A Community on Ecosystem Services (ACES) conferences as a program and planning committee member since 2012 and more recently as Co-Chair. In addition to her many professional accomplishments, Shonté considers her greatest accomplishments being a mother, wife, and woodworker loving life in beautiful and rural Northern VA.



Dr. Emily Pindilli

ACES 2022 Co-Chair

Director, Science and Decisions Center, and Chief Economist, U.S. Geological Survey

Emily Pindilli is the Director of the Science and Decisions Center, and Chief Economist for U.S. Geological Survey in Reston, Virginia. Dr. Pindilli joined USGS in 2012 and has focused on a diverse portfolio of environmental and informational economics research topics including: the value of scientific information; ecosystem services assessment and valuation; methods to integrate multi-disciplinary analyses to support land use decision-making; lifecycle analyses of resource development and conservation; and environmental markets. Prior to joining USGS, Dr. Pindilli worked in the private sector where she analyzed the value of earth observations, intelligent transportation systems, biofuels sustainability, and assessed conventional and unconventional fuels issues. She earned her B.A. in economics from James Madison University and a M.S. in environmental science and policy and PhD in environmental policy focusing on environmental economics from George Mason University.



Dr. Christopher G. Hartley

Senior Environmental Markets Analyst

U.S. Department of Agriculture (USDA), Office of Environmental Markets

Dr. Christopher Hartley is responsible for the development of policy, tools, and metrics to facilitate private investment in conservation and the participation of farmers, ranchers, and forest landowners in emerging environmental markets. He previously worked for the Natural Resources Conservation Service in Washington, DC and in California building partnerships to accelerate voluntary conservation and served with the U.S. Peace Corps as an agricultural extension agent in Senegal, West Africa. He is a Certified Crop Advisor, and a licensed Pest Control Advisor with more than 25 years of experience working in support of production agriculture and the promotion of clean air, clean water, and a safe and abundant food supply. Dr. Hartley earned a Ph.D. in Ecology, emphasis Agroecology, M.Sc. Agronomy, MSc. International Agricultural Development from the University of California at Davis.

Opening Plenary Session Panelists

Tuesday, December 13, 2022

8:30am – 9:45am

Arlington Ballroom Salon IV

Panel Discussion: From Science to Society – Advancing Ecosystem Services for Decision Making

The benefits of systematically considering ecosystem services in decision making are well understood but finding paths to doing so has at times been challenging. This plenary features four speakers offering diverse, state-of-the-art perspectives on the role of ecosystem services in society and decision making – ranging from White House, international, and private-sector efforts to embed ecosystem services in decision making to improving indigenous engagement in natural capital accounting in Australia.

Panelists:

Dr. Tania Briceno, Chief Economist, Intrinsic Exchange Group

Dr. Stephenne Harding, Senior Director for Lands, White House Council on Environmental Quality

Anna Normyle, Ph.D. Student, Australian National University, Fenner School of Environment & Society

Dr. Klara Johanna Winkler, Deputy Science Director: NSERC - ResNet, McGill University



Dr. Tania Briceno

Chief Economist

Intrinsic Exchange Group

Dr. Tania Briceno has more than 15 years of experience as an ecological economist conducting environmental valuations, socioeconomic analyses, and ecosystem service assessments. She oversees IEG's standards for ecosystem service valuations and ensures they are implemented properly for each IEG NAC. Prior to joining IEG, Tania worked in various organizations conducting ecosystem service valuations for government agencies, special interest groups, and the private sector. She served as Lead Economist at Conservation Strategy Fund and was part of the leadership team for Earth Economics. She also worked for the National Round Table on the Environment and Economy in Canada and at various universities in Europe and North America. Tania holds a Ph.D. in Environmental Economics from University of Montreal, a Masters in Ecological Economics from Leeds University, and a BA in Economics and International Development from McGill University. In 2022, she received the Herman Daly Award from the US Society of Ecological Economists in recognition of her work to employ ecological economics to create practical applications and implement solutions that are sustainable in scale, equitable in distribution, and efficient in allocation.



Stephenne Harding

Senior Director for Lands

White House Council on Environmental Quality

Stephenne is the Senior Director for Lands at the White House Council on Environmental Quality where she leads a team working on America the Beautiful, conservation, restoration, and protection of America's iconic lands. The team works to imbue the importance of conservation and restoration in all the administration's actions. Prior to returning to the White House Stephenne ran her own consulting practice, Great Northern Strategies, supporting non-profits at the nexus of policy and politics.

Prior to those roles, Stephenne served as National Geographic Society's Senior Director for the Campaign for Nature, a Senior Policy Advisor for U.S. Senator Tom Udall (D-NM), an Associate Director at the White House Council on

Opening Plenary Session Panelists (continued)

Stephene Harding (continued)

Environmental Quality, the Deputy Director at the Department of the Interior and a Policy Adviser to Senator Jon Tester (D-MT). She holds a Master's in Public Administration from the Maxwell School at Syracuse University and an undergraduate degree from Willamette University.

Before graduate school, Stephene was vagabond who lived and traveled on every inhabited continent and worked as a raft guide, backpacking guide, and a ski instructor in the U.S. and Germany. When not at work, you can find her still traveling as much as possible and working to get outside to hike, bike, float, fish, and ski with her husband, Shaun and their dog, Marra.



Anna Normyle

Ph.D. Student

Australian National University, Fenner School of Environment & Society

Anna is a Westpac Future Leaders Scholar completing her doctoral studies at the Fenner School of Environment and Society, The Australian National University. Anna's research interests include applied GIS and remote sensing, and ecosystem accounting, with a specific focus on cultural and environmental management applications in Indigenous Australia. Her doctoral project is working collaboratively with the Yawuru Traditional Owners of the land and sea Country of Australia's Kimberley region to assess how Indigenous knowledge and land management practices can be incorporated within Australia's National System for Environmental-Economic Accounting.



Dr. Klara Johanna Winkler

Deputy Science Director

NSERC - ResNet, Postdoctoral Researcher, Bright Spots at McGill University

Klara is a sustainability scientist interested in human-nature relationships and processes of sustainable transformation. She uses a governance perspective to research these phenomena on multiple levels of social-ecological systems – from local to supranational. With her research, Klara aims to better understand how actions of individuals fit into the broader network of societal activities and how they relate to and affect each other. Working landscapes in highly-developed countries are the focus of her research as they are the places where change is urgently needed in order to provide a stable ecological system that can contribute to human well-being today and in the future.

Pollinator Workshop Presenters

Bee Social, Bee Informed!

Tuesday, December 13, 2022

5:30pm – 6:30pm

Arlington Ballroom Salon IV

Bees and other pollinators are critical to ecosystem health and our food supply. We are interested in advancing a science-based conversation that will support better metrics and business models to consider appropriate investments in pollinators. Come prepared to listen and to share your own thoughts on how we can support pollinators while also meeting society expectations for affordable energy, food, and water.

Pollinator Social Presenters:

Dr. Lara Drizd, U.S. Fish and Wildlife Service | "Making a List and Checking it Twice"

Jessica Fox, Electric Power Research Institute | "Power Companies Collaborating to Understand Pollinators"

Dr. Chris Hartley*, USDA Office of Environmental Markets | "The ABC's of Pollinators in the Federal Alphabet Soup"

**Read Dr. Chris Hartley's biography on page 8*

Workshop Coordinators: Electric Power Research Institute (EPRI) Power-in-Pollinator Initiative, the National Ecosystem Services Partnership (NESP), and the United States Department of Agriculture (USDA)



Dr. Lara Drizd

Endangered Species Biologist

U.S. Fish and Wildlife Service (USFWS)

Lara Drizd is a Species Assessment Team Project Manager with the Ecological Services Program of the U.S. Fish and Wildlife Service. She works in the Headquarters Office in Falls Church, Virginia. As a project manager, she leads teams of biological experts crafting

Species Status Assessments to inform classification decisions under the Endangered Species Act. She also helps decision-makers apply the standards in the Act to determine if species warrant listing as endangered or threatened. Ms. Drizd has been engaged in pollinator conservation and the classification of the monarch butterfly since 2015. She earned a B.A. in Environmental Studies from New College of Florida and an M.S. in Wildlife Ecology and Conservation from the University of Florida.



Jessica Fox

Senior Technical Executive

Electric Power Research Institute (EPRI)

Jessica Fox is a conservation biologist leading efforts on water management, pollinators, environmental markets, ecosystem services, sustainability and related work. She works for the Electric Power Research Institute, a non-profit organization focused on environmental science related to electricity generation and use. In 2018, Ms. Fox launched the EPRI Power-in-Pollinators Initiative, which is now the largest effort in North America for electric power companies to collaborate on pollinator conservation research and projects., Fox led EPRI's Energy Sustainability Interest Group to become the largest collaborative in the industry to advance critical issues related to sustainable electricity. In 2015, Ms. Fox accepted the United States Water Prize for creating the Ohio River Basin Water Quality Trading Project. Her projects have been covered by the Wall Street Journal, The Economist, National Public Radio, Bloomberg, and others. She previously worked as a molecular biologist leading conservation genetics projects on dragonflies in Costa Rica, at Stanford University sequencing and mapping the human genome, and as invasive weed field biologist for U.S. Bureau of Land Management. She has a Bachelor's of Science from University of California at Davis, and a Master's of Science from Stanford University.

Conservation and Cocktails – The Clean Water Act at 50

Tuesday, December 13, 2022

6:30pm – 7:30pm

Arlington Ballroom Salon IV

The Clean Water Act established national water quality standards, restricted pollution, and invested in wastewater treatment and better wetlands management. Today, our waters are dramatically cleaner and yet, significant challenges still remain.

As we celebrate 50 years of the Clean Water Act, the National Capital Chapter of the Soil and Water Conservation Society will lead a special session featuring Nancy Stoner, President of the Potomac River Keeper Network and one of the nation's most experienced water policy experts who recently served as Acting Assistant Administrator at the U.S. Environmental Protection Agency (EPA).

You won't want to miss this session!



Featured Presenter

Nancy Stoner

President

Potomac Riverkeeper Network

Nancy Stoner is the President of Potomac Riverkeeper Network. One of the nation's most experienced water policy experts, Nancy has a rich and distinguished background in protecting our nation's water. Nancy began her career as an attorney in the Environment and Natural Resources Division of the U.S. Department of Justice in Washington, DC, where she litigated and analyzed legislative proposals on a broad range of environmental and natural resource statutes. She also worked for many years at the Environmental Protection Agency (EPA), where she recently served as Acting Assistant Administrator for Water. In that position Nancy managed the agency's program for implementing the Clean Water Act and Safe Drinking Water Act nationwide to protect surface water resources and ensure the safety of tap water, supervising a staff of more than 600 and a budget of more than \$3 billion in grants, loans and contract support. She also supervised the development of national rules to protect surface waters, drinking water sources and tap water and represented the agency in congressional hearings, national conferences, symposia and press conferences. Nancy also served as Co-Director, Water Program, Natural Resources Defense Council, where she co-directed a national program to promote sound water resource management nationally and in specific watersheds, such as the Great Lakes, Chesapeake Bay, and Anacostia River.

Nancy most recently served as Water Program Director and Senior Fellow for the Pisces Foundation where she developed the foundation's strategy to protect freshwater resources in the U.S. using integrated water management (IWM) to maximize the value from water resources for people and nature. She also supervised a \$7 million investment annually to implement IWM in urban and agricultural watersheds.

Nancy graduated from the Yale Law School, New Haven, CT and was awarded a Juris Doctorate in 1986. She was also awarded a Bachelor of Arts with Highest Distinction, Phi Beta Kappa, from the University of Virginia, Charlottesville, VA. She lives in Silver Spring, MD with her husband, Marc Machlin. She has two grown children, Laura and Jared. She enjoys whitewater rafting, tubing, canoeing, birding, and gardening.

AGENDA-AT-A-GLANCE

Monday, December 12, 2022	
11:00am - 5:30pm	Conference Registration Open
11:00am - 5:00pm	Exhibiting Sponsors & Poster Presenters Move-In Displays
5:00pm - 6:00pm	Welcome Networking Social in the Poster Hall
Tuesday, December 13, 2022	
7:30am - 5:30pm	Conference Registration Open
7:30am - 8:30am	Morning Refreshments & Poster Set-Up
8:30am - 9:45am	Opening Plenary Session
9:45am - 10:15am	AM Break in Poster Hall
10:15am - 12:00pm	Concurrent Sessions
12:00pm - 1:30pm	Lunch on Own
1:30pm - 3:15pm	Concurrent Sessions
3:15pm - 3:45pm	PM Break in Poster Hall
3:45pm - 5:30pm	Concurrent Sessions
5:30pm - 6:30pm	Pollinator Workshop – Bee Social. Bee Informed!
6:30pm - 7:30pm	Conservation and Cocktails – The Clean Water Act at 50
Wednesday, December 14, 2022	
7:30am - 5:30pm	Conference Registration Open
7:30am - 8:30am	Morning Refreshments
8:30am - 10:15am	Concurrent Sessions
10:15am - 10:45am	AM Break in Poster Hall
10:45am - 12:30pm	Concurrent Sessions
12:30pm - 2:00pm	Lunch on Own
2:00pm - 3:45pm	Concurrent Sessions
3:45pm - 6:00pm	Poster Session & Networking Social
Thursday, December 15, 2022	
7:30am - 4:30pm	Conference Registration Open
7:30am - 8:30am	Morning Refreshments
8:30am - 10:15am	Concurrent Sessions
10:15am - 10:45am	AM Break in Poster Hall
10:45am - 12:30pm	Concurrent Sessions
12:30pm - 2:00pm	Lunch on Own
2:00pm - 3:45pm	Concurrent Sessions
3:45pm - 4:30pm	Closing Plenary Session
4:30pm - 6:00pm	Conference Concludes – Sponsors and Poster Presenters Dismantle Displays

DETAILED AGENDA

Monday, December 12, 2022	
11:00am-5:30pm	Conference Registration Open (<i>Skyview Terrace</i>)
	<p>Space for Impromptu Meetings</p> <p>Rooms are available for impromptu attendee meetings throughout the week. Take advantage of having your national and international ecosystem services colleagues gathered in the same location to hold briefings or workgroup discussions to spur collaboration and information exchange. Signup sheets to reserve space are on the announcement board inside the entrance of the Poster and Exhibit Hall.</p> <p><i>Please Note: Audio visual equipment is not provided.</i></p>
11:00am-5:00pm	Exhibitors and Poster Presenters Install Displays (<i>Arlington Ballroom Salons 1-3</i>)
5:00pm-6:00pm	<p>Welcome Networking Social in the Poster Hall (Arlington Ballroom Salons 1-3)</p> <p>Join us for food, libations and networking!</p> <p>It's been four long years since we last met face-to-face, so don't miss this opportunity to kick off the conference, catch up with colleagues and see who else is here!</p>

Tuesday, December 13, 2022	
7:30am-5:30pm	<p>Conference Registration Open (<i>Skyview Terrace</i>)</p> <p><i>Reminder: Space is Available for Impromptu Meetings</i></p>
7:30am-8:30am	Morning Refreshments (<i>Arlington Ballroom Salons 1-3</i>)
8:30am-9:45am	<p>Opening Plenary Session (Arlington Ballroom Salon IV)</p> <p>Panel Discussion: From Science to Society – Advancing Ecosystem Services for Decision Making</p> <p>The benefits of systematically considering ecosystem services in decision making are well understood, but finding paths to doing so has at times been challenging. This plenary features four speakers offering diverse, state-of-the-art perspectives on the role of ecosystem services in society and decision making – ranging from White House, international, and private-sector efforts to embed ecosystem services in decision making to improving indigenous engagement in natural capital accounting in Australia.</p> <p>Moderator: Dr. Ken Bagstad, Research Economist U.S. Geological Survey</p> <p>Plenary Session Schedule:</p> <p>8:30am Welcome from Organizers 8:40am Introduction and Overview by Moderator 8:45am Moderated Panel Discussion</p> <p>Panelists:</p> <p>Dr. Tania Briceno, Chief Economist, Intrinsic Exchange Group Dr. Stephenne Harding, Senior Director for Lands, White House Council on Environmental Quality Anna Normyle, Ph.D. Student, Australian National University, Fenner School of Environment & Society Dr. Klara Johanna Winkler, Deputy Science Director, NSERC - ResNet, McGill University</p>
9:45am-10:15am	AM Break (<i>Arlington Ballroom Salons 1-3</i>)

Tuesday, December 13, 2022 (continued)				
Concurrent Sessions				
10:15am-12:00pm	Session 1	Session 2	Session 3	Session 4
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Technical Advances in Natural Capital Accounting in the United States	Ecosystem Services Provided by Wetlands and Floodplains	Partnerships for Climate-Smart Commodities: Testing and Developing New Markets	Implementing Environmental Justice with Ecosystem Services through Knowledge and Value Pluralism
Moderator	Lydia Olander	Marzieh Motallebi	William Hohenstein	Kristin Hoelting
10:15am	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
10:20am	Ken Bagstad Lessons Learned and Paths Forward from First-generation SEEA EA Pilots in the U.S.	Kristina Hopkins What Is a Floodplain Worth? Estimating Floodplain Benefits in the Chesapeake and Delaware Watersheds	PANELISTS: William Hohenstein Robert Parkhurst Ryan Smith Dan Yeoman Presentations will discuss the potential economic and environmental impacts of efforts to meet the growing consumer demand for climate-smart agricultural products, provide an analysis of the estimated premiums on goods to enter these markets, the on-farm activities needed to supply climate-smart markets, and the projected environmental and greenhouse gas benefits to be achieved at scale.	Lucas Bair Adaptive Management of Regulated Rivers: Eliciting indigenous knowledge and perspectives to inform monitoring and research
10:40am	Marc Russell Review of EPA Resources for Natural Capital Accounting	Lucas Clay Quantifying Ecosystem Services by Land Cover Change in the Edisto River Basin, SC		Kristin Hoelting Retrospective Analysis of Cultural-Benefits-Knowledge: Elwha River Dam Removal and Restoration
11:00am	Kirsten Oleson Coastal Ecosystem Accounting for Hawai'i	Jacqueline Welles A Method to Assess and Value Floodplain Attenuation Services in the Schuylkill Watershed		Erik Stanfield and Jojo Matson Navajo Resource Monitoring in the Glen Canyon Adaptive Management Program: Using Ecosystem Services Frameworks to Inform Adaptive Management
11:20am	Katie Warnell Updating Regional Ecosystem Accounts for the U.S. Southeast	Pascal Badiou Understanding the Role of Freshwater Mineral Wetlands in Carbon Cycling in the Prairie Pothole Region - Canada		Pierre Glynn Cultural Ecosystem Services: Interactions of Knowledge, Governance, and Past, Present, and Future Conditions
11:40am	Travis Warziniack Natural Capital Accounting for the USDA Forest Service	Frances O'Donnell Understanding Ecosystem Services Benefits Provided by Geographically Isolated Wetlands		Discussion
12:00pm-1:30pm	Lunch on Own Note: The Marriott restaurant is not open for lunch. A list of local restaurant options is available at the registration desk.			

Tuesday, December 13, 2022 (continued)				
Concurrent Sessions				
1:30pm-3:15pm	Session 5	Session 6	Session 7	Session 8
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Ecosystem Services Assessments as a Transferable Tool for Management	From the Trenches: Innovative Ecosystem Service Measurement and Finance by Hook or by Crook	Bringing Cultural Ecosystem Services and Environmental Justice Into Economics for Decision-Making	Recreation
Moderator	Richard Fulford	Gretchen Greene	Hannah Stroud	Ian Luby
1:30pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
1:35pm	Susan Yee The Ecosystem Services Gradient: An Integrated Approach for Identifying Benefits of Restoration	Deborah McGrath Carbon, Coffee and Climate Justice: Results from a 10-Year Payment for Ecosystem Services (PES) Project in Haiti	PANELISTS: Charles Goodhue Alison Krepp Kate Quigley Danielle Schwarzmann Pete Wiley This panel will discuss the challenges and opportunities associated with incorporating cultural ecosystem services, environmental justice, and ecosystem service valuation data into economic decision-making.	Baishali Bakshi Climate Change, Forest Composition, and Outdoor Recreation in northeastern Minnesota
1:55pm	Joel Hoffman R2R2R: A Life Cycle Approach to Ecosystem Services Assessments at Contaminated Sites	Andrew Seidl #finance4nature: Identifying, Quantifying and Bridging The Global Biodiversity Finance Gap		Zach Ancona Social Value Distributions Using Solves for Multiple User Groups Surveyed in a Coastal National Park
2:15pm	Marc Russell Natural Capital Accounting as a Monitoring Tool for Decision Making	Emily Gaskin What Is the Value of a Coral Reef? A Legal Framework for Valuing Marine Ecosystem Services in Court		Wei-Lun Tsai Measuring Nature-Based Recreation using Human Mobility Data
2:35pm	Justin Bousquin Comparing Wetland Projects Based on Who Benefits	Seth Brown Innovative Financing, Market-Based and Project Delivery Tools for Green Stormwater Infrastructure		Trygve Madsen How Mobile Device Data Can Inform Outdoor Recreation Management
2:55pm	Richard Fulford Practical Strategies for Decision Support Based on Structured Decision Making and Ecosystem Services	Florence Amate Motivating Smart Grid Adoption in Chicago		Octavio Valdez Lafarga Bayesian Information Criterion Approaches to Valuing the Environment: An Application to the Boundary Waters Canoe Area Wilderness
3:15-3:45pm	PM Break (Arlington Ballroom Salons 1-3)			

Tuesday, December 13, 2022 (continued)				
Concurrent Sessions				
3:45pm-5:30pm	Session 9	Session 10	Session 11	Session 12
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	America the Beautiful and the Conservation and Stewardship Atlas	Cultivating Ecosystem Services in Working Croplands	NEPA, Multiple Knowledge Systems, Plural ES Values & Environmental Justice	Species & Habitats
Moderator	Scott Chiavacci	Amber Campbell	Lucas Bair	Mustapha Alhassan
3:45pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
3:50pm	Mark Wiltermuth American Conservation and Stewardship Atlas Update	Humberto Blanco Managing Cover Crops to Enhance Soil Ecosystem Services in Soils Vulnerable to Environmental Pressures	<p>PANELISTS: Jared Hautamaki Kristin Hoelting Charles Ka'ai'ai Cheryl Kelly</p> <p>This panel will focus on how an Environmental Justice-oriented ES approach could support National Environmental Policy Act (NEPA) analyses that more successfully protect traditional, Indigenous, and long, continuous mutually beneficial uses of the environment.</p>	Darius Semmens Considering Ecosystem Service Benefits of Regional Habitat Restoration for Monarch Butterflies
4:10pm	Christopher Hartley What Counts? Building a Framework to Identify Conservation in American Conservation and Stewardship Atlas	Paul DeLaune Improving Soil Ecosystem Health and Resilience through Cover Crops and Pasture Cropping		Audra Hinson Aquatic Protected Lands as Non-Traditional Habitat Solution for Native Pollinator Populations in Predominately Agricultural Landscapes
4:30pm	Lydia Olander Tracking Benefits of Natural and Working Lands Over Time.	Sangu Angadi Circular Buffer Strips of Perennial Grasses to Improve Multiple Ecosystem Services in Center Pivot Irrigated Agriculture in the Southern Great Plains		Barbara Jones Wolves, Woodland Caribou and Beaver: Conservation, Ecotourism, and the Branding of Charismatic Fauna in the Era of Climate Change
4:50pm	Phillip Rodbell Identifying Nature-Deprived Communities	Chia-Hua Lin The Buzz about Soybeans: Improving Pollination Services and Productivity in Soybean Cropping Systems		Matt Weber Valuing Wild Salmon Recovery in Oregon's Most Urbanized Watershed
5:10pm	Discussion	Sarah Karpanty Assessing the Relationships between Pollinator-friendly Plantings and Wildlife-related Ecosystem Services on Farms in the Mid-Atlantic Coastal Plain		Discussion
5:30pm	Pollinator Workshop (Arlington IV) Jessica Fox , Electric Power Research Institute, Chris Hartley , USDA Office of Environmental Markets, and Lara Drizd , U.S. Fish and Wildlife Service			
6:30pm	Conservation and Cocktails – The Clean Water Act at 50 (Arlington IV) Nancy Stoner , President of the Potomac River Keeper Network			

Wednesday, December 14, 2022				
7:30am-5:30pm	Conference Registration Open (<i>Skyview Terrace</i>) <i>Reminder: Space is Available for Impromptu Meetings</i>			
7:30am-8:30am	Morning Refreshments - <i>Arlington Ballroom Salons 1-3</i>			
Concurrent Sessions				
8:30am-10:15am	Session 13	Session 14	Session 15	Session 16
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Markets-Payments for Ecosystem Services	Rangeland Ecosystem Services	Approaches & Tools for Conservation	
Moderator	Marc Russell	Amy Ganguli	Zach Ancona	
8:30am	Introduction & Overview	Introduction & Overview	Introduction & Overview	
8:35am	Joan Ureta Ecological Business Profile: A Practical Approach to Establishing Environmental Markets in South Carolina	Alan Knapp How Will Climate Change and Altered Precipitation Regimes Impact Semi-Arid Grasslands?	Daniel Hayden America's Estuaries: Small Places, Big Impact	
8:55am	Pramisha Thapaliya Determinants of Farmers' Willingness to Accept Carbon Payments for Switching to Conservation Management Practices	Melinda Smith Exceeding Extreme Drought Thresholds Magnifies Productivity Losses in Grasslands Globally	Sara O'Brien Cross-Sector Water Collaboratives: A Critical Ecosystem Management Tool in a Rapidly-Changing World	
9:15am	Livia Madureira Ecosystems Services Supply by Agriculture: Using Choice Experiments to Estimate Trade-Offs Between Monetary and Non-Monetary Incentives	Kristin Hulvey Managing for Multiple Ecosystem Services in Semi-arid Rangelands	Ben Sherrouse An Open-Source GIS Tool to Assess Social Values for Cultural Ecosystem Services	
9:35am	Discussion	Megan Nasto The Effects of Livestock Grazing on Soil Health and Carbon in Semi-arid Rangelands	Kenneth Bagstad Interoperability for Ecosystem Services: The Problem, Solutions, and Paths Forward	
9:55am		Roisin Stanbrook Impact and Value of Dung Beetles in Central Florida Rangelands	Steven Bartell Ecosystem Services Require a Biophysical Economic Context	
10:15am-10:45am	AM Break (<i>Arlington Ballroom Salons 1-3</i>)			

Wednesday, December 14, 2022 (continued)				
Concurrent Sessions				
10:45am-12:30pm	Session 17	Session 18	Session 19	Session 20
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Finding Agency in Developing Natural Capital Accounts	The Final Ecosystem Goods and Services Voltron: An Integrated Set of Tools for Ecosystem Analysis	How Do We Make Benefit-cost Analysis Work for Nature-based Solutions?	Global Perspectives
Moderator	Stephen Posner	Leah Sharpe	Lydia Olander	Scott Chiavacci
10:45am	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
10:50am	Jane “Carter” Ingram Opportunities for Businesses to Use and Support Development of SEEA-Aligned Natural Capital Accounts	Paul Ringold Where to Start with Final Ecosystem Goods and Services (FEES): Classification and Metrics	PANELISTS: Todd Bridges Jennifer Helgeson Matthew Oreska Kate Quigley Ariana Sutton-Grier This panel will focus on the challenges and opportunities for updating benefit cost analysis (BCA) in federal decision-making processes to level the playing field for nature-based solutions.	Panayotis Dimopoulos Mapping and Assessment of Ecosystems and their Services in the European Union: A National Scale Implementation in Greece
11:10am	Jeffrey Wielgus Assessing the Contribution of Ecosystems to Ocean-Dependent Industries	Christina Horstmann What Ecosystem Services Matter?: The FEES Community Scoping Tool		Ioannis Kokkoris Ecosystem Services as a Tool for Protected Areas Integrated Management: Case Studies from the Mediterranean - Greece
11:30am	Ben Simon Incorporating Ecosystem Services into Natural Resource Decision Making at DOI within a Natural Capital Accounting Framework	Anne Neale How to Map what Matters: EnviroAtlas		Kaysara Khatun The Management of Sargassum in the Yucatan Peninsula, Mexico: Applying a Pluralistic Approach towards Marine Conservation and Regional Development
11:50am	Kirsten Oleson Experiences from State-Level Natural Capital Accounting in Hawaii	Tammy Newcomer-Johnson How to Model what Matters: FEES and the EcoService Models Library		Juan Sebastian Lozano Velasquez Monetization of Hydrological Ecosystem Services for Hydropower Production: Two Study Cases from the Tropical Andes
12:10pm	Doug MacNair Time to Take Stock: Improving Natural Capital Accounting with More Emphasis on Measuring Stocks	Leah Sharpe The Final Ecosystem Goods and Services (FEES) Voltron: The Power of Tools Together		Leander Raes Estimating Ecosystem Service Provision to Evaluate and Support Ecosystem-based Adaptation Measures in Guatemala
12:30pm-2:00pm	Lunch on Own Note: The Marriott restaurant is not open for lunch. A list of local restaurant options is available at the registration desk.			

Wednesday, December 14, 2022 (continued)				
Concurrent Sessions				
2:00pm-3:45pm	Session 21	Session 22	Session 23	Session 24
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Effective Incentives for ES from Urbanizing Agriculture	Coastal and Wetland Restoration	The Importance of Private Land Conservation in Meeting President Biden's 30 by 30 Conservation Goal	Integrating Ecosystem Services into USDA Forest Service Processes and Programs
Moderator	Lisa Wainger	Carl Taylor	Joe Nicolette	Lara Buluc
2:00pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
2:05pm	Daniel Read Assessing Effectiveness of Financial and Behavioral Interventions at Promoting Voluntary Conservation Adoption in Agri-Environments	Kristin Byrd An Ecosystem Services Assessment of the Nisqually River Delta, Puget Sound, Washington	Peter Kareiva Value of Conservation of Private Lands	Travis Warziniack Examining Novel Approaches to Account for Ecosystem Services Benefits in National Forest Planning
2:25pm	Douglas Wrenn Additionality and the Adoption of Riparian Buffers in the Face of Urbanization	Lou Nadeau Estimating the Economic Value of Ecosystem Services from Great Lakes Coastal Wetlands for Restoration Decision-Making	Mark Bailey Field Data Collection for Land Conservation	Kate Marcille Trends in Ecosystem Services Assessment and Evaluation for National Forest Planning
2:45pm	Wei Zhang Demand for Ecosystem Services: Evidence from the Environmental Quality Incentives Program	Katie Warnell Sea Level Rise Drives Habitat and Carbon Loss in the U.S. Mid-Atlantic Coastal Zone	Mark Rockel Economics of Valuing Public Interest	Jose Sanchez Effects of Climate Change on Ecosystem Services in Southern California
3:05pm	David Ablor Consumer-Driven Markets for Ecosystem Services from Agriculture in Urbanizing Landscapes	Chris Bowles Southport Sacramento River Levee Setback: Adaptive Management of a Floodplain Restoration Project	Michael Rockel Communicating the Value of Private Land Conservation	Katherine Brownson Restoring Chesapeake Forests for Ecosystem Services, Climate Resiliency and Environmental Justice
3:25pm	Chenyang Hu Improving Ecosystem Services from U.S. Agriculture: Yield Reserve vs. Land Retirement	Yichen Shen Analyzing Ecosystem Benefits of Mangrove Restoration in Liberia	Katie Warnell Geospatial Applications in Land Conservation Connectivity	Sherry Reckler & Nikola Smith Leveraging Conservation Finance and Partnerships with Ecosystem Services
3:45pm-6:00pm	Poster Session and Networking Social (Arlington Ballroom Salons 1-3) Poster presentations play a key role in the exchange of information. Considerable time is dedicated to viewing them, giving scientists, policy makers, planners, practitioners and managers valuable opportunities to interact and share details of their work, successes and lessons learned. Don't miss this opportunity to view posters and network with colleagues to learn more about national and global ecosystem services.			

Thursday, December 15, 2022				
7:30am-4:30pm	Conference Registration Open (<i>Skyview Terrace</i>) Space is Available for Impromptu Meetings			
7:30am-8:30am	Morning Refreshments (<i>Arlington Ballroom Salons 1-3</i>)			
Concurrent Sessions				
8:30am-10:15am	Session 25	Session 26	Session 27	Session 28
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Social Factors, Equal Access, and Environmental Justice in Ecosystem Services Science	Recent Advances and Tools in Forest Ecosystem Management for Numerous Ecosystem Services	Ecosystem Services and Offshore Oil & Gas and Wind Structures	The State of Environment Markets
Moderator	Kristin Hoelting	Diomy Zamora	Nicholas Nelson	Christopher Hartley
8:30am	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
8:35am	Lisa Wainger Rethinking Social Vulnerability Indices: Separating Household Susceptibility to Flood-Induced Harm from Exposure Risk	Thu Ya Kyaw Multifunctional Ecosystems: Nitrogen Mitigation by Short Rotation Woody Crops in the Lower Mississippi Alluvial Valley	PANELISTS: Larry Johnson Paul Krause Joseph Nicolette Mark Rockel Kristen Strellec This session will explore the evolution of assessment approaches, use cases, and regulatory frameworks associated with ecosystem service value as they have been integrated into offshore energy infrastructure commissioning and decommissioning decision-making. Incorporating the flow of ecosystem services over time is critical when considering commissioning and decommissioning alternatives, because decisions will directly and indirectly affect future generations. Through a combination of case studies, literature review, and subject matter experts, we will demonstrate win-win solutions for the public, operators, and the government.	PANELISTS: Christopher Boomsma Stephen Donofrio Christopher Hartley Sara O'Brien Over the past 30 years environmental markets and market-based approaches to conservation have developed from novel concepts into valuable tools to increase conservation on private lands. Join us for an assessment of the current state of environmental markets and suggestions for how to improve them.
8:55am	Jeffrey Kline Evaluating the Differential Influence of Perceived Amenities and Access Barriers Affecting Urban Greenspace Use by People of Different Groups	Michael Thompson Optimized Management Strategies to Support Bioenergy Feedstock Yield and Ecosystem Services in Degraded Forest Ecosystems		
9:15am	Meghann Jarchow Socioeconomic Characteristics Affect Residents' Values Toward Landscapes in the Upper Missouri River Basin	Emily Meineke Urban Heat Islands as Windows into Climate and Ecosystem Service Provisioning by Street Trees		
9:35am	Hebin Lin Balancing Ecosystem Services, Environmental Justice, and Economic Prosperity In Arizona	Javier Lugo Perez The Importance of Shade Trees in Promoting Carbon Storage in the Coffee Agroforest Systems of Puerto Rico		
9:55am	Klara Winkler How Marginalized Groups Use Nature In Canada	Discussion		
10:15am-10:45am	AM Break (<i>Arlington Ballroom Salons 1-3</i>)			

Thursday, December 15, 2022 (continued)				
Concurrent Sessions				
10:45am-12:30pm	Session 29	Session 30	Session 31	Session 32
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Green Infrastructure & Nature Based Solutions	Water Quality, Storage, and Management	From Carbon to the Cosmos: How National Marine Sanctuaries Evaluate and Incorporate Ecosystem Services into Meaningful Decision-Making	Stakeholder Informed Approaches to Overcoming Barriers
Moderator	Zach Ancona	Chris Huber	Steve Gittings	Adam Wilke
10:45am	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
10:50am	Meredith Hovis FloodWise: Using Nature-based Solutions (NBS) for Flood Reduction for Farms and Communities in Eastern North Carolina	Joel Corona Economic Valuation in a Changing Climate: The Implications of Water Quality Index Parameter Selection in the Context of Climate Impacts	Kathy Broughton Nejem Raheem Stan Rogers Danielle Schwarzmann Hans Van Tilburg Natural and social scientists, cultural heritage practitioners, and marine sanctuary managers will consider the policy, legal, and societal benefits of “braiding” modern and traditional knowledge to enhance our understanding of the relationships between people and places of marine sanctuaries, and to improve deliberations and the application of co-management frameworks.	Weston Eaton Advancing Scholarship and Practice of Stakeholder Engagement in Working Landscapes
11:10am	Megan Rippy Eliciting Cultural Services through Virtual Experiences with Green Stormwater Infrastructure	Jai Singh Eco-FIP: An Enhanced Method for Evaluating Large-Scale, Multi-Objective Floodplain Habitat Restoration Opportunities	1. What legal frameworks guide integration of traditional and modern knowledge systems in your work?	Jodi Brandt Farmland Loss in the Western United States: Implications for Ecosystem Services Supply and Demand, and Potential Policy Solutions
11:30am	Sara Mason Measuring the Impacts of Coastal Restoration on People: How Much is Changing, and for Whom?	Frank Lupi Getting Off the Ladder: Disentangling Water Quality Indices to Enhance the Valuation of Divergent Ecosystem Services	2. What are the challenges in improving inclusivity of cultures given the mandates?	Amy Quandt Land Repurposing in the Southern Central Valley, California: Stakeholder Perspectives and Recommendations
11:50am	Lauren Krauss Adaptive Strategy Biases in Engineered Ecosystems: Implications for Plant Community Dynamics and the Provisioning of Ecosystem Services to People	Manuel Zamorano Water Storage Strategies in Florida’s Northern Everglades	3. How have you incorporated science into the evaluation of ecosystem services and what have you seen as primary challenges?	Katherine Nelson Features of Diverse and Productive Agricultural Systems: Biophysical and Human Dimensions of Crop Production in U.S. Counties
12:10pm	Tibor Vegh Determinants of Landowner Participation in Programs to Deliver Natural Infrastructure as a Watershed Service: A Review	Matt Weber Value of Improved Information for Oyster Aquaculture Adaptations to the Economic Risks of Climate Change	4. What benefits to your discipline would arise from the braiding of modern and indigenous knowledge?	Maureen McCarthy Native Climate: Seeing Climate Resilience Through Native and Western Science Eyes
12:30pm-2:00pm	Lunch on Own Note: The Marriott restaurant is not open for lunch. A list of local restaurant options is available at the registration desk.			

Thursday, December 15, 2022 (continued)				
Concurrent Sessions				
2:00pm-3:45pm	Session 33	Session 34	Session 35	Session 36
Location	Grand Ballroom Salons A & B	Grand Ballroom Salons C, D & E	Grand Ballroom Salons F, G & H	Grand Ballroom Salons J & K
	Public Land and Resource Management	Urban Ecosystem Services & Perceptions	Applying Natural Capital Accounts in the European Union and the United States: A Synthesis	Land Ownership, Place, and Local Knowledge
Moderator	Darius Semmens	Scott Chiavacci	Carl Shapiro	Sophia Liu
2:00pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
2:05pm	Ryan Calder Integrated Mechanistic and Economic Modeling of Ecosystem Services to Inform Land-use Decisions under Uncertainty	Sophia Green Identifying Barriers to Use of Urban Natural Areas and Trails In a Post-Industrial Waterfront Community	Marialuisa Tamborra Joint Research Centre of the European Commission, The Integrated System for Natural Capital Accounts (INCA): From Piloting to Regulating	Thomas Ochuodho Impacts of Land Ownership and Forest Fragmentation on Forestland's Water-Related Ecosystem Services Provision and Dynamics in Kentucky
2:25pm	Mustapha Alhassan Application of the Ratio Method in Alternative Specific Reservoir Recreation Visitation Estimation	Trygve Madsen The Ecosystem Services Benefits of Community-driven Green Infrastructure: Insights from the Water Wise Model in New Orleans	Scott Wentland Bureau of Economic Analysis, Department of Commerce	James Bays Volunteer Action to Restore Ecosystem Services in Urban Lakes: 15 Years of Restoration of Crescent Lake, St. Petersburg FL
2:45pm	Ian Luby Valuation and Management of Toxic Harmful Algal Blooms at National Parks	Alanna Shapiro Assessing Selected Physical and Socioeconomic Explanatory Factors, Urban Heat, and Ecosystem Services in Miami Metropolitan Area	Giuseppe Ottavianelli European Space Agency: Earth Observation for Ecosystem Accounting	Carl Taylor Updating Land Trust Conservation Strategies for Climate Change Resilience
3:05pm	Lisa Wainger Broadening Benefits and Anticipating Tradeoffs by Using an Ecosystem Services Framework in USACE Planning	Peter Ibsen An Eight-city Analysis of How Urban Land Cover Drives Heat Mitigation Based on Regional Climate	Jane "Carter" Ingram The Pollination Group	Perry Williams Sustaining Rural Livelihoods, Livestock Grazing, and Sage-Grouse Habitat in Western Sagebrush Systems
3:25pm	Eric Sant Relevant Landscape Metrics to Support the Development of a Landscape Carbon Market	Discussion	Discussion	Discussion
3:45pm-4:30pm	Closing Synthesis & Panel Discussion [Grand Ballroom Salon F, G & H]			
4:30pm - 6:00pm	Exhibitors and Poster Presenters Dismantle Displays			
Conference Concludes				

POSTER SESSION INFORMATION

Arlington Ballroom Salons 1-3

A formal poster session is scheduled Wednesday, December 14th from 3:45pm–6:00pm. Presenters will be stationed at their posters to answer questions and share more about their work. We encourage you to take the initiative to explore and visit each poster to learn more about the incredible work being done around the world. Mid-way through the session, there will be some additional snacks and complimentary libations so be sure to stay until the end!

Poster presentations play a key role in the exchange of information. Posters will be on display throughout the conference in the Exhibit Hall, the primary gathering spot for morning, mid-day, and afternoon refreshments, as well as during the welcome reception and the formal poster session.

We have allotted considerable time for viewing them throughout the agenda so attendees can interact with poster presenters and use these opportunities to share and discuss successes and lessons learned. Be sure to visit each and every poster, and see what's happening around the world!

Consult the Poster Directory on the next page to view the poster presentation lineup.

POSTER INSTALL & REMOVAL TIMES

Poster Installation:	<p>Monday, December 12, 11:00am – 5:00pm</p> <p>Please check in at registration first to find out your assigned board number. Be sure to join us for the welcome social that starts at 5:00pm.</p> <p><i>Location: Arlington Ballroom Salons 1-3</i></p>
Formal Poster Session:	<p>Wednesday, December 14, 3:45pm – 6:00pm</p> <p>We have dedicated ample time for viewing posters throughout the conference, and to ensure maximum attendance at the poster session, we have also dedicated a premium period of viewing time along with snacks and refreshments.</p> <p><i>(Presenters are to be stationed at their posters from 4:15pm–5:30pm.)</i></p>
*Poster Removal:	<p>Thursday, December 15, 4:30pm – 6:00pm</p>
<p>*Organizers are not responsible for lost posters discarded by the board vendor. Thank you.</p>	

POSTER DIRECTORY

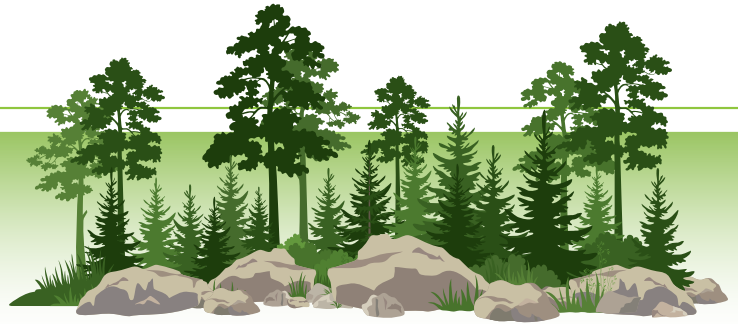
Posters are listed in order by **presenter's last name**.

Poster #	First Name	Last Name	Organization	State	Country	Abstract Title
6	Cassandra	Allsup	University of Wisconsin-Madison	WI	United States	Capitalizing on the Mycorrhizal Relationships of Tree Seedlings to Enhance Restoration Success in Changing Climates
27	Sangu	Angadi	New Mexico State University	NM	United States	Circular Grass Buffers for Sustainability of Center-Pivot Irrigated Agriculture Facing Transition to Dryland: Response of Soil Organic Matter and Nutrients
28	Sangu	Angadi	New Mexico State University	NM	United States	Native Perennial Grasses as Circular Buffer Strips Improves Water Dynamics of Center Pivot Irrigated Production SystemsEMS
13	Seth	Appiah Kubi	A Rocha Ghana	Greater Accra	Ghana	Assessing the Value of the Atewa Forest
15	Michelle	Atkinson	University of Florida IFAS Extension	FL	United States	Tapping into the Urban Afforestation Benefits of Micro-Forests
24	Brett	Barney	University of Minnesota	MN	United States	Improving Nitrogen-Fixing Potential of Endophyte Bacteria
1	Christopher	Boomsma	Decode 6, ACSESS	WI	United States	Decode 6: Bridging the Education Gap in Ecosystem Services Markets
18	Anthony	Dvaskas	Orsted North America	NY	United States	Understanding the Interaction between Offshore Wind and Ecosystem Services: Application of an Ecosystem Accounting Approach
7	Steven	Haring	University of Oregon	OR	United States	Agroecological Restoration with Native Cover Crops in Hazelnut Orchards in the Willamette Valley, Oregon
2	Brook	Herman	ERDC	MS	United States	Developing an Ecosystem Goods and Services Assessment Framework: Products of US Army Corps of Engineers Research
29	Chiharu	Hongo	Chiba University	Chiba	Japan	Use of Satellite Data to Estimate Soil Organic Matter Concentration of Paddy Field in Indonesia
19	Christopher	Huber	U.S. Geological Survey	CO	United States	Climate Change and Outdoor Recreation Benefits of National Forests and Grasslands
14	James	Knighton	University of Connecticut	Queensland	United States	Drought Sensitivity Across Northeastern Forests is Related to the Age of Transpired Water
31	Jasmeet	Lamba	Auburn University	AL	United States	Influence of Manure Application and Soil Physicochemical Properties on Leaching of Metals in Pastures
23	Ashley	Larsen	UC Santa Barbara	CA	United States	Impact of Nearby Fallowing on Pesticide Use
32	Francisco H C	Lima	Federal University of Ceará - Brazil	Ceará	Brazil	Ecosystem Services and Environmental Perception in Lagos in Northeast Brazil
9	Sophia B	Liu	U.S. Geological Survey	VA	United States	Accelerating the Use and Value of Participatory Science for Ecosystem Services

Poster #	First Name	Last Name	Organization	State	Country	Abstract Title
21	Kristie	Maczko	Sustainable Rangelands Roundtable - Univ of Wyoming	CO	United States	Valuing Ecosystem Services from U.S. Cattle Ranches and Farms
4	Joseph	McMahon	The University of Queensland	Queensland	Australia	Water Quality Offsetting – Challenges and Potential for Allowing Economic Development While Protecting Ecological Assets
30	Taylor	Minich	Environmental Pathways Modeling Branch	NC	United States	Mapping Livestock and Poultry Production by County with the USDA Census of Agriculture
33	Aisha	Muhammad Aliyu	Kano State College of Education and Preliminary Studies	Kano	Nigeria	Assessment of the Aquatic Ecosystems for Improved Ecosystem Services Provision in Kano, North-western Nigeria
8	Daniel	Pratson	University of Vermont	VT	United States	Relational Values in Empirical Research: A Systematic Review
12	John	Regan	Penn State University	PA	United States	Microbial Responses to Environmental Perturbations that Affect Phosphorus Availability and Retention in Soil
5	Vicki	Sandiford	US EPA	NC	United States	Nature's Benefits Educational Card Game
3	Brittany	Scharf	University of Florida	FL	United States	Be Seagrass Safe
16	Robert	Shriver	University of Nevada, Reno	NV	United States	Anticipating the Impacts of Climate Change on Forest and Rangeland Resources with Landscape-Scale Demographic Models
26	Maria	Stahl	Utah State University	UT	United States	Protecting Rangelands in a Changing Climate: Using a Heritage Cattle Breed to Maintain Ecosystem Function Under Livestock Production
17	Maria	Stefanidou	Environmental Engineering Laboratory, Department of Civil Engineering, University of Patras	Achaia	Greece	Green Infrastructure and Ecosystem Services at Two Metropolitan Areas of Greece
20	Weizhe	Weng	University of Florida	FL	United States	Housing Market Capitalization of Freshwater Lake Fisheries: Evidence from Oneida Lake, NY
10	Molly	Wick	University of Minnesota	MN	United States	How Do Social Factors Influence Coastal Cultural Ecosystem Services? A Case Study in the St. Louis River Estuary
22	Michaelyne	Wilkinson	New Mexico State University, Entomology, Plant Pathology and Weed Science Dept.	NM	United States	Effect of Native Grass Buffer Strips on Native Pollinator Species in Pivot Irrigated Corn
11	Mei-Hua	Yuan	Research Center for Environmental Changes, Academia Sinica	Taipei	Taiwan	Nation-based Solutions as a Method to Relieve the Pressure on the Food-Energy-Water Nexus in Cities: Exemplified through Ecosystem Service Assessment

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Monetary Value

Environmental Value

Ecological &
Socioeconomic
Cost Benefit
Analysis



-5x

+x

+10x

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ACES - Session #23

The Importance of Private Land Conservation in Meeting President Biden's 30 by 30 Conservation Goal

12/14 @2pm - Grand Ballroom Salons F, G, H

Moderator: **Joe Nicolette**

Our Participating Presenters:

Michael Rockel

Topic: *Communicating the Value of Private Land Conservation*

Mark Rockel

Topic: *Economics of Valuing Public Interest*

ACES - Session #27

Ecosystem Services and Offshore Oil & Gas and Wind Structures (Panel Discussion)

12/15 @8:30am - Grand Ballroom Salons F, G, H

Moderator: **Nicholas Nelson**

Our Participating Panelists:

Joseph Nicolette, Mark Rockel

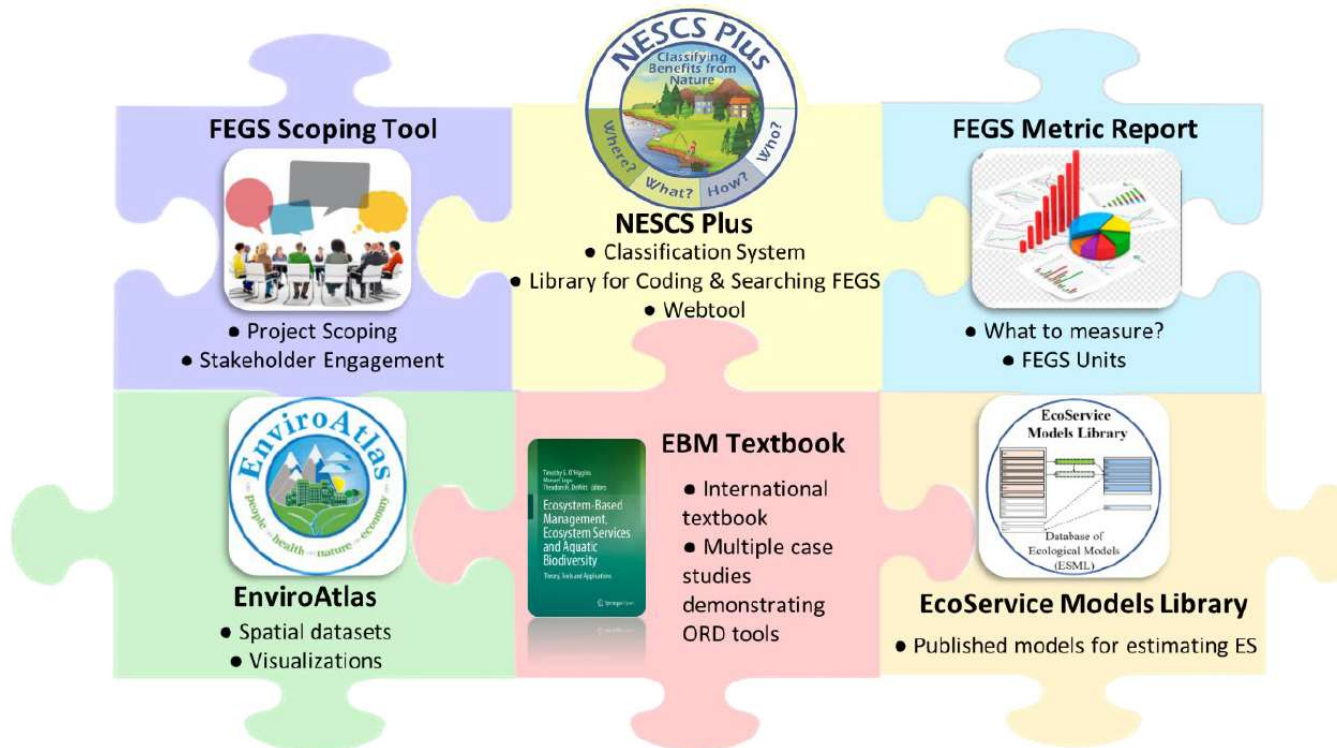
Ecosystem Service
Economics



The Future of Environmental Solutions

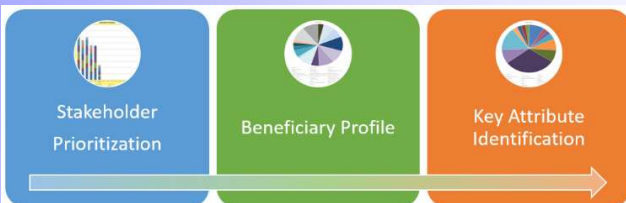
EPA's Connected Ecosystem Services Tools

EPA researchers are developing resources and tools to help communities incorporate the benefits of local ecosystems into their environmental decisions and planning.



FEGS Scoping Tool

The Final Ecosystem Goods and Services (FEGS) Scoping Tool is a decision support tool designed to help users identify and prioritize stakeholders, beneficiaries, and environmental attributes in a structured, transparent, repeatable process.



www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs-scoping-tool



NESCS Plus

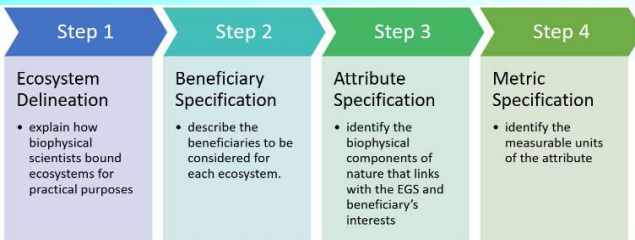
A classification system for Final Ecosystem Goods and Services (FEGS), which serves as a framework for

analyzing how changes to ecosystems impact human welfare. NESCS Plus also serves as a tool for organizing and connecting different ecosystem services research efforts and related projects.

www.epa.gov/eco-research/nescs-plus

FEGS Metric Report

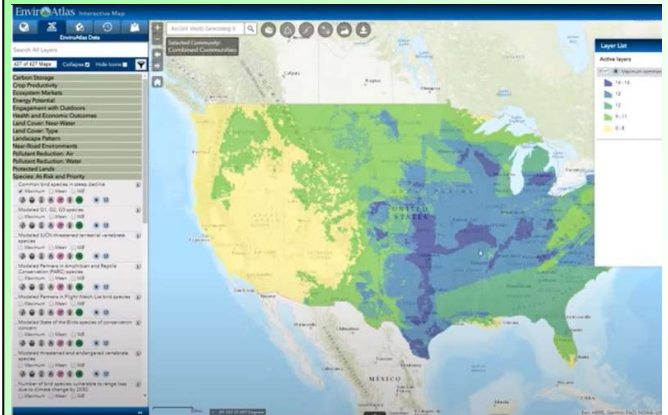
The “Metrics for National and Regional Assessment of Aquatic, Marine, and Terrestrial Final Ecosystem Goods and Services” report is designed to provide environmental professionals with the background and methods necessary to integrate FEGS metrics into environmental assessment and planning.



www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs-metrics-report

EnviroAtlas

EnviroAtlas is an interactive web-based tool that states, communities, and citizens can use to help inform policy and planning decisions that impact the places where people live, learn, work and play.



www.epa.gov/enviroatlas

Timothy G. O'Higgins
Manuel Lago
Theodore H. DeWitt Editors

Ecosystem-Based Management, Ecosystem Services and Aquatic Biodiversity

Theory, Tools and Applications

Springer Open

Ecosystem-Based Management

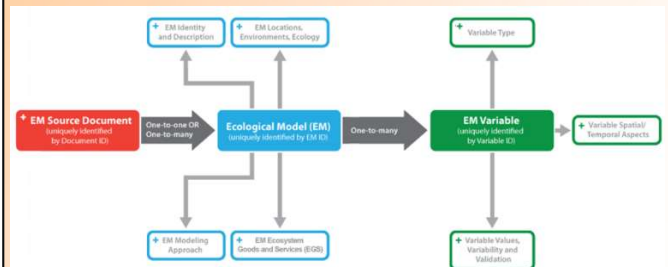
This book brings together cutting-edge insights into ecosystem-based management from the United States and Europe, and includes practical

examples of incorporating ecosystem services into decision-making, focusing on aquatic environments.

<https://link.springer.com/book/10.1007/978-3-030-45843-0>

EcoService Models Library

The EcoService Models Library (ESML) is an online database for finding, examining, and comparing ecological models that may be useful for quantifying ecosystem goods and services.



<https://esml.epa.gov>

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ABSTRACT COMPILATION

Abstracts are listed in alphabetical order by **presenter's last name**.

CONSUMER-DRIVEN MARKETS FOR ECOSYSTEM SERVICES FROM AGRICULTURE IN URBANIZING LANDSCAPES

David Ablor

Department of Agricultural Economics, Sociology, and Education, Penn State University, University Park, PA, USA

This presentation examines the viability and potential effectiveness of consumer-driven markets for ecosystem services from agriculture in urbanizing landscapes. These are markets where consumers pay a price premium for ecosystem-friendly food products in which the products are produced in a way that generates more ecosystem services than conventional farming practices. Urbanizing landscapes refer to the types of agriculture found in suburban and exurban areas, where farms are interspersed with housing, retail, and other urban land uses. These farms tend to be smaller and more diverse in what they produce than farms in rural areas of the US. Three issues impacting the viability and effectiveness of consumer-driven markets for ecosystem services from agriculture in urbanizing landscapes will be examined: (1) How much consumers are willing to pay for ecosystem-friendly food products, and how to effectively communicate these product characteristics to consumers. (2) The extent to which the value attached by consumers to ecosystem-friendly food products would make its way back through supply chains to the farms that produce these products. (3) Whether agricultural production practices that generate ecosystem services have economies of scale favoring large farms and disfavoring the smaller farms in urbanizing landscapes. At this stage of the research, a literature review on these three issues. (1) Willingness to pay for ecosystem services is generally low but rise when the issues are ones that consumers can see such as water quality in local streams. Communicating the ecosystem-friendly nature of a food product would be challenging given the many existing food marketing claims and labels. (2) Retail-farm price relationships in food supply chains are context-specific, making it hard to draw conclusions about how much of the value attached by consumers to ecosystem-friendly food products would make its way back to farms. (3) Capital-intensive practices that enhance ecosystem services have economies of scale favoring large farms, but an open question is whether scale economies extend to other practices. Consumer-driven markets have attracted attention as an alternative to government subsidies or regulations for increasing ecosystem services from agriculture. However, there are fundamental questions about viability and effectiveness requiring additional market development research.

EMISSION REDUCTIONS PROGRAM FOR ADDRESSING DRIVERS OF DEFORESTATION AND FOREST DEGRADATION: AN INSIGHT FROM THE TERAI ARC LANDSCAPE IN SOUTHERN NEPAL

Shankar Adhikari¹, and Himlal Baral²

¹ REDD Implementation Centre, Ministry of Forests and Environment, Kathmandu, Nepal

² Centre for International Forestry Research, Jalan CIFOR, Bogor Barat, Indonesia.

As part of the REDD+ program, for the past decade, Nepal has been working with the World Bank's Forest Carbon Partnership Facility on its Emission Reductions Program (ER-Program). The ER-Program was designed for a program area covering 13 districts in the Terai Arc Landscape. Approved in 2018, the Emission Reductions Program Document (ERPD) identified six major drivers of deforestation and forest degradation in the program area: unsustainable and illegal harvesting of timber and fuelwood; overgrazing; forest fires; encroachment and conversion of forest land for other land uses; resettlement; and infrastructure development. The ER-Program aims to address these drivers and help the conservation and enhancement of existing forest carbon stock through the sustainable management of forest resources. To do so, seven program interventions have been designed, ranging from localized and improved community-based forest management, through private sector engagement in the forestry sector and alternative energy promotion, to integrated land-use planning. The February 2021 Emission Reductions Payment Agreement (ERPA) between the Government of Nepal and the World Bank has paved the way for official implementation of these interventions on the ground. These interventions unlock the potentiality of up to USD 45 million in results-based payments for emission reductions of up to nine million tons of carbon dioxide equivalent by 2025. Accordingly, the ER-Program is expected to address the drivers of emissions-causing deforestation and forest degradation and enhance forest carbon stock, ultimately paving the way for results-based payments for future emissions reductions.

APPLICATION OF THE RATIO METHOD IN ALTERNATIVE SPECIFIC RESERVOIR RECREATION VISITATION ESTIMATION

Mustapha Alhassan

U.S. Bureau of Reclamation, Technical Service Center, Denver, CO, USA

To efficiently manage a reservoir for risk reduction or enhancement of its intended beneficial purposes, resource planners—including government agencies—may modify reservoir operations (i.e., reservoir re-operation). Reservoir re-operation changes reservoir water levels and downstream river flows compared to baseline (No Action) conditions. In addition to its primary objectives, a reservoir re-operation can have potentially significant impacts on reservoir and downstream recreation visitation and quality of experience. Understanding the relationship between fluctuating water levels and recreation visitation has important implications for facility managers, who must forecast recreation facility requirements, plan for facility modifications (e.g., expansion or contraction), and schedule facility maintenance. Modeling this relationship is also important for economists, who use visitation estimates as a primary input for the recreation economic analyses. This study focuses on the application of the ratio method to estimate visitation and recreation benefits of a reservoir under different reservoir re-operation alternatives. The study assumes that reservoir surface area positively correlates with visitation. Assuming a constant net consumer surplus per visitor day, the value of recreation for re-operation alternatives can be estimated based on visitation estimates. The main finding is that for a geographic location where the value per visitor day is fixed, benefits of reservoir recreation largely depend on the change in surface area between the proposed Action and No Action alternatives.

CAPITALIZING ON THE MYCORRHIZAL RELATIONSHIPS OF TREE SEEDLINGS TO ENHANCE RESTORATION SUCCESS IN CHANGING CLIMATES

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Ambitious reforestation targets to combat climate change will require expansion and optimization of the reforestation pipeline. Successful transplantation of nursery grown seedlings is a key bottleneck in this pipeline. While the impact of seed sourcing is well documented, less is known about how the nursery environment itself can prepare seedlings for success or failure in particular conditions after transplanting. Nursery conditions may increase transplanted success by recruitment of locally adapted microbial associations, especially root symbiotic fungi. Mycorrhizal fungi are key mediators of tree tolerance to abiotic conditions, such as nutrient or drought stress. Mycorrhizal associations developed during nursery production may have unintentional effects on restoration success. While underexplored, nursery seedlings are known to develop diverse fungal associations, which can have consequences for out planting success. Here we assess the effect of nursery management and location on rhizosphere microbial communities on bare-root seedling stock for a diversity of species. To assess whether bare-root seedlings bring different fungal communities to planting sites, we obtained seedlings from four public bare root nurseries (one each in IA, MO, IL, and WI), as well as a private nursery in northern IL. We obtained 2-5 species from each nursery, including a mix of softwood and hardwood species, and species that associate with both arbuscular and ectomycorrhizal fungi. We characterized the fungal communities on seedling roots using the ITS2 gene. The sequences were clustered into exact sequence variations and identified to species level. We used the FungalTraits database to assign fungal species to ecological guilds (AM and EM). A permutation MANOVA tested whether fungal community composition differed by nursery, while controlling for seedling genus. Soil fungal communities differed strongly between softwood (conifers) versus hardwoods (Angiosperms), but within these tree groups nursery location had the strongest control over fungal communities. There were fungal differences at ecological guilds within nurseries. We are currently assessing survival and growth of transplanted seedlings in ambient and droughted conditions in central Illinois. Documenting fungal associates of bare root seedlings of nurseries across the Midwest leads to assessment of tree-fungal interactions in nursery management practices for transplant success.

MOTIVATING SMARTGRID ADOPTION IN CHICAGO

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Decarbonizing the energy grid is an urgent priority for the state of Illinois, utility providers, and people everywhere to preserve the climate-regulating ecosystem services of our atmosphere. But the actions needed to accomplish this involve more than science, more than policies, more than regulation, and more than utility direction, they involve community education, involvement, and an interactive partnership with utilities if the massive transition is to occur.

On the forefront of thinking about the energy transition is the ComEd program called Community of the Future. The goal of the program is for pilot communities to serve as learning centers where Smart technologies and other decarbonization strategies can be modified and adjusted to complement each other. Without these centers, climate change mitigation will be much delayed and additional ecosystem services will be lost.

This talk will review the Community of the Future program and holistic outcomes, highlighting how the ecosystem services of decarbonization will come only hand in hand with the other community benefits. A logic model and metrics for the program will be shared.

SOCIAL VALUE DISTRIBUTIONS USING SOLVES FOR MULTIPLE USER GROUPS SURVEYED IN A COASTAL NATIONAL PARK

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Managing public lands to maximize societal benefits requires spatially explicit understanding of societal valuation, and public participation geographic information systems (PPGIS) are increasingly used in coastal settings to accomplish this task. Social Values for Ecosystem Services (SolVES), a PPGIS tool that systematizes the mapping and modeling of social values and cultural ecosystem services, is promising for use in coastal settings but has seen relatively limited applications relative to other PPGIS approaches; it has also, to our knowledge, not yet been applied in a barrier island setting. In this study, we surveyed two visitor groups and residents living near Cape Lookout National Seashore (North Carolina, USA) to understand their social values in the context of the park's management needs. We developed social-value models to evaluate differences between three user groups (fall visitors, summer visitors, and residents) and to evaluate how respondents' experiences, attitudes, and recreational activities influence the locations they value and their most strongly held value types, which included aesthetic, recreation, biodiversity, future, therapeutic, and historic values. We found that accessibility, user types and the seasonality of major recreational activities, and the linear configuration of the barrier island system at Cape Lookout are important influences on the social values held by visitors and residents. The modeling results provide information relevant to management at Cape Lookout and can inform the design of future PPGIS studies in coastal and marine settings.

CIRCULAR GRASS BUFFERS FOR SUSTAINABILITY OF CENTER-PIVOT IRRIGATED AGRICULTURE FACING TRANSITION TO DRYLAND: RESPONSE OF SOIL ORGANIC MATTER AND NUTRIENTS

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Depleting soil health and declining water table in the Ogallala aquifer, the primary source of water for irrigated crop production, have threatened the sustainability of agriculture in the US High Plains region, primarily in the Southern High Plains. Grass buffers could provide multiple ecosystem services to irrigated cropping systems, including erosion control, soil carbon sequestration, and soil health improvements. However, the soil health impacts of circular grass buffer strips in center-pivot irrigated agriculture are not documented well. This study aimed to evaluate soil organic matter (SOM), nutrients, and other selected soil health indicators under circular buffer strip grass (BSG), adjacent buffer strip corn (BSC), and continuous conventional corn (CCC) in the 0-80 cm soil profile. Five circular perennial grass strips were established, alternating with five corn strips in a 3.88 ha quarter-circle area under a center pivot irrigation system in fall 2016. Soil samples were collected from the center of corn and grass strips for five years (2017–2021) and analyzed for inorganic N, soil pH, electrical conductivity (EC), cation exchange capacity (CEC), SOM, and soil nutrients. The CCC had 1.6 and 1.96 times higher inorganic N than BSC in 0–20 and 60–80 cm. The inorganic N was significantly lower under BSG than other treatments in 0–20 cm, 20–40, and 40–60 cm depths, while SOM storage was not different among treatments. Despite no irrigation and limited fertilizer application, BSG maintained SOM comparable to BSC and CCC. At 0–20 cm, soil pH was 0.1 and 0.2 units lower in CCC than in BSC and BSG. Soil EC was 37.5 and 33% greater in CCC than BSG in 0–20 and 20–40 cm depths. Available P at 40–60 cm was significantly greater in CCC than in other treatments. Soil Ca, Mg, and K did not differ among treatments. A long-term comprehensive study will help in accurately estimating grass buffer impacts on soil health, this study provides an insight into the SOM dynamics and differences in soil health indicators among the cropping systems.

CIRCULAR BUFFERS STRIPS OF PERENNIAL GRASSES TO IMPROVE MULTIPLE ECOSYSTEM SERVICES IN CENTER PIVOT IRRIGATED AGRICULTURE IN THE SOUTHERN GREAT PLAINS

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Ogallala aquifer has converted southern Great Plains (SGP), known for 1930's dust bowl, in to one of the highly productive irrigated agriculture regions of the country. However, declining Ogallala and increasing climate extremes are threatening sustainability of agriculture. Using current partial pivots (part irrigated) as an opportunity, we developed a concept of 'Circular Buffer Strip (CBS)', where dryland portion is rearranged into circles of buffer strips of native cool and warm season perennial grass mixtures alternating with crop strips to enhance multiple ecosystem services and improve climate resiliency. Potential benefits include 1. Improve water cycle and water use efficiency (efficient capture of heavy intensity, offseason precipitation and reduce evaporative and runoff losses) 2. Improve productivity (reduce stress, improve microclimate) 3. Protect soil and crop (reduce wind, soil abrasion injury) 4. Increase biodiversity (microbial, arthropod, plant, wildlife, pollinators) 5. Improve carbon sequestration (deeper root, longer growing season, and higher NPP) 6. Climate resiliency (reduce greenhouse gas emissions, reduce input use) 7. Improve resource use and resource use efficiency (circular rings trap agrochemicals, water and soil moving in any direction) 8. Better quality of life (reduced pollution, improved air quality, diverse wildlife, reduce pesticide use) 9. Practical benefits to producers (well pressure, pivot maintenance). A long term, landscape study is conducted from 2016 with NIFA funding to assess temporal and spatial distribution of benefits from single and multiple buffers. CBS improved crop microclimate during early in the growing season. CBS was effective in wind moderation early in the growing season, especially when wind was perpendicular to strips (in circular design they are always) and reduced wind speed by 62% and 58% in 2019 and 2020, respectively. Soil moisture at 5 cm depth was up to 26% higher. The system was more efficient in conserving large rainfall events (\approx 50mm). This improved water extraction from the soil profile, reduced water stress and improved biomass production in CBS corn around storm events. Improved water conservation and efficient use improved corn yield by 10 to 15% and benefits extended to 72 m from outer edge. As a result, corn water use efficiency in CBS was 18% higher than CT over two years. Soil health, greenhouse gas emission, insect and bird biodiversity were also benefited from CBS.

NATIVE PERENNIAL GRASSES AS CIRCULAR BUFFER STRIPS IMPROVES WATER DYNAMICS OF CENTER PIVOT IRRIGATED PRODUCTION SYSTEMS

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Future of center pivot irrigated production in the Southern High Plains looks uncertain due to rapid declining of Ogallala Aquifer (OA) and its effect on degrading of multiple ecosystem services. This is evident from increasing number of partial pivots wherein farmers are forced to keep a portion of pivot circle under dryland production due to decreasing irrigation capacities. Mitigating unwanted water removal from the system can help improve efficiency of water cycle and sustain irrigated production in the region. Innovative Circular Grass Buffer Strips (CBS) system proposes a landscape modification of partial pivots by rearranging dryland portion as multiple circular buffer strips of native perennial grasses placed alternately with strips of irrigated portion. The overall goal is to improve ecosystem services while sustaining intensive irrigated production. Improved water dynamics of the center pivot is one of many potential benefits that CBS can provide. Two-year study was conducted at NMSU Ag Science Center, Clovis NM to look at surface wind speeds, soil moisture dynamics, and conservation of two intense rainfall events with and without grass buffer strips. Experimental field included two quarter sections of two adjacent center pivots of the science center. At one pivot, 5 perennial grass strips of 30ft width using 7 grass species mixture were established alternating with 60ft wide annual crop strips, while the other with no strips was control (CT). Compared to CT, irrigated crop strip of CBS experienced 11 and 28% lower wind speeds at soil surface during first six weeks of corn growing period when wind stress is maximum in 2019 and 2020, respectively. Overall, surface soil moisture in CBS corn was 7 and 9% higher than CT during two respective years. Further, after an irrigation event, a steeper slope and lower area under the hourly-soil moisture curve was observed in CT than CBS. With perennial grass strips, conservation of two heavy and intense rainfalls in irrigated corn strip was increased by 138 and 91% as compared to CT. Results indicates that strategically designed CBS system is effectively utilizing native vegetation to improve water cycle of the center pivots by reducing evaporation loss of irrigation water and rainwater runoff. With declining OA threatening the future of irrigated agricultural, the unique CBS can sustain rural agricultural economy of the region while providing several ecosystem services which comes with perennial systems.

ASSESSING THE VALUE OF THE ATEWA FOREST

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The Atewa Range is a strip of unique upland forest surrounded by a mixture of farms, small scale gold mines and villages in the eastern region of Ghana. The forest functions as the source of three important rivers which are the crucial source of water to more than five (5) million Ghanaians and habitat for endemic fauna and flora species. The Atewa Range supports several communities who live on the fringes, as well as being home to a large diversity of plants and animals. The forest also provides important climate amelioration services. A section of the forest is protected as the Atewa Range Forest Reserve and recognized as a Global Significant Biodiversity Area (GSBA). Despite this status, the forest both inside and outside the Forest Reserve are under threat of degradation from illegal timber and non-timber harvesting, farm encroachment and small-scale gold mines. The potential of bauxite mining by government in the future is even a bigger threat. This is affecting water flows and water quality and those dependent on water downstream in the three river basins, including businesses, the households of over 1 million people in Accra, as well as local communities and farmers that live around the Forest Reserve. To understand how changes in the Atewa Range may affect the future of key forest functions for both upstream and downstream groups, in particular risks to the quantity and quality of water supply in the river basins, an ecosystem valuation study was commissioned. This study aimed to demonstrate the costs and benefits in economic terms of current developments in the Atewa Range compared to potential alternatives and support the Government of Ghana in deciding what the most optimal and sustainable management regime is for the Atewa Range. The study followed the framework set out in the internationally recognized UN Economics of Ecosystems and Biodiversity (TEEB) initiative. The study demonstrates the costs and benefits in economic terms of current developments in the Atewa Range compared to potential alternatives and support the Government of Ghana in deciding what the most optimal and sustainable management regime is for Atewa Range. This study investigated the effect of four different land use scenarios in the Atewa Range by assessing changes in the value of ecosystem services. The result of an extended cost-benefit analysis indicates that increasing protection in the existing Forest Reserve and managing a buffer zone around it more sustainably would yield the highest benefit for the people that depend on the Atewa Forest and the Rivers. Although the Forest Reserve is officially protected, this status is not enough to generate sufficient funds for effective management. To increase the level of protection, it is recommended that the status of the Forest Reserve be updated to that of a National Park. This will ensure a more stringent management objectives for the current reserve area and an effective step towards the conservation of Atewa's ecosystem services.

TAPPING INTO THE URBAN AFFORESTATION BENEFITS OF MICRO FORESTS

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Purpose: Many rapidly urbanizing communities recognize the importance of preserving and expanding tree canopy. However, balancing competing priorities between providing greenspace with land development demands and continues to be a challenge. Micro forests can provide a feasible solution to this challenge by providing the ecosystem benefits of tree canopy expansion, on relatively small parcels of greenspace. Micro forests are a bio-diverse group of densely planted native trees, based on the Miyawaki Method, and the World Economic Forum estimates that planting micro forests can increase the worldwide capacity of communities to sequester up to 10 gigatons of carbon by the year 2050. The UF/IFAS Extension *Treejuvenation™ Florida* urban forestry program partnered with a local veterans' community volunteer group, to promote the ecosystem benefits of increased tree canopy, using a micro forest project. The SURF micro forest was established with 250 trees on a strip of land approximately 14,000 sq. ft., in a local park. To promote support for the micro forest, and encourage similar efforts in other locations, UF/IFAS Extension organized a Tree-Trail-Tour urban forestry community engagement event, to educate visitors on the specific ecosystem benefits of each tree. Participants on the SURF micro-forest Tree-Trail-Tour, indicated an increase in knowledge about ecosystem benefits of urban trees, and the contribution of micro-forests to mitigating climate change, and efforts are underway to install micro forests in additional locations. Installing micro forests is a feasible solution to addressing the challenge of balancing urban communities' needs for ecosystem benefits of increased tree canopy, with limited land availability. Using micro forests as urban forestry Extension demonstration sites, can promote awareness of the benefits of urban trees, as well as increase support for the contribution of urban afforestation efforts to climate change mitigation.

UNDERSTANDING THE ROLE OF FRESHWATER MINERAL WETLANDS IN CARBON CYCLING IN THE PRAIRIE POTHOLE REGION CANADA

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Recent estimates of Natural Climate Solutions (NCS) in Canada suggest that wetlands can play an important role in helping Canada meet its commitments under the Paris accord. However, there is substantial uncertainty associated with these estimates which make it challenging for governments to incorporate wetlands as NCS. The growing interest to use wetland management and restoration as a NCS, requires improved estimates of wetland carbon (C) sequestration and greenhouse gas (GHG) exchange across wetland types. Our research focused on small, isolated wetlands in the Prairie Pothole Region (PPR) of Canada since these are among the most threatened ecosystems in Canada, despite their important role in C cycling, climate regulation, water quality and quantity regulation, and biodiversity. Our research used a combination of Eddy covariance flux towers (intensive) and dissolved gas measurements (extensive) to examine differences in GHG emission and carbon sequestration and their drivers. Flux towers were installed at two isolated wetlands embedded in grasslands and cropland ecosystems in the PPR of southwestern Manitoba. Dissolved gas sampling was conducted at a series of 48 wetlands spread out across the Prairie Parkland region of Canada (AB, SK, and MB) with wetland sites embedded in perennial cover or cropland. We will present findings from our first two years of monitoring including results from the first deployment of Eddy covariance systems on prairie pothole wetlands. Lastly, we will discuss implications of our results for designing better wetland management programs with the goal of enhancing their ability to deliver NCS.

INTEROPERABILITY FOR ECOSYSTEM SERVICES: THE PROBLEM, SOLUTIONS, AND PATHS FORWARD

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Interoperability is the ability of independently produced data and models to seamlessly work together with minimal effort and is one of the key tenets espoused by the FAIR Principles for modern open science: that science be Findable, Accessible, Interoperable, and Reusable. Interoperable ecosystem services data and models offer the promise of faster, cheaper, and higher-quality assessments that systematically reuse preexisting science rather than continually reinventing the wheel. Interoperability is also critical to large-scale approaches like natural capital accounting, which relies on highly heterogeneous data that must be repeatedly used to generate long-term time series ecosystem service accounts. Yet despite a decade of advances in open science, interoperability is still relatively poorly understood by most ecosystem services scientists, and widespread achievement of interoperability in our field remains stalled. This presentation will briefly introduce the concept of interoperability and why it matters to scientists and practitioners in the field of ecosystem services. It will then cover solutions to the interoperability problem, drawing primarily from fifteen years of work on the Artificial Intelligence for Environment and Sustainability (ARIES) Project, which is making data and models interoperable for ecosystem services and natural capital accounting, as well as recent experiences with making U.S. data and models interoperable. These opportunities and challenges can collectively illustrate a path forward to more widespread use of interoperable data and models in the ecosystem services community in the U.S. and beyond.

LESSONS LEARNED AND PATHS FORWARD FROM FIRST-GENERATION SEEA EA PILOTS IN THE U.S.

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In 2016, the development of pilot natural capital accounts for the U.S. began and was based on the international System of Environmental-Economic Accounting (SEEA). Since then, a group of scientists from various U.S. government agencies, academics, and other collaborators built a set of pilots SEEA accounts for land, water, and ecosystems. More recently in April 2022, the Office of Science and Technology Policy announced its intent to develop a natural capital accounting strategy for the U.S., with formal development of a full set of accounts over the next ten to fifteen years, which lends further momentum to the previously experimental U.S. natural capital accounting work. This presentation will introduce the U.S. natural capital accounting effort in the context of SEEA, discuss key lessons learned to date, and describe ongoing efforts with more comprehensive ecosystem accounts for urban systems and crop pollination.

FIELD DATA COLLECTION FOR LAND CONSERVATION

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A Baseline Documentation Report (BDR) examines and documents the natural and known cultural resources of a land tract. The combination of text, photos, and maps within document and reference the specific property conditions and features from desktop reviews and on-foot visits. The purpose of the report is to document the conservation values, non-financial, and current conditions of the conservation easement property. With only minor modifications, routine baseline surveys could provide scientifically valuable information on biodiversity in a form that would help the United States more effectively protect its biodiversity. Properties under consideration for conservation easements vary enormously in size, remoteness, access, habitat character and quality, and the species present. It would be foolish to dictate a rigid protocol to be followed identically on different properties. However, a menu of best practices could make data from easement surveys a valuable conservation resource. We propose the following best-practice guidelines: Identify the spatial boundaries of the easement and estimate the percent of the area in different major habitat types within those boundaries. For any taxonomic group being surveyed, describe the survey method and, most importantly, quantify the sampling effort (time spent observing, length of plant transects walked and sampled, number of stream seine hauls, etc.). Examine (and ideally plot) the cumulative number of species observed as the sampling effort increases. To the extent possible, sample in multiple seasons to detect species that vary in their seasonal activities. Employ targeted sampling for species of high conservation value that might reasonably be expected on the parcel. Summarize for each easement property high priority conservation assets defined as all federally listed species, and all species with conservation status S1, S2, or S3 according to NatureServe. Lastly, lessons learned from the field data collection efforts leading to these recommendations will be discussed.

ADAPTIVE MANAGEMENT OF REGULATED RIVERS: ELICITING INDIGENOUS KNOWLEDGE AND PERSPECTIVES TO INFORM MONITORING AND RESEARCH

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Adaptive management (AM) reduces uncertainty in the dynamics of social and ecological systems with the goal of improving resource conditions and management. The Glen Canyon Dam Adaptive Management Program is a long-standing program that implements AM through monitoring and research of the Colorado River ecosystem below Glen Canyon Dam. The objective of the program is to make science-based recommendations to the Secretary of the Interior concerning how to operate Glen Canyon Dam in a manner that benefits and sustains the downstream environment and its sociocultural values. Five Native American tribal stakeholders participate in the program. A longstanding challenge within the program has been how to incorporate cultural benefits of tribal stakeholders into an AM decision-framework. We propose that ongoing dialogue within the program that is grounded in an Opportunities Framework for improved consideration of cultural benefits of ecosystem service offers one approach for systematically identifying opportunities to improve integration of cultural benefits. A key element of the Opportunities Framework is that it requires a critical assessment of existing decision-frameworks. We illustrate this approach for the integration of cultural benefits into AM using elements of a mathematical dynamic programming model focused on invasive and native fish management. Our results indicate that critical review of existing decision-frameworks and explicit approaches to incorporate cultural benefits are crucial steps. However, based on our experience, we caution that successful integration of cultural benefits in AM requires institutional support and capacity.

CLIMATE CHANGE, FOREST COMPOSITION, AND OUTDOOR RECREATION IN NORTHEASTERN MINNESOTA

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Climate change will flip the boreal-temperate forests of northern Minnesota to temperate-grassland by the end of the century, affecting outdoor recreation, a valuable ecosystem service, and a key economic driver for the state, at 69% (national average: 54%) participation and over \$3 billion in annual expenditures in hunting, fishing, and wildlife watching. Yet, the links between climate change, forest composition, and recreation have not received due attention. Outdoor recreation includes hunting, which affects deer, which in turn can affect the links between climate change and forest composition through latent effects like herbivory. In this thesis we examine and evaluate the links between four main variables: climate change, forest composition, deer, and outdoor recreation, and a variety of other relevant predictors, using a combination of econometric models including generalized mixed models (glm) and structural equation models (sem), to region-specific data in the Laurentian mixed forest province (lmf) of northern Minnesota. We find a strong empirical relationship between forest composition and outdoor recreation in the presence of climate and deer, which could affect several outdoor recreation categories in future. Our results improve understanding of these complex relationships to better inform Minnesota's climate adaptation strategies and contribute to the valuation literature on cultural ecosystem services.

IMPROVING NITROGEN-FIXING POTENTIAL OF ENDOPHYTE BACTERIA

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Nitrogen is a key nutrient for the optimal growth of crops. Most of the nitrogen that supports modern agricultural production is derived from industrially generated fertilizers through the Haber Bosch process. Microbes capable of fixing atmospheric nitrogen through the enzyme nitrogenase are responsible for much of the remaining crop. *Gluconacetobacter diazotrophicus* is a model nitrogen-fixing (diazotroph) that is commonly found in association with sugarcane. Our research project aims to understand the factors that govern successful initiation and maintenance of the endophyte relationship between the model bacterium *G. diazotrophicus* and important crop model plants. We are studying the interactions between *G. diazotrophicus* and wheat, tomato, and pennycress. Studies are underway that should illuminate the genes that enable this endophyte relationship through the application of saturated transposon library sequencing (Tn-Seq) of a mutant library grown in the presence of these model plants. Additionally, we have undertaken efforts to increase the amounts of ammonium provided by these endophyte bacteria to the plant host. We have successfully increased the amounts of biologically available nitrogen provided by *G. diazotrophicus* through simple manipulations of the genome, which demonstrate a key success on one of the two primary pillars of our research goals. We anticipate publishing these results soon and testing the potential to improve the growth of model crops in the laboratory by the end of our funding cycle. These results demonstrate the potential of enhancing the biological nitrogen fixation potential of *G. diazotrophicus*.

ECOSYSTEM SERVICES REQUIRE A BIOPHYSICAL ECONOMIC CONTEXT

Steven M. Bartell

Stantec, Inc.

This presentation will explore the incorporation of ecosystem services (ES) in developing a biophysical economy as an alternative to the mainstream continuous growth economic paradigm. The proposed economic structure and function focuses on the US economy. However, the fundamental approach appears portable to other countries. The basic premise of this study is that ES can provide useful metrics in support of sustainable development and corporate environment, social, and governance (ESG) reporting. ES measured and managed in the form of “stocks” of natural resources (e.g., fish, lumber) are routinely monitored by government agencies. The resulting data can be readily incorporated into sustainable development programs and corporate ESG assessments. ES “flows” or regulating services (e.g., hydrologic flows, soil formation, nutrient cycling) are more challenging to monitor, but can provide leading indicators for the efficient management and assessment of human and natural systems in relation to economic and ecological sustainability. This presentation will crosswalk the use of selected stock and flow ES as natural capital accounts in support of ESG assessment and reporting by manufacturing and service-oriented corporations. A key finding of this work is the recognition that improved performance in the management of ES in relation to sustainable development relies mainly on efficiency gains that are limited at least by thermodynamics. Feeding efficiency gains into an economic system that requires continuous growth might buy time, but it won’t guarantee sustainability. In the end, growth will swamp gains in efficiency and the resulting corporate and societal environmental footprints can exceed those prior to increases in efficiency in managing stocks and flows as natural capital accounts in ESG assessments and reporting. Replacing the current mainstream neoclassical economic paradigm with one more closely aligned with the principles of biophysical economics appears as a practical solution to a developing a flourishing economy and sustainably inhabiting the planet. The presentation concludes with a recommended structure and function of a biophysical economy derived from modification of existing economic institutions, policies, and practices in the US. Follow-on work will explore mechanisms for global scaling of a biophysical economy through the modification and application of integrated world-wide ecological and socio-economic models.

VOLUNTEER ACTION TO RESTORE ECOSYSTEM SERVICES IN URBAN LAKES: 15 YEARS OF RESTORATION OF CRESCENT LAKE, ST. PETERSBURG FL

James Bays

Stewards of Our Urban Lakes, Inc., St. Petersburg, FL, USA

To restore or enhance ecosystem services provided by urban water bodies, the level of service achievable through institutional actions by city or regional water management agencies constrained by budget and mission may fall below the need or potential. To address this potential, volunteers frequently are organized to implement planting projects, clean up debris, perform monitoring and engage and educate the public. This paper summarizes the history, activity and findings of a community-based volunteer group organized to improve Crescent Lake in St. Petersburg, FL. Beginning in 2007, the Friends of Crescent Lake has played a defining role in the transformation of the littoral zone of 21-acre Crescent Lake from a sparsely vegetated lawn-edged shoreline to a diverse and productive emergent wetland. The lake receives stormwater from a 394-acre residential and commercial watershed and water levels are controlled passively by a fixed overflow weir and discharges by storm sewer to Tampa Bay, where the flow is a freshwater source to manatees. Two planted marshes, each at one end of the north-south oriented lake, have grown through natural colonization and now provide e 1.5 acres of habitat for wetland birds, reptiles and amphibians, as well passive nutrient transformation and sequestration. Now an eBird “hotspot”, the lake hosts 148 species of birds, whose diversity and abundance has increased in direct proportion with vegetative cover. Volunteers routinely remove invasive vegetation and assist with installation of native marsh plants. Volunteers sample monthly for analysis by the statewide Lakewatch program. Debris removal is a routine activity performed by neighborhood residents, and companies offering volunteers for community service. A total of 1,045 volunteer-hours were contributed in 2021. Attendance at monthly clean-ups typically averages 30 volunteers. Multiple factors have played a role in sustaining Crescent Lake stewardship over the years: a strong organizational core, including a community-focused chairperson and a lake scientist; safe shoreline access; support and recognition from City staff; and seed grants from national and regional agencies. These attributes are described in detail with the objective of providing a template for success for other organizations. The Friends of Crescent Lake and the actions taken can be a model for encouraging and sustaining other urban lake-user communities successfully.

MANAGING COVER CROPS TO ENHANCE SOIL ECOSYSTEM SERVICES IN SOILS VULNERABLE TO ENVIRONMENTAL PRESSURES

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Agricultural systems face many environmental challenges including droughts, flooding, and other extreme events. Such challenges have more adverse implications on highly erodible (i.e., sloping), leaching-prone (i.e., sandy), and low C soils than flat and highly fertile soils. A potential strategy to improve the health and ecosystem services of environmentally sensitive soils could be the use of cover crops (CCs). Yet, research on these soils is scant as most studies focused on flat, fine-textured, and highly fertile soils. Our presentation will discuss this. The few published studies suggest brassica and grass CCs can reduce nitrate leaching by about 70% relative to fallow in sandy soils. In addition, CCs in the U.S. showed CCs can increase soil C between 0 and 0.92 Mg C ha⁻¹ yr⁻¹, with highest rates in low C soils and after at least 5 yr. of CC adoption. Cover crops might be able to restore the lost soil C in sloping or eroded fields, which have low C saturation levels, but improvement in soil services from CCs is linked to CC biomass production. Because CCs often produce low amounts of biomass (< 2 Mg ha⁻¹), innovative CC management strategies are needed. To meet this goal, we have three on-going CC experiments (5-yr sandy site, 1-yr sandy site, and 1-yr sloping site) in the western US Corn Belt funded by USDA-NIFA. The CC management strategies include early planting of winter rye CC into standing crops and traditional post-harvest planting of CCs with early and late termination in no-till corn-soybean systems. At the 5-yr sandy site, early planting increased CC biomass from 0.37 to 0.57 Mg ha⁻¹, which reduced nitrate concentration in the 0-10 cm depth but not in deeper depths compared with post-harvest planted CC. At the 1-yr sites, CC biomass production did not exceed 0.32 Mg ha⁻¹, which resulted in limited positive effects on soils. Results suggest CCs can improve soil ecosystem services, but sufficient time and biomass are required. Early planted and late-terminated CCs can have small effects on soil ecosystem services due to low biomass production under current cropping systems in the region. Without innovative agroecosystem redesign, CCs may not improve all soil ecosystem services in environmentally sensitive soils.

DECODE 6: BRIDGING THE EDUCATION GAP IN ECOSYSTEM SERVICES MARKETS

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The proliferation of new ecosystem service markets and initiatives is creating confusion at the grower interface. There are few trusted sources of unbiased, science-based information. The sources that do exist are often regionalized, lack deep scientific and industry networks, do not include continuing education and certification programs, and are sometimes perceived as biased. Stakeholders making decisions that impact ecosystem services need excellent unbiased, scientific, easy-to-digest educational materials. Decode 6 bridges this education gap by serving as the trusted source for unbiased educational materials about carbon and ecosystem services. Built on scientific research and expert input, Decode 6 provides stakeholders with the clear, bite-sized insights they need to evaluate today's opportunities in ecosystem services practices and markets. The site is intended for audiences including certified agronomists, soil scientists, growers, land managers, policymakers, industry members, conservationists, and other non-profit organizations in the ecosystem services space. We performed in-depth interviews with key stakeholders from each segment of our intended audience prior to site development. Our conversations created a comprehensive view of the education gaps the platform must address, as well as the educational modalities we needed to use. We discovered that key stakeholders crave educational content that is bite-sized, to-the-point, and presented in multiple mediums (including videos, podcast episodes, written materials, illustrative figures, and embedded links to related research). Decode 6 also includes accessibility features baked right into the website's development. Likewise, Decode 6 includes constant consideration of diversity, equity, and inclusion (DEI) in serving the underserved populations who need excellent, freely available education. The site relies on a highly collaborative curation of a deep roster of expert sources, with new partnerships and contributors frequently invited. Building on the information we gathered during stakeholder interviews, Decode 6 will cover six key topic areas: 1) Carbon; 2) Markets & Economics; 3) Water; 4) Nutrients; 5) Biodiversity & Habitat; and 6) Climate. Decode6.org officially launches in November 2022, but we're just getting started. The Decode 6 team will continue evaluating information needs related to ecosystem services to develop excellent educational content. We rely on close collaborations with experts in the space to collate and curate this critical information. If you are a subject matter expert and interested in contributing, visit us at Decode6.org or get in touch with the project team.

COMPARING WETLAND PROJECTS BASED ON WHO BENEFITS

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Ecological conservation and restoration projects are often proposed to preserve or restore natural systems to a functional state to provide benefits to people. Increasingly, local decision makers tasked with prioritizing these projects have been asked to consider not only the ecology of ecosystem services production, but also the socioeconomics of the people receiving benefits. The value of these additional considerations is apparent, but their addition can be a significant burden, especially for initial screening exercises. Though these decisions require local-scale data and have a unique decision context, that does not mean that the approach must be locally developed, or data locally collected. We present the Rapid Benefit Indicators as a flexible and transferable approach that leverages national scale datasets and spatial frameworks to provide insights to help support these decisions consistently and transparently. The specific focus is on the use of Rapid Benefit Indicators for comparisons based on delivery of flood reduction benefits from freshwater wetlands. We will discuss the hydrologic frameworks that can be used with the Rapid Benefit Indicators approach to integrate both ecological processes and socio-demographic characteristics and describe some of the tools on the horizon to make that task more efficient. We revisit some of the datasets used with Rapid Benefit Indicators in the past such as FEMA flood maps, CDC's Social Vulnerability Index and EPA dasymetric population maps, and showcase a few new alternatives. These alternative spatial frameworks and datasets are presented to allow one to tailor the analysis to the local decision context, including how the socio-demographic characteristics of people who benefit can be considered for equity trade-offs.

SOUTHPORT SACRAMENTO RIVER LEVEE SETBACK: ADAPTIVE MANAGEMENT OF A FLOODPLAIN RESTORATION PROJECT

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Many flood control levees along rivers in the California Central Valley originated as dredged material removed from the channel following massive sedimentation associated with the 19th century gold rush. Dredge spoils were placed on natural levees and therefore eliminated most of the active floodplain. Despite various improvements, much of the flood control infrastructure remains unsound and riparian and floodplain resources (e.g., salmonid rearing habitat) are degraded. To address these issues, a major levee setback was constructed along a five-mile reach of the Sacramento River in West Sacramento in 2018, creating 140 acres of riparian and floodplain habitat. The new floodplain was about 10 ft lower than the existing floodplain, requiring excavation of about 2.1 million yd³ of material. The new floodplain design comprised hydrodynamic modeling and geomorphic interpretation to maximize ecological functions. We used the two-dimensional hydrodynamic and sediment transport model, MIKE21C, as an analytical tool for assessing floodplain inundation relative to specific ecological criteria and morphological change (erosion and sedimentation) under existing and design conditions. The resulting restoration design fell within the constraints of the overall flood protection project with special habitat features such as instream wood structures, variation in floodplain topography, and large-scale plantings to enhance salmonid rearing habitat. Inundation modeling allowed delineation of zones for riparian forest, shaded riverine aquatic, and seasonal wetland habitat. Project plans included monitoring and adaptive management. Vegetation monitoring followed standard protocols for on-the-ground visual inspection to document plant survival, cover, and health to meet regulatory requirements for mitigation. Aerial surveys provided supplemental support when delineating vegetation zones required for the post-project wetland delineation. Erosion and sedimentation were monitored using visual inspection, drone photography, and ground surveys. Monitoring revealed that the hydrologic regime following construction activated adaptive management plans. An extended period of inundation occurred during the 2018-2019 flood season causing minor localized erosion and significant localized sediment deposition. Adaptive management measures included excavating a low-flow swale that provided connection to the river after it filled with sediment during the first high flow season and adjusting the planting palette following sediment deposition / topographic change. The following two years (2019 - 2021) were very dry, which required supplemental irrigation for the planted vegetation and adjusting the delineation of the designed vegetation zones after native riparian species colonists outcompeted plantings in areas initially intended as wetlands. In hindsight, project implementation might have been more efficient if final topographic contouring and planting of the new floodplain had been delayed until after the first major high flow. This approach might have eliminated the need to develop predetermined vegetation zones, as natural recruitment could have been leveraged to produce a more sustainable plant community mosaic.

FARMLAND LOSS IN THE WESTERN UNITED STATES: IMPLICATIONS FOR ECOSYSTEM SERVICES SUPPLY AND DEMAND, AND POTENTIAL POLICY SOLUTIONS

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Every day, the U.S. loses 2,000 acres of agricultural lands to development. While it is not possible to protect all farmland from development, there is general agreement that we should try to protect high-priority agricultural lands. Agricultural and developed lands both provide a variety of benefits to humans, but how these competing land uses complement each other to provide a full suite of ecosystem services (ES) is not well-understood. Furthermore, little is known about how diverse stakeholders perceive farmland protection, which restricts our ability to design effective policy. Our research aims to fill these knowledge gaps. We present seven years of research in the Boise Metropolitan Area, Idaho, a rapidly developing agricultural landscape. We use spatial models, survey research, qualitative and semi-structured interviews, and policy analysis to measure and assess the various factors influencing farmland loss and protection. Our spatial models indicate that by 2050, 16-32% of the region's agricultural land will be developed. Furthermore, higher quality agricultural land is 15 times more likely to be developed than lower quality agricultural land. The landscape in 2050 will have a net loss in ES supply, but an increased demand for ES. Our social surveys indicate that 80% of residents are Extremely, Very, or Somewhat concerned about farmland loss. Survey respondents ranked food production as the most highly valued ES, followed by water quality, freshwater provision, recreation, and habitat for species. We found that long-term residents tend to value different ES than short-term residents, which has important political implications. We also present findings from several qualitative interviews with key stakeholders about obstacles to, and potential mechanisms for, farmland protection. Overall, our results indicate that the loss of farmland, and in particular the loss of high-quality farmland, results in a net loss in the landscape-scale supply of ES. Our social surveys demonstrate that the public is concerned about farmland loss, and that they highly value a variety of ES associated with farmland. However, our policy analysis indicates substantial barriers for action for farmland protection, therefore highlighting key areas for policy change. Our results can help guide strategic planning that considers both ecological and social factors around farmland protection.

INNOVATIVE FINANCING, MARKET-BASED AND PROJECT DELIVERY TOOLS FOR GREEN STORMWATER INFRASTRUCTURE

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The stormwater sector is nascent and evolving. Urban stormwater runoff has been referred to in the literature as an “intractable problem” and currently represents the only major source of water pollution that is increasing in many watersheds across the country. A solution to address urban runoff that is gaining momentum is green stormwater infrastructure (GSI). Being a solution using natural elements, GSI provides numerous environmental services (ES). While GSI is a growing field with significant ES value, the challenges associated with implementing and maintaining GSI has limited the scale of investments of these practices. A variety of innovative market-based, alternative project delivery, and funding and financing tools and approaches have arisen to help meet these challenges. Transaction-oriented approaches focus on trading markets used at a variety of scales, while other approaches are rooted in engaging the private sector through cost-share grants or subsidies to incentivize interested private properties to invest in GSI. Other approaches seek to drive down the costs for urban retrofits down while increasing the pace and scale of implementation through project delivery frameworks that break from the traditional design-bid-build paradigm, such as the full-delivery/mitigation model and the Community-Based Public-Private Partnership (CBP3) program approach. Still other new approaches are based solely in financing, such as the “pay for success” model which is structured to award private “impact” investors a financial return scaled with the level of “success” attained in a highly censored urban sewer shed. Lastly, highly innovative “retail-level” models that connect private property owners with GSI implementers and project investors are showing promising results in the “ground-up” paradigm of GSI implementation. Some common themes emerge when considering these new and emerging approaches. First, there is a stronger role played by the private sector, either as financier and/or as project delivering agent. Second, there is a greater amount of flexibility provided by these approaches to meet regulatory and non-regulatory requirements. Third, private properties with stormwater-focused assets are being engaged in new ways through incentives. Last, we are seeing a commoditization of stormwater infrastructure, which can help to greatly expand the overall scale and reach of treatment provided for stormwater runoff in urban and suburban areas. These market-based, funding/financing, and alternative project delivery approaches along with limitations, challenges and the potentiality of these approaches will be presented to drive discussion.

RESTORING CHESAPEAKE FORESTS FOR ECOSYSTEM SERVICES, CLIMATE RESILIENCY, AND ENVIRONMENTAL JUSTICE

Katherine Brownson

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The Chesapeake Bay watershed encompasses 64,000 acres and is the largest estuary in North America. The watershed is 60% forested; however, most of these forests are in private ownership and have been fragmented due to rapid development. The Chesapeake Bay Partnership formed in 1983 in response to declining water quality in the Bay and has long-established goals for forests, underscoring broad support for the expansion and stewardship of forests to improve water quality and other ecosystem services. Given the important role of forests in restoring this landscape, in 2012, the USFS worked with partners to produce a Chesapeake Forest Restoration Strategy (FRS), which was subsequently updated in 2020. The updated Strategy was used as the basis for the first watershed-scale Shared Stewardship agreement. The updated FRS identifies forest restoration opportunities in developed, agricultural, and forested landscapes, including strategies for reforestation, afforestation, and improving ecosystem health and function in existing forests. It also includes a new chapter on forest restoration and climate change, which addresses the role of forest restoration for climate change mitigation and adaptation, as well as strategies for climate-informed forest restoration. The FRS highlights the particular importance of targeting forest restoration efforts to historically underserved communities that may be especially vulnerable to the impacts of climate change. This presentation will describe the process and outcomes of working in partnership to identify and act upon shared forest restoration priorities. Since the FRS was updated, partners have developed several programs and initiatives designed to integrate climate resiliency and environmental justice into forest restoration, including efforts to target tree planting to historically underserved communities and to use forest buffers to cool warming water temperatures. While Chesapeake Bay partners have been working collaboratively for decades, the updated FRS and Shared Stewardship agreement provide a framework to help prioritize forest restoration activities to meet the lofty ecosystem goals of the Bay Partnership. This approach could be applied in other watersheds to improve the likelihood that forest restoration will benefit ecosystem services, climate resiliency, and environmental justice efforts.

AN ECOSYSTEM SERVICES ASSESSMENT OF THE NISQUALLY RIVER DELTA, PUGET SOUND, WASHINGTON

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Coastal land managers, for example in the National Wildlife Refuge System, manage resources to support wildlife populations and compatible uses but must also plan for changes resulting from stressors such as global sea level rise (SLR). The Nisqually River Delta (Delta) in Puget Sound supports threatened salmon fisheries, migratory birds and recreation opportunities. Delta wildlife populations and habitats are co-managed by the Nisqually Indian Tribe (Tribe) and the Billy Frank Jr. Nisqually National Wildlife Refuge (Refuge). We conducted an ecosystem services assessment of the benefits associated with management and restoration of Delta coastal habitats. Based on stakeholder priorities, we analyzed ecosystem services associated with recreational birdwatching, carbon sequestration, and fisheries. To understand what Delta features, relate to birdwatching, and using eBird data as a proxy for visitation, we evaluated the effects of season, public access, habitat features, bird species, and distance to major cities on the number of birders visiting 117 Puget Sound estuaries using generalized additive mixed models. The number of birders were greatest during winter at locations between 10-20 km from major cities. Birders increased with increasing sizes of open access, aquatic habitat, and emergent wetland, though models explained a low proportion of variation, indicating that additional factors influence birding visits. We also used a process-based soil accretion model (Coastal Wetland Equilibrium Model) combined with a habitat classification model (MOSAICS) to estimate the effects of SLR and suspended sediment on coastal habitats, soil carbon accumulation, and its economic value (Social Cost of Carbon Dioxide). After 100 years, most high salt marsh would remain with < 100 cm SLR, but substantial area would convert to transitional salt marsh and mudflat with ≥ 100 cm SLR. Total carbon accumulation plateaued or declined with ≥ 100 cm SLR, yet its economic value continued to rise over time, suggesting that the value of this service was resilient to SLR. A spatially explicit bioenergetics model indicated that prey-rich habitats such as salt marshes and eelgrass meadows were most likely to facilitate salmon growth, and that reductions in their area and accessibility due to SLR could have severe consequences for salmon. The assessment highlights factors that could be managed given SLR, and considers the multiple values associated with coastal ecosystem services.

INTEGRATED MECHANISTIC AND ECONOMIC MODELING OF ECOSYSTEM SERVICES TO INFORM LAND-USE DECISIONS UNDER UNCERTAINTY

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Management of public lands in the United States is guided by site-specific objectives that can be synergistic or competing and that affect stakeholders unequally. Furthermore, actions available to land managers affect outcomes of interest in ways that are often incompletely understood. For example, in the United States, military bases variously serve as habitat for vulnerable or endangered species, provide flood protection to nearby communities, permit hunting and fishing, and sequester carbon from the atmosphere. Military bases and diverse other types of public lands provide other socially and economically relevant services that depend on certain biophysical conditions. Base managers and other policymakers seek tools to improve their understanding of (1) how alternative land-use practices may affect the range of biophysical outcomes of interest on and off the sites they manage; and (2) the total and relative economic importance of changes to those outcomes. Here, we report on our work developing generalizable conceptual, mechanistic, and economic modeling capacity for ecosystem services in order to guide decision-making on public lands by way of two distinct case studies: Eglin Air Force Base, Florida, and Gallinas Creek, California (USA). We report on an iterative methodology that elicits conceptual models from stakeholders and subject-matter experts, synthesizes mechanistic models for biophysical outcomes of interest, and maps biophysical outcomes to economic values. We demonstrate how confidence in decision optima is increased by adopting an integrated modeling framework that tracks uncertainties that are correlated across decision alternatives. Results show that decision optima and distribution of impacts on stakeholders is sensitive to semi-subjective and frequently overlooked decision parameters such as risk tolerance, payback horizon, and economic discount rate. Primary methodological challenges include development of a generalizable modeling framework able to represent site-specific biophysical interactions (e.g., flooding dynamics). This points to the importance of “emulated” models, i.e., simplified statistical representations of biophysical models, which can more easily be tuned to site-specific conditions and evaluated probabilistically.

QUANTIFYING ECOSYSTEM SERVICES BY LAND COVER CHANGE IN THE EDISTO RIVER BASIN, SC

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In South Carolina, the Edisto River Basin (ERB) is one of the most biodiverse watersheds in the southeast US. It has one of the longest free-flowing blackwater river systems in the US and provides myriad ecosystem services (ES) due to its rich habitat, water resources, and protected areas. The purpose of this study was to identify how land use change affects ES and to quantify the ecosystem service in this region. To quantify ecosystem services in the ERB, we utilized the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model for three major ecosystem services: water yield, sediment retention, and carbon stocks. This model utilizes ecological function datasets to calculate a supply of ecosystem services in 30 meters by 30 meter pixels. Outputs were produced for seven years, between 2001 and 2016, to determine the impact of land use change on ES. The outputs provide a scale of the relative benefits for each ecosystem service. The models show that land use change to developed areas is a large driver in decreasing ecosystem services compared to forested lands and wetlands. This type of analysis is important and recommended to aid in quantification of ES for conservation programs and restoration.

ECONOMIC VALUATION IN A CHANGING CLIMATE: THE IMPLICATIONS OF WATER QUALITY INDEX PARAMETER SELECTION IN THE CONTEXT OF CLIMATE IMPACTS

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Researchers and analysts have commonly used a three-step approach to value the impacts of policy decisions on water quality: 1) model/measure the change in water quality impact, 2) map impacts to individual water quality parameters to a general water quality index (WQI), and 3) value changes to the general WQI. The choice of water quality parameters to include in the WQI can affect the baseline and policy WQI levels and therefore influence the value attributed to policy decisions. Valuing the impacts of climate change on water quality is an emerging research area. Despite interest, there has been limited research on differences in water quality valuation between an index based on climate change-sensitive water quality parameters and current WQIs using the approach described above. We develop a WQI based on water quality parameters most likely to be affected by climate change and compare it to other commonly used WQIs. We use two different climate scenarios (RCP4.5, RCP8.5) and a range of general circulation models to identify policy scenarios appropriate to compare the valuation of water quality impacts. We apply these scenarios to watersheds representing different Level I Ecoregions using the HAWQS-BenSPLASH integrated assessment model to compare how the choice of WQI affects valuation. Our findings inform the importance of parameter selection when developing climate sensitive WQIs for valuation.

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IMPROVING SOIL ECOSYSTEM HEALTH AND RESILIENCE THROUGH COVER CROPS AND PASTURE CROPPING

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Poor crop and grazing management practices have decreased soil health and reduced crop/forage yields in many parts of the Southern Great Plains. Adoption of ecologically sensitive conservation management practices can potentially provide many benefits such as enhanced carbon sequestration, soil nutrient cycling, soil stability, and watershed function. The goal of this study is to evaluate the potential soil health benefits of cover crops (CCs) and pasture cropping practices. The CC experiments have been conducted at Chillicothe, TX since 2011. The dryland experiment treatments included: 1) conventional tillage without a CC (CT-NCC); 2) no-till without a CC (NT-NCC); and NT with: 3) crimson clover; 4) Austrian field pea; 5) hairy vetch; 6) wheat, and 7) multi-species mixture CCs. The irrigated experiment treatments included: 1) CT-NCC; 2) NT-NCC; 3) NT with wheat, and 4) NT with the mixture. Measured data from these CC experiments were used to evaluate the DeNitrification DeComposition (DNDC) model. The evaluated model was used to run long-term (25 years) simulations. Results indicated that hairy-vetch, Austrian-pea, and mixed CCs produced substantially higher aboveground biomass and increased soil organic carbon and total nitrogen stocks compared to CT-NCC, NT-NCC, and other CCs. Pasture cropping integrates direct seeding of annual crops into dormant perennial grasses. Pasture cropping experiments were established at the Pittman Ranch near Muenster, TX and the Nance Ranch near Canyon, TX in 2021. Since establishment, measurements of soil properties, soil water and temperature, and vegetation characteristics have been made at regular intervals manually and using sensors and Unpiloted Aerial Vehicles (UAVs). Preliminary observations from these experiments will also be presented in this talk. Results from these experiments taking place over contrasting environmental conditions are useful to make sound recommendations on conservation management practices.

MAPPING AND ASSESSMENT OF ECOSYSTEMS AND THEIR SERVICES IN THE EUROPEAN UNION: A NATIONAL SCALE IMPLEMENTATION IN GREECE

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Mapping and Assessment of Ecosystems and their Services (MAES) reached the top of the policy agenda in the European Union (EU) and has been encapsulated into the EU Biodiversity Strategy and the EU Green Deal. In this context, an eight-year Integrated LIFE Project (LIFE-IP 4 NATURA) aiming to support (among other actions) the MAES implementation in Greece is funded by the EU; it involves twelve partners (state authorities, universities, and NGOs) and is coordinated by the Ministry of Environment and Energy. Goals of the study: (a) drafting the ecosystem type map of Greece, (b) assess ecosystems condition (EC), (c) map and assess ecosystem services (ES), (d) provide baseline data for natural capital accounting (NCA) and (e) support decision and policy making. An extensive literature review and data collection on ecosystem mapping, EC attributes and ES has been performed, while simultaneously a web-based platform has been developed for field surveys on ecosystem delineation, EC and ES assessment in data scarce regions. Literature and field-based, spatial-referenced data have been used alongside remote sensing techniques to map ecosystem types. Forestry, agriculture, recreation, and biodiversity datasets in combination with field ES data have been incorporated in the study, standardized, and processed in order to create the baseline for ES supply and/or potential supply, using the Common International Classification of Ecosystem Services (CICES). Main results refer to: (a) the development of a web-based, field survey platform to collect data for EC and ES and reporting on EC using an integrated, originally developed algorithm, (b) the first nation-wide ecosystem type map of Greece, (c) ES and ES priority maps of Greece, (d) a technical guide and baseline data to support NCA. By this, Greece is now placed among the EU Member States, with the highest score in the MAES implementation progress, and this study provides a country level case-study, on how MAES implementation is feasible even in data scarce regions. However, local (large) scale assessments are needed to capture information especially on local stakeholders' perception and needs, to guide and support decision making at sub-national level. Moreover, the present study provides tangible outcomes towards reaching sustainable development goals under the national, EU and international legal framework for nature conservation and restoration, spatial planning, integrated development, and human well-being.

UNDERSTANDING THE INTERACTION BETWEEN OFFSHORE WIND AND ECOSYSTEM SERVICES: APPLICATION OF AN ECOSYSTEM ACCOUNTING APPROACH

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Offshore wind is a key renewable energy solution to the challenge of ongoing emissions from fossil fuel-based energy infrastructure and their related climate change impacts. Multiple studies have demonstrated the potential for offshore wind turbine structures to support marine life through an “artificial reef” effect. For example, a recent study from the Block Island Wind Farm indicated increased catch per unit effort of black sea bass and cod following construction of the turbines at that location. However, further analysis is needed to understand the broader biodiversity and ecosystem service impacts of these new offshore structures, particularly as the offshore wind sector increases in scale in North America. This poster will provide a review of existing literature related to habitat change and creation and species use at offshore wind turbines in North America and Europe. It will then translate this information into a spatially explicit framework for tracking ecosystem services. This ecosystem services linkage has not yet, to our knowledge, been conducted at an offshore wind site, making this an important pilot investigation of this approach. The outcomes of this analysis will contribute to both understanding of the challenges in applying the ecosystem services framework to offshore wind and the broadening literature on corporate applications of ecosystem services analysis.

ADVANCING SCHOLARSHIP AND PRACTICE OF STAKEHOLDER ENGAGEMENT IN WORKING LANDSCAPES

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Solutions to complex agri-environmental problems require cooperation and participation of large numbers of diverse actors. Stakeholder engagement is increasingly used to achieve this. However, a growing number of funders, scientists, and stakeholders alike are asking whether and how engagement achieves beneficial change including socio-environmental outcomes. To address this gap, the project organizing team convened a series of virtual workshops that joined over 160 international researchers and practitioners for interactive activities to achieve three goals: (a) build a new diverse network of researchers and practitioners with a shared interest in improving the practice and science of engagement; (b) develop new scholarship addressing pressing knowledge gaps; and (c) co-produce a future research agenda for stakeholder engagement on working landscapes. The resulting research agenda consists of 34 research opportunities grouped into six themes: (1) Justice, Equity, Diversity, and Inclusion; (2) Ethics; (3) Research & Practice; (4) Context; (5) Process; and (6) Outcomes and Measurement. This presentation will describe the need for improving stakeholder engagement knowledge and practice, the facilitated co-production process and resulting research agenda, highlight scholarship developed through the workshops, next steps, and opportunities for participation with this growing network.

PRACTICAL STRATEGIES FOR DECISION SUPPORT BASED ON STRUCTURED DECISION MAKING AND ECOSYSTEM SERVICES

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The consideration of ecosystem services in local decision making is greatly aided by the development of a formal decisional framework. The concept of Final Ecosystem Goods and Services (FEGS) explicitly connects ecosystem services to people and this connection greatly aids the process of ecosystem service assessment. Here we present the results of a case study application of practical strategies for incorporating FEGS, and more broadly ecosystem services, into the decision-making process. The goal was to look for common elements across a suite of case studies in different regions of the country and dealing with different issues so to inform the transfer and use of these practical strategies in new communities. Whether a decision process is in early or late stages, or whether a process includes informal or formal decision analysis, there are multiple points where ecosystem services concepts can be integrated. This decisional framework is centered on Structured Decision Making (SDM) as an organizing framework to illustrate the role ecosystem services can play in a values-focused decision-process. Ecosystem services can help clarify the potential impacts of a decision based on supply and delivery of those services and help identify beneficiaries for inclusion as stakeholders in the deliberative process. Ecosystem services may directly represent stakeholder objectives or may be means toward achieving other objectives. Ecosystem services can bring to light creative alternatives for achieving other social, economic, health, or general well-being objectives. Ecosystem services assessments can inform ecological production functions (EPFs) and ecological benefits functions (EBFs) to link decision alternatives to stakeholder objectives. The decision process can consider ecosystem services objectives alongside other kinds of objectives (e.g., social, economic) that may or may not be related to ecosystem conditions. Monitoring FEGS after a decision is implemented can help determine whether the incorporation of ecosystem services leads to measurable benefits, or what levels of ecosystem function are needed for meaningful change. An evaluation of impacts on ecosystem services from past decisions can provide a learning opportunity to adapt future decisions.

WHAT IS THE VALUE OF A CORAL REEF? A LEGAL FRAMEWORK FOR VALUING MARINE ECOSYSTEM SERVICES IN COURT

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Courts are often called upon to consider the appropriate measure of damages that will adequately compensate the public for losses sustained from injuries to the marine environment. Generally, these natural resource damage assessments undervalue marine resources because they fail to consider the full suite of ecosystem services that they provide. Although ecosystem services are implicitly protected under several federal statutes, including the Clean Water Act and the Endangered Species Act, they are rarely integrated into judicial decision-making in the United States. As a result, damage assessments rarely reflect the total economic value of the resource lost. Historically, courts only considered the market value of a resource when calculating damages for injuries to natural resources. For example, in 1980 the Washington State Court of Appeals opined that the economic value of a public fishery was equivalent to the market value of the fish. In the 1989 landmark decision *State of Ohio v. U.S. Department of the Interior* the United States District Court for the District of Columbia shifted the long-held judicial approach to natural resource damage assessments in the United States. In that case, ruled that it was unreasonable to view market price as the exclusive factor when determining the value of a natural resource. The court further noted that the public should be compensated for all use values to ensure the fair and equitable distribution of resources – and that difficulty measuring those values should not be an impediment to full recovery. Despite these judicial advances, natural resource damage assessments still fall short in many jurisdictions. This presentation will consider the various methods courts across the United States have adopted to value natural resources and will propose an ecosystem services approach that better reflects environmental damages to marine ecosystems.

CULTURAL ECOSYSTEM SERVICES: INTERACTIONS OF KNOWLEDGE, GOVERNANCE, AND PAST, PRESENT, AND FUTURE CONDITIONS

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Nature's Contributions to People and Ecosystem Services (NCP/ES) consider "non-material" services, including some "cultural ecosystem services." Socio-cultural processes, interactions with nature, and associated histories, reflect and affect the value that non-material services have for given communities, often at an unconscious level. Knowledge (conscious or innate) of the services provided and perceptions of their value can come from several sources. There may be relational knowledge and values acquired through recent interpersonal interactions. Knowledge of and values for NCP/ES can also be derived from: culturally embedded knowledge acquired and transmitted through norms, traditions, and ways-of-life; and/or from place-based knowledge – the knowledge acquired by individuals and communities over time through their experiential learning within a given socio-ecological system (SES). For individuals and over shorter time periods, knowledge and value may also develop tacitly, from repeated experience. The diversity of sources of knowledge and perceived values interacts in complex ways and affects how people and communities perceive SESs – and how they perceive NCP/ES. Different groups and communities hold differing perceptions and valuations, that complement and/or confound scientific information and knowledge. This can affect the management and governance of SESs. When conflict arises, it may (or may not) resolve through adaptive governance processes, or through changes in how the community or group weights different knowledge and values. We present findings from several case studies (Lake Taupo, New Zealand; Kosterhavet National Park, Sweden; Tidal Elbe River, Germany). We posit that a greater understanding of sources of knowledge and values inherently adopted by communities and individuals is important for improving science, management, and policy associated with SESs. Narratives and emotional resonances that are associated with different groups, perspectives, and values can inform such understanding and evaluation. A more explicit consideration of the histories and development timescales of different sources of knowledge and values, and assessments of applicability to present conditions and for anticipated futures, is also critically important. We provide an elicitation framework to improve understanding of non-material services and cultural ecosystem services that includes these considerations of knowledge forms, values, and time scales.

BRINGING CULTURAL ECOSYSTEM SERVICES AND ENVIRONMENTAL JUSTICE INTO ECONOMICS FOR DECISION-MAKING

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This panel session brings together federal government and consultants who have worked with various National Oceanic and Atmospheric Administration program offices to quantify and leverage ecosystem service values. The purposes of this session are for the panel to 1) discuss the opportunities and challenges of incorporating cultural ecosystem services into economics to support decision-making frameworks; 2) discuss opportunities and challenges to embed Environmental Justice (EJ) into the ecosystem service valuation process and incorporate EJ into results; and 3) discuss approaches to fill ecosystem service valuation data gaps to support decision-making. The panel will present case studies and examples to offer insights and reveal their lessons learned from collaboration with economists, other social scientists, and non-economists. When using ecosystem service valuations to support a given decision-making framework, economists need to consider how to deal with data gaps, incorporate environmental justice (including equity, inclusion, access, and justice); and consider the best mechanism for ensuring any non-monetized cultural values are blended into a given economic framework. There are many challenges of incorporating environmental justice to support decision-making both from a process perspective and results perspective. How do we ensure multiple perspective are incorporated into valuation? How do we present the distribution of benefits? Additionally, the non-material nature of cultural ecosystem services provides a challenge to those who wish to include these services in economic assessments. Unlike many provisioning or regulating service, many cultural services do not translate into market values. The value of a cultural service can also change based on the relationship individuals and communities have with a particular place. Despite these challenges, understanding cultural ecosystem service values is an important part of sustainable management of natural environments and resources.

IDENTIFYING BARRIERS TO USE OF URBAN NATURAL AREAS AND TRAILS IN A POST-INDUSTRIAL WATERFRONT COMMUNITY

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Despite awareness that restored wetlands can provide a variety of ecosystem services to local communities, particularly those that are socially vulnerable and have poor access to the waterfront, very little is known about neighborhood access to and community use of the restored green and blue spaces. This research study uses a mixed methods approach to understand community access to and use of restored wetlands and nearby park areas through exploring the underlying barriers of use and access that are associated with safety, stigma, and connectivity. Our field study is in Duluth, Minnesota. As a result of historic industry on the western Duluth waterfront, state, federal, and tribal partners worked to restore 230 acres of coastal wetland habitat in the bays of the St. Louis River estuary known as Kingsbury Bay and Grassy Point. The goals of the restoration projects were to restore coastal wetland quality and to improve user amenities, including trails, fishing piers, and bird-watching platforms. The restoration projects were completed in October 2021. During the same period, significant progress was made to complete a new river heritage trail, named the Waabizheshikana trail, along the restoration area. To survey and count trail users in the restoration area and adjacent communities, an SMS chat bot survey and 12 infrared trail counters were deployed at 6 sites. Two consecutive summer seasons of chat bot data capture difference in user origin, users' activity while on site, and factors associated with safety, connectivity, and stigma. One full year of trail counter data is utilized for a connectivity analysis and comparison of trail use pre- and post-restoration. In addition to site surveys and counts, a review of historical local plans and policies supports a timeline of major historical events that significantly contributed to negatively associated impacts within the communities near the restoration. Recommendations informed by this research are intended to support neighborhood connectivity to green and blue space so that ecosystem services of restored urban waterways and parks will better promote community health and wellbeing of underprivileged communities.

AGROECOLOGICAL RESTORATION WITH NATIVE COVER CROPS IN HAZELNUT ORCHARDS IN THE WILLAMETTE VALLEY, OREGON

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Cover crops are effective tools for enhancing the ecological function of agricultural systems by increasing vegetation cover and supporting useful biodiversity. Oregon hazelnut orchards are typically managed with bare orchard floors, but these spaces could be used to house native Willamette Valley oak-prairie understory plants.

We examined native plant seed mixes for their potential use within existing hazelnut production systems. In a replicated, small plot experiment in commercial orchards, we compared two native cover crop mixes (one made of annual species and the other consisting of perennial species) against a domesticated cover crop mix and conventional management (no cover crop). We replicated the experiment in orchards of three different ages, with corresponding differences in canopy cover, tree architecture, and horticultural management. Cover crop programs were evaluated based on their survival in the orchards, contributions to agricultural management goals, and effects on ecosystem function.

Native cover crops generally matched or exceeded the other management treatments in terms of plant survival, agricultural management, and ecosystem function. Both native cover crop mixes emerged successfully in the first year of the study. The native perennial seed mix survived into the second year of the study without reseeding, and it also provided the greatest reduction in weed cover, offered the greatest erosion control services, and hosted the greatest pollinator diversity and abundance. Native cover crop mixes can add ecological value to hazelnut orchards and create a site for agroecological restoration in impacted working landscapes. We argue that long-term, commercial scale agroecological research is necessary for demonstration and adoption of management practices that support multiple ecosystem services in agriculture.

WHAT COUNTS? BUILDING A FRAMEWORK TO IDENTIFY CONSERVATION IN AMERICAN CONSERVATION AND STEWARDSHIP ATLAS

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Following the America the Beautiful principle to “use science as a guide”, this presentation provides insights into the construction of an evidence-based framework for the American Conservation and Stewardship Atlas. The discussion will highlight several factors that contribute to conservation success, including durability, management level, and enabling conditions presented within a policy-based framework to “to support conservation and restoration efforts across all lands and waters, including by incentivizing voluntary stewardship efforts on private lands and by supporting the efforts and visions of States and Tribal Nations.”

AMERICA’S ESTUARIES: SMALL PLACES, BIG IMPACT

Daniel Hayden

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Comprising just 4% of continental US land mass, estuary communities are home to 40% of the US population and 47% of the economy. From rural to urban communities’ healthy estuaries are at the core of local economies and job growth. New in the 2021 Report are details about the blue carbon value of estuaries and their natural infrastructure value. The presentation will outline the core contribution of estuarine communities and highlight policy areas to protect them. The analysis covers 254 US coastal counties in the continental US. Economic analysis of the contribution of continental US coastal counties make to US GNP using primarily US Census information. Additionally, six case studies detail the blue carbon and natural infrastructure value of estuaries based primarily on NOAA data, US Census Data, eco-economic modeling from the blue carbon community and econometric approaches used by the insurance community. The 2021 Report demonstrates there is some good news. We can mitigate the dire impacts of climate change by protecting and restoring our coasts. We can also recognize the increased value natural infrastructure for coastal communities and the global economy which should support conservation efforts. Since estuary regions are among the most economically dynamic in the US, investments in resilience are essential to national wellbeing. The Natural Infrastructure value of healthy, intact estuaries to attenuate storms and protect coastal properties means we need to do more to protect and restore them. The value of blue carbon has the power to increase the actual and perceived value of estuaries, and the long-term potential to leverage markets to finance protection and restoration. Protecting our ports and coastal communities is an essential part of a functioning economy. Given the powerful economic impact of estuaries there is a need for more protection and investment. First, we must ensure appropriate protection of existing wetlands. Secondly, we must invest in their restoration to ensure climate resilience, protecting property and life. Finally, the value of the blue carbon and natural infrastructure must be consistently invested and incorporated into planning decisions.

DEVELOPING AN ECOSYSTEM GOODS AND SERVICES ASSESSMENT FRAMEWORK: PRODUCTS OF US ARMY CORPS OF ENGINEERS RESEARCH

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Assessing and quantifying benefits generated from U.S. Army Corps of Engineers (USACE) water resources projects is a critical component of the USACE planning process. The nature of how benefits are modeled, measured, and quantified depends on the authority under which the project is funded. Most projects do not assess a broad suite of environmental, economic, and social benefits, but there is growing interest in addressing benefits more comprehensively. A decade of research promoted by USACE Headquarters and funded by the Ecosystem Management and Restoration Research Program (EMRRP) has addressed the role of Ecosystem Goods and Services (EGS) in USACE civil works planning, and how EGS benefits might be incorporated into project planning. The purpose of this poster is to present a synthesis of the research on how to integrate EGS assessments into the USACE planning process funded by the EMRRP.

This research took a methodical approach starting with a review of EGS literature and culminating with the publication of a proposed framework, example applications, and additional work on benefit relevant indicators. Research efforts included a review of Federal policy on EGS, a retrospective of USACE's use of EGS on large projects, and an evaluation of existing literature and tools to inform a proposed EGS analytic framework, tailored to USACE planning policy. The EGS Assessment Framework was evaluated and tested throughout its development, allowing feedback and iterative refinement of the framework prior to publication. The framework was evaluated by applying it to a number of ecosystem restoration planning projects, ecosystem management programs, and multi-purpose projects. However, the EGS Assessment Framework is designed to be general enough to have relevance for any activity in which an ecosystem is affected, and therefore EGS may be generated or altered. The framework does not address benefits from USACE projects not mediated by an ecosystem, though it could be used in concert with other tools to address comprehensive benefits.

The research took a methodical approach while adapting to a changing policy environment, and the resulting reports, decision tools and example application offer insights for future application of EGS assessment in USACE decision-making. This poster highlights the overall research approach and multiple products include links to reports and resources.

AQUATIC PROTECTED LANDS AS NON-TRADITIONAL HABITAT SOLUTION FOR NATIVE POLLINATOR POPULATIONS IN PREDOMINATELY AGRICULTURAL LANDSCAPES

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Freshwater wetlands and riparian systems provide some of the most important ecosystem services vital to the sustainability of anthropogenic society and interests. While many wetlands are found within agricultural landscapes that benefit from pollinator services, pollinator habitat and support are seldom considered as a key service provided by these wetland ecosystems. The purpose of this study is to explore the viability of protected aquatic lands as a notable provider of habitat and floral resources for pollinator services in a predominantly agricultural landscape. We created a novel database of USDA easements on the Delmarva Peninsula, encompassing 9 different easement programs, including Conservation Reserve Program, Wetland Reserve Program, and Agricultural Conservation Easement Program. We then used the database to model pollinator services and resources important for agricultural production in this region using InVEST modeling. We considered ecological as well as agricultural interests, assessing not only pollinator biodiversity, but also changes in crop yields and their economic implications. We found that uplands within wetland easements provided the greatest potential for pollinator services, followed by herbaceous and forested wetlands respectively. In crops that can utilize pollinators but are not part of the rented honeybee market, such as soybeans and apples (in Maryland), we found that the proximity of protected aquatic lands can provide up to a 16% yield increase which can be significant for the incorporation of these lands into agricultural landscapes where they can provide pollinator service as well as other ecological benefits. We conclude that the usage of aquatic ecosystems within agriculture can provide substantial benefits to the efficiency and balance of agricultural landscapes both ecologically and economically. We recommend further investigation into the optimization of conservation easement placement within agricultural landscapes to promote pollinator services for crop production and how best to promote pollinator resources in current protected landscapes.

RETROSPECTIVE ANALYSIS OF CULTURAL-BENEFITS-KNOWLEDGE: ELWHA RIVER DAM REMOVAL AND RESTORATION

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Environmental decision-makers need tools to support improved consideration of the diverse cultural benefits arising from human relationships to ecosystems. The cultural benefits of ecosystem services (ES) make foundational contributions to human well-being, and yet are consistently underrepresented in research products intended to inform decision-making. In particular, the relational or holistic values of cultural benefits linked to continuous, place-based, and reciprocal human-nature relationships such as cultural identity, maintenance of knowledge systems, and the opportunity to live in right relationship with ecosystems are inadequately conveyed through existing instrumental approaches to ES assessment and ecosystem valuation.

We propose a step-by-step decision-support Framework to systematically identify opportunities for improved integration of a wider suite of cultural benefits, and their associated plural values and human-nature relationships. The Framework is based on theoretical contributions arising from a Critical Interpretive Synthesis of environmental management literature. It supports expanded thinking about the diversity of forms in which cultural-benefits-knowledge can be conveyed, and available opportunities to learn from these knowledge forms.

We illustrate the potential of the Framework through retrospective application to the Elwha River dam removal and fisheries restoration decision-making process in Washington State. In interviews, several groups articulated relationally, or holistically valuable cultural benefits associated with the Elwha ecosystem. Analysis of interviews and historical documents reveal examples of how these groups made this benefits-knowledge available to decision-makers in multiple forms. The case study further highlights that opportunities for integration of cultural-benefits-knowledge vary across phases of decision-making.

R2R2R: A LIFE CYCLE APPROACH TO ECOSYSTEM SERVICES ASSESSMENTS AT CONTAMINATED SITES

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Remediation to Restoration to Revitalization (R2R2R) is a framework to identify ecological and policy-based relationships between waterfront revitalization and large-scale aquatic sediment remediation or habitat restoration projects. Undertaking large-scale ecological restoration projects along urban waterfronts provides an opportunity to improve aquatic and riparian habitat, as well as to enhance community well-being by reconnecting communities with their riverbanks and shorelines. However, to consider both opportunities simultaneously, a community-based decision support process is required, particularly to incorporate the knowledge and values of the community into decision-making. As such, in the R2R2R framework, translating ecological restoration to improved ecosystem services (ES) assessments to public benefits such as fishing, boating, and swimming is critical to support decision-making. As a life cycle approach, R2R2R involves a comparative analysis of potential remediation and restoration designs. An ES analysis based on the design alternatives along with a community values analysis is conducted to compare the community wellbeing impacts associated with ES provided by the alternatives. To do so, specific pathways are analyzed to characterize the direction, magnitude, and likelihood of impacts on the well-being of a variety of groups affected by the decision. In numerous case studies conducted to date, we have found different alternatives each can produce a different mix of ES, which can differently impact the health of several populations. Ultimately, this leads to both social and ecological trade-offs among alternatives. Further, we have found that including community input into decision-making can mitigate negative impacts to well-being and improve the benefits from the project. We conclude that R2R2R represents a first step in establishing a community of practice for integrating ecosystem service and community values into decision-support for remediation of urban waterfronts.

USE OF SATELLITE DATA TO ESTIMATE SOIL ORGANIC MATTER CONCENTRATION OF PADDY FIELD IN INDONESIA

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In these years, a drastic increase in agricultural production costs has been induced, which was triggered by the sharp rise in costs relating to agricultural production materials such as fertilizers and oil. The substantial negative influence is anticipated to spread over to the management of the farmers. As one of the measures against this influence, a plan of effective fertilizer application and a comprehensive review of prescription for the fertilizer application have become a critical issue. We previously reported the development of an estimation method to evaluate soil carbon stocks and organic matter concentration in a plowed field in Hokkaido, Japan, using satellite data. This time, we report new research results on the estimation of soil organic matter concentration in paddy fields in Indonesia with the use of a similar approach as the previous one. In our research, at first, time series change of backscattering coefficient of VH polarization data was analyzed with 6 different imageries of Sentinel-1 GRD taken in between mid-March and mid-May of 2018. As the result, we could distinguish between the paddy after irrigation and the one before irrigation, by setting up -21dB as the threshold of the backscattering coefficient. The relation between soil organic matter concentration in paddy after irrigation and reflectance of each band of L2A processed Sentinel-2 data was analyzed. The result showed a significant negative correlation from the visible band to the near infrared band. Multiple regression analysis was made with the result that the following formula having red-edge as a predictor variable was created at a 1% significant level to calculate the soil organic matter concentration. +Organic matter concentration (%) = -39.9*red edge reflectance+14.2 It was indicated that red edge reflectance having a longer wavelength would be better than the red band for estimating the concentration since the soil type in this research area was Inceptisols (red colored soil). Then, the 10 holds cross-validation was used to examine the error of the estimation, resulting in 0.73% of RMSE. Finally, a visualized map of the organic matter concentration was created by applying the estimation formula to GIS parcel data of the area. It is suggested that the result could be utilized for the management of fertilization and that a dry and wet state in soil could be evaluated by superimposing the information of irrigation canals.

WHAT IS A FLOODPLAIN WORTH? ESTIMATING FLOODPLAIN BENEFITS IN THE CHESAPEAKE AND DELAWARE WATERSHEDS

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Floodplains provide critical ecosystem services to people by retaining floodwaters, sediments, and nutrients. Geospatial analyses, field data collection, and modeling were integrated to quantify a portfolio of services that floodplains provide to downstream communities within the Delaware River and Chesapeake Bay watersheds: 1) sediment and nutrient retention and 2) flood attenuation. Field and geospatial datasets were combined to develop predictive models estimating sediment trapping and export for streams within the non-tidal portion of Delaware River and Chesapeake Bay watersheds. Nitrogen fluxes from streambanks and floodplains were summarized at various scales and valued using a benefits transfer approach. Floodplain flood attenuation services were assessed through a pilot study focused on the Schuylkill River Watershed in the Delaware Basin. Geospatial analysis and published flood frequency estimates were used to assess a baseline and counterfactual (i.e., floodplain storage removed) scenario for annual exceedance probabilities of 50-, 20-, 10-, 4-, 2-, 1-percent, which correspond to the 2-, 5-, 10-, 25-, 50-, and 100- year recurrence intervals, respectively. Flood attenuation was valued using the Federal Emergency Management Agency's Hazus model to compare differences in structural damage between baseline and counterfactual scenarios. Together this portfolio of floodplain ecosystem services provides a monetary estimate of what a floodplain is worth for storing floodwaters, sediments, and nutrients.

WHAT ECOSYSTEM SERVICES MATTER? THE FEGS COMMUNITY SCOPING TOOL

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Human well-being relies on goods and services provided by ecosystems to sustain our society, human health, and economy. These benefits from nature are often overlooked or taken for granted in decision making. Decision and policy makers struggle to protect and manage natural habitats and resources while balancing conflicting interests across a diverse group of human users. By beginning with the decision's pertinent stakeholder groups and identifying the ways in which they directly benefit from the environment (i.e., the Final Ecosystem Goods and Services (FEGS)), managers can weigh the impacts to relevant FEGS when determining management actions. It is easy to focus on FEGS that are frequently measured (e.g., land area available for recreation) or commonly discussed (e.g., carbon sequestration) without considering whether they are: (1) highly relevant to the decision context; (2) meaningful to or desired by stakeholders; and (3) of direct benefit to stakeholders. The FEGS Community Scoping Tool is designed to help community-level decision makers make decisions by identifying and prioritizing stakeholders, the ways in which they use the environment, and biophysical attributes of nature that they use. The structured decision-making tool helps to clearly identify the highest priority FEGS for their decision context in a transparent, repeatable process. The relevant attributes can then be used to evaluate decision alternatives for environmental managers and answer questions posed by economists and social scientists on how environmental benefits support human well-being. If environmental issues are considered alongside social and economic consequences, wiser decisions and better outcomes can satisfy more stakeholders with competing interests.

FLOODWISE: USING NATURE-BASED SOLUTIONS (NBS) FOR FLOOD REDUCTION FOR FARMS AND COMMUNITIES IN EASTERN NORTH CAROLINA

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This presentation describes our new line of research and development that examines the merits of Nature-based Solutions (NBS) for flood reduction for farms and rural communities in Eastern North Carolina. The project team has termed this line of research “*FloodWise*” to describe the water quality, flood mitigation, farm benefits, community engagement, and governance connections. This project identified and estimated the establishment and maintenance costs for the ten most promising NBS for flood reduction in Eastern NC, such as common farm practices of no-till, cover crops, and tree planting to more complex NBS of wetland creation, water farming, and low-rise earthen berms and retention basins with flashboard risers. These practices can collect and store water on farm and forest lands and attenuate rapid downstream flooding by releasing storm flow naturally or through soft engineered structures. A survey of farm landowners in Robeson County, North Carolina found that about 70% of the owners were usually willing to participate in a NBS program like the Farm Bill conservation programs, assuming that their installation costs were covered, and they receive government conservation and water farming payments for storing that water on their properties. They had about the same annual willingness to accept (WTA) payment rates as Farm Bill programs, of approximately \$130 per acre per year for 10 years. Future research aims to design potential NBS for select pilot farms, and perhaps install practices. Policy instruments and solutions needed to facilitate such NBS also will be identified and outlined.

IMPROVING ECOSYSTEM SERVICES FROM U.S. AGRICULTURE: YIELD RESERVE VS. LAND RETIREMENT

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Agricultural activity is the largest source of nutrient runoff to streams in the US. Federal and state governments have taken actions to protect and restore water quality, but progress is not satisfactory. High fertilizer use in US agriculture is one of the main factors causing nitrogen and phosphorus deliveries to streams.

One approach to reducing water pollution is a yield reserve program whereby nutrient applications are lowered below recommended rates (Metcalf et al. 2007). A second approach is land retirement such as the Conservation Reserve Program (CRP). However, few if any studies have compared these approaches in terms of their impacts on the US agriculture sector as well as their potential ecosystem benefits. We examine the regional and national effects of yield reserve and land retirement (CRP) on revenues, costs, and output from the U.S. agriculture sector as well as the potential ecosystem benefits from nitrogen reductions. For the analysis, we use the REAP (Regional Environment and Agriculture Programming) model, a partial equilibrium model developed by USDA’s Economic Research Service (Johansson, Peters, and House, 2007).

Yield reserve shocks are implemented as subsidies for reducing fertilizer applications, and therefore, reduced variable costs and reduced crop yields. Yield loss in response to the subsidy and reduced fertilizer use are estimated using studies of the response of crop yield to nitrogen applications (Vanotti, M. B., & Bundy, L. G. 1994). Land retirement shocks are implemented as increasing land retirement with CRP.

Potential ecosystem benefits in these scenarios are quantified as reduction of excess nitrogen. A nitrogen use efficiency (NUE) ratio based on the nitrogen inputs and nutrient harvest removal will be estimated nationally and by region using the output from REAP. We expect yield reserve and increased land retirement to increase NUE and ecosystem benefits by reducing nitrogen at risk of delivery to surface and groundwater. The relative costs, ecosystem benefits, and agriculture sector impacts are subject to investigation.

CLIMATE CHANGE AND OUTDOOR RECREATION BENEFITS OF NATIONAL FORESTS AND GRASSLANDS

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National Forests and National Grasslands in Colorado offer a diverse range of outdoor recreation opportunities enjoyed by millions of people each year. However, a changing climate and a growing state population are challenges that may affect how and when people enjoy the outdoors, and forest managers need adaptation strategies to ensure future viability of certain outdoor recreation activities. This economic analysis investigates current and future outdoor recreation uses on Colorado's national forests and grasslands with the goal of improving information available to forest managers for planning purposes. We combine economic valuation information with U.S. Forest Service visitation data and find that warm-weather activities (such as hiking and camping) and cold weather activities (such as downhill skiing and snowshoeing) in forests are among the most-highly valued types of recreation uses under current conditions. We then extend this analysis to investigate the potential impacts from climate change on recreation use by mid-century. Results show that warm-weather activities are expected to have a net increase in annual recreation days, while wildlife-related activities (such as hunting and fishing) and winter activities are projected to have a net decrease in the number of recreation days because of a changing climate. A simultaneous challenge facing forest managers is the expected increase in visitor use driven by population growth in the state. The total number of recreation days for forests is expected to approximately double by 2060. While climate change will result in a shift in outdoor recreation participation, a significant future challenge is to design forest plan alternatives to address the total increase in visitor use and its changing composition of activities. This might include providing more trails, as well as more dispersed and developed camping infrastructure. One opportunity is to redirect the displaced demand for winter recreation toward the currently under-utilized national grasslands by developing more recreation infrastructure in the national grasslands.

MANAGING FOR MULTIPLE ECOSYSTEM SERVICES IN SEMI-ARID RANGELANDS

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Across western public rangelands, managers increasingly seek to balance cattle production with multiple other ecosystem services (ES) – such as wildlife habitat, clean water, and carbon sequestration. This interest is driven in part by an existing stewardship ethic, in part by a threat of litigation against federal agencies, and recently by the promise of ES market profits. One potential management strategy to balance rangeland ES is to employ rotational grazing, which allows managers to modify livestock's disturbance on ecosystem processes. This in turn might alter tradeoffs among ES. Currently, however, experts debate rotational grazing's benefits, and few studies examine its role in managing multiple ES. To understand rotational grazing's potential, we examined how ES vary across gradients of timing and duration in semi-arid rangelands in northern Utah. Our sites included pastures with short-(2 week), medium-(2 month), or long-duration (4 month) grazing; Medium-duration sites were grazed either early or late in the season. We collected 3 years of data on forage production, sage-grouse habitat, streambank stability, and water quality. We found that including distinct gradients of duration and timing allowed us to link livestock disturbance to ecosystem processes that regulate rangeland ES. Duration affected most ES, with short durations leading to taller forage, better sage-grouse habitat, cleaner water, and more soil organic carbon, compared to longer durations. We also found that the timing of grazing affected streambank stability, vegetation recovery, and water quality by seasonally affecting processes such as plant growth. Our results insinuate that past studies may have obscured relationships between ES and grazing by lumping rotations with different durations/timings into a single treatment. Ultimately, our results suggest a powerful role for rotational grazing in rangeland management and highlight the effectiveness of timing and duration to balance cattle production with another rangeland ES.

AN 8 CITY ANALYSIS OF HOW URBAN LAND COVER DRIVES HEAT MITIGATION BASED ON REGIONAL CLIMATE

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Multiple cities in the United States consider alterations to urban land cover (i.e., replacing impervious surfaces with tree canopy), a useful strategy to incorporate heat-mitigating ecosystem services into urban planning. However, the biophysical processes by which land cover influences urban heat are partially driven by macro-scale climatic properties. Considering this fact, we have conducted an analysis across eight U.S. cities of varying regional climates to determine the relative contributions of urban land cover types that drive extreme urban air temperatures. We have found both the cooling-potential of tree canopy and the warming potential of built structures strongly correlate with regional temperatures. Moreover, the overall contribution of both impervious and vegetated land covers to influencing urban air temperatures decreases in more humid regions. As regional climates shift, these results can aid in understanding how the magnitude of land cover-derived ecosystem services may shift as well. Furthermore, our results highlight the issues with a “one-size-fits-all” approach to using tree-canopy as a uniform strategy for urban cooling, as well as the potential trade-offs between urban air-cooling ecosystem services and urban water use in arid climates.

OPPORTUNITIES FOR BUSINESSES TO USE AND SUPPORT DEVELOPMENT OF SEEA-ALIGNED NATURAL CAPITAL ACCOUNTS

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This paper outlines how businesses can use natural capital accounts (NCA) aligned to the System of Environmental Economic Accounting (SEEA) standard to support measurement and management of natural capital upon which businesses depend and impact. As businesses are increasingly encouraged to measure and disclose their efforts to manage natural capital and their nature-related risks, through emerging frameworks such as the Taskforce on Nature-related Financial Disclosures (TNFD), high quality, credible information on land, water, ecosystems, and biodiversity will be required but may not be directly collected and/or easily available to companies. Natural capital accounts may be able to fill some of these information needs and support business decisions associated with strategic planning, new investments, supply chain management, operations management, and enterprise risk management. Businesses also have important roles to play in supporting and advancing SEEA-aligned NCA by contributing information that could be useful for the accounts and by providing input on the accounts as they develop so that they provide decision-relevant information for both the private and the public sectors. This paper will discuss how SEEA-aligned NCA data and analyses developed for the United States and other countries can support a range of business decisions and help address some of the common challenges that businesses face in accessing and using natural capital data, while recognizing key areas of improvement that will be needed to increase utility of NCA for the private sector.

SOCIOECONOMIC CHARACTERISTICS AFFECT RESIDENTS' VALUES TOWARD LANDSCAPES IN THE UPPER MISSOURI RIVER BASIN

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The Upper Missouri River Basin (UMRB) – which includes Montana, Wyoming, South Dakota, and North Dakota – is among the least densely populated regions of the United States, and the landscapes of the UMRB are foundational to the economy of the region. Agriculture, energy, and (landscape-based) tourism is among the top economic activities in these states. The purpose of this research was to explore the values that residents of the UMRB held for their landscapes. We conducted door-to-door surveys of more than 1000 residents across the UMRB to collect spatially explicit data on the residents' landscape social values. We are using the SolVES (Social Values for Ecosystem Services) platform to map and quantify how residents' socioeconomic characteristics affect the distribution of social values across the landscape. Agriculture, recreation, and conservation were the most frequently identified social values, and energy extraction and production was the fifth (of eleven) most frequently identified social value. Although agriculture was the most identified social value, there were few hot spots of the value because it was broadly valued across the UMRB. This differed from the spatial distributions of recreation, conservation, and energy values which were more concentrated in distinct areas on the landscape. Preliminary analyses show that the gender, level of education, length of residence, and income of the residents affects the intensity and spatial extent of their landscape social values. This analysis of landscape social values across the UMRB, a region that spans the Rockies to the Corn Belt, is the largest ever modeled with SolVES. We can compare how land ownership – most land in Wyoming is publicly owned, whereas less than 10% of land in the Dakotas are publicly owned – affects landscape social values, and how uncommon landscape features, such as water bodies, are disproportionately valued throughout the region. Additionally, understanding how resident socioeconomic characteristics affect landscape social values can inform discussions around land use and land-use change.

WOLVES, WOODLAND CARIBOU AND BEAVER: CONSERVATION, ECOTOURISM, AND THE BRANDING OF CHARISMATIC FAUNA IN THE ERA OF CLIMATE CHANGE

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Ecotourism offers society a meaningful alternative to mass tourism. By relying on an ecosystem services approach to valuing many of our natural resources, ecotourism can contribute to the protection of critical species and their habitat. This approach recognizes both the monetary and non-monetary values of these resources in a way that can encourage a dialogue about the importance of protecting our natural ecosystems. This monetary and non-monetary distinction can be confusing, but by putting a dollar value on nature is not about generating a cash flow but rather for policy makers to better understand policy decision trade-offs. In this way, assigning value can help ensure that a policy maker doesn't mistakenly trade more valuable things for those with less value.

By assigning value through ecotourism to charismatic fauna, the environmental health of entire ecosystems from boreal forests to riparian corridors can benefit. For wolves, an ecotour experience can turn people's dislike or fear of wolves into fascination and encourage an appreciation for their role in maintaining healthy landscapes. For woodland caribou, their status as an umbrella species makes them critical indicators of ecosystem health. Yet in recent years their survival has been jeopardized by the popularity of alpine recreation that through activities like heliskiing and cat skiing have put large numbers of people in caribou habitat. As an alternative to these high-impact activities, caribou ecotourism would allow alpine recreationalists the chance to fund caribou recovery and habitat all while reducing their impact on this ecosystem. By valuing caribou through the marketplace, tourism providers are then better equipped to see value in modifying their business model towards one that supports the caribou's role on the land. For beaver, educating people about their role in mitigating climate change and ecosystem recovery is occurring through many modalities. In Great Britain and parts of Europe an important modality is beaver ecotourism, where it is being used not only to redevelop rural economies, but to educate people about the critical ecosystem services beaver provide.

To make these connections, this paper will investigate how, by successfully branding certain charismatic fauna, the ecosystem services model, more specifically ecotourism, can assign value to ecosystems that will allow for better decision-making regarding conservation and natural resource use.

NEPA, MULTIPLE KNOWLEDGE SYSTEMS, PLURAL ES VALUES & ENVIRONMENTAL JUSTICE: WHERE DO WE GO FROM HERE?

Organizers/Moderators: Charles M. Ka'ai'ai,¹ Kristin R. Hoelting²

¹Western Pacific Regional Fishery Management Council (Retired), Honolulu, HI, USA

²Colorado State University, Human Dimensions of Natural Resources Department, Fort Collins, CO, USA

There is growing momentum in the ecosystem services (ES) field around how to create space for multiple worldviews, including multiple human-nature relationships and well-beings, and the diverse services and plural values to which they give rise. Discussions include the importance of relational, non-instrumental values linked to ecosystems, and the current marginalization of worldviews that understand nature as a subject rather than an object for human protection or fulfillment. These on-going conversations and critiques are critical to bringing the ES approach into alignment with Environmental Justice, including distributional, procedural, and recognition justice for current and future generations.

In this panel, we will discuss how an Environmental Justice-oriented ES approach could help us utilize the National Environmental Policy Act (NEPA) to its full potential. NEPA, though highly successful in mitigating and preventing tangible resource impacts, has thus far been less successful in protecting traditional, Indigenous, and long, continuous mutually beneficial uses of the environment. There is urgent need, linked to both equity and ecological sustainability, to better recognize and protect services and values associated with traditional lifeways and worldviews.

NEPA, with its emphasis on understanding impacts, offers an important opportunity to integrate multiple knowledge systems and plural values of ES in decision-making. Current templates for preparation of EISs, EAs, and CEs include many elements related to ES, including economic, socio-cultural, and ecological impacts. However, they do not currently address value pluralism and are often presented in a piecemeal fashion that fails to offer readers a holistic understanding of impacts. The Council on Environmental Quality and Federal agencies could institute and implement a requirement for ES assessment within NEPA that emphasizes plural values and facilitates cohesive discussion of all categories of ES.

Session panelists:

Mr. Charles M. Ka'ai'ai, Community and Indigenous Program Coordinator, Western Pacific Regional Fishery Management Council (Retired)

Ms. Cheryl Kelly, DOI Office of Environmental Policy and Compliance

Mr. Jared Hautamaki, EPA American Indian Environmental Office, (on-detail) White House Council on Native American Affairs

Dr. Kristin Hoelting, Colorado State University, Human Dimensions of Natural Resources

VALUE OF CONSERVATION OF PRIVATE LANDS

Peter Kareiva

Aquarium of Pacific, Long Beach, California

Placing conservation easements on private lands could contribute greatly to biodiversity protection in the United States. However, a paucity of data prevents us from knowing to what extent this potential is met. We will discuss biodiversity surveys of properties that could help mitigate this data shortage and contribute to a national database on private land biodiversity. We will then discuss the examined 49 private properties totaling 3,048 ha in Alabama where we tallied high priority (i.e., at-risk) species that were recorded within this portfolio of land parcels protected by conservation easements. The number was 116 species in total, or 38 high-priority species per 1,000 ha. Not only was the number of these documented at-risk species per unit area high compared to the number documented from nearby Conecuh National Forest (~38 vs. ~5 per 1,000 ha), 92 of the species recorded from the private lands had not been recorded from the much larger Conecuh National Forest (33,993 ha). This emphasizes the opportunity for well-positioned easements to complement and be a valuable addition to large networks of public lands.

ASSESSING THE RELATIONSHIPS BETWEEN POLLINATOR-FRIENDLY PLANTINGS AND WILDLIFE-RELATED ECOSYSTEM SERVICES ON FARMS IN THE MID-ATLANTIC COASTAL PLAIN

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Pollinator-friendly wildflower and native grass plantings are increasingly incentivized by state and federal agencies to improve ecosystem services provided by pollinating insects on farmland. However, the potential ecosystem service benefits, or even disservices, of pollinator-friendly plantings relative to wildlife are of interest to both landowners and conservation managers. First, we used point counts to study bird species diversity, presence, density, and nesting on farms planted with and without pollinator-friendly plantings to evaluate the potential value of these plantings to bird-related cultural, recreational, and pest-regulating ecosystem service values. Second, we quantified bat relative activity, given their importance as insect foragers, through recorded echolocation calls and explored how relative nightly activity varied across common cover types on a farm. Third, we determined whether white-tailed deer and wild turkey population metrics, given their provisioning value to landowners, differed between farms with and without pollinator-friendly plots. We conducted this research on 20 farms on the Eastern Shore of Virginia and Maryland during 2017 and 2018. Landscape-level habitat features were the most influential factors concerning metrics of the 110 bird species we detected on our study farms, but the presence of pollinator-friendly plantings did influence some bird species. We found nesting in the pollinator-friendly plots by red-winged blackbirds (*Agelaius phoeniceus*; n=7). We documented seven species of bats on our study farms, including big brown bat (*Eptesicus fuscus*), evening bat (*Nycticeius humeralis*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bats (*Lasiurus borealis*), hoary bats (*Lasiurus cinereus*), little brown bat (*Myotis lucifugus*), and tricolored bat (*Perimyotis subflavus*). Relative activity, measured by calls per night, varied by cover type on the farms, with relative activity highest for all 7 species on the edge of the crop fields and forest, not in the pollinator-friendly plots. However, all 7 bat species were recorded in the pollinator plot. Of all wild species photographed on our study farms, white-tailed deer were most abundant. White-tailed deer were detected at all survey locations at least once, and the occupancy of deer decreased as the percentage of developed land within 1km of a farm increased in each survey season. Overall, wild turkey had a low presence on all survey sites with an occupancy ranging from 0.18-0.53. Pollinator plot presence or absence was not found to influence detection or occupancy of either of these target game species. Our study is one of just a few in North America to demonstrate some potential benefits of pollinator-friendly plantings to multiple different wildlife species with cultural, recreational, and insect-regulating ecosystem service benefits to landowners. Generally, birds, bats, and our focal game species' presence relied on surrounding landscape variables and forest-edge configurations more than the presence of pollinator friendly plantings. This is probably in part due to the small size of our pollinator plots. We recommend that future work explore potentially increasing the size of pollinator plot plantings or placing pollinator plantings in locations on the landscape with the most surrounding natural area, and least development, to maximize the benefits of this resource to diverse wildlife species with home ranges that are often larger than any one farm.

THE MANAGEMENT OF SARGASSUM IN THE YUCATAN PENINSULA, MEXICO: APPLYING A PLURALISTIC APPROACH TOWARDS MARINE CONSERVATION AND REGIONAL DEVELOPMENT

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The degradation and/or destruction of an ecosystem transcends boundaries with the most profound and direct impacts occurring on local environmental and socio-economic conditions. This is evident in the marine ecosystem of the Yucatan Peninsula – Mexico, due to the enormous amount of Sargassum that appears at varying levels throughout a given year. The study focuses on the design of optimal management and conservation practices at landscape level through, improving knowledge-sharing and mobilization, increased community participation, responsibility-sharing and trans-boundary initiatives. Using a pluralistic approach, it applies a variety of research methods which intersect with operationalizing ecosystem management practices, with an aim of reducing detrimental livelihood and environmental impacts and improving sustainable development overall. Initial findings suggest that local people have a very good understanding of the consequences of the problem, however, are not aware of opportunities that exist for socio-economic development. The study finds that participation in ecosystem management strategies creates a sense of ownership for communities and motivates conservation and can contribute towards socio-economic development. Further opportunities exist for sustainable tourism, and for Payment for Ecosystem Services (PES) revenues. Moreover, the study demonstrates that the Sargassum invasion impacts go beyond local but is also an international problem due to links to climate change, and the transboundary nature of Sargassum movement. Applying a broad perspective can act as a driver for action at national level where the priorities for central government may not necessarily focus on small coastal regions. Finally, the study explores the significance of citizen science in terms of local development and knowledge when integrated with social science methodologies, of which there is a dearth. The pluralistic approach finds similarities between participatory research taking place in many developing countries and explores how these can assist ‘ethical’ research and practice in terms of community inclusion, the collation of data and access to knowledge more broadly. By exploring these themes in a non-reductionist manner, we provide in-depth information, tools, and data on ‘good practice’ strategies and evidence-based policymaking to develop sustainable marine conservation practices which have community inclusiveness at its core.

EVALUATING THE DIFFERENTIAL INFLUENCE OF PERCEIVED AMENITIES AND ACCESS BARRIERS AFFECTING URBAN GREENSPACE USE BY PEOPLE OF DIFFERENT GROUPS

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Urban green space provides ecosystem service benefits, including heat island mitigation, air filtration, storm water management, recreation and health benefits including improved respiratory health, obesity reduction, and greater social cohesion. However, there are growing environmental justice concerns about how well these ecosystem services benefits are distributed among people of different racial, ethnic, and other groups. We examine the influence urban greenspace amenities and access barriers, as perceived by park users in Portland, OR. We develop a conceptual framework for examining amenities and access barriers that urban park users perceive when accessing urban green space. We test this framework using survey data gathered from Portland, OR residents. Specifically, we develop regression models to evaluate the influence of specific park amenities and perceived access barriers on survey respondents’ urban greenspace visitation levels. We find that more than 80% of the respondents have used urban parks and greenspace in Portland, OR over the previous year, indicating their significant importance to Portland residents. While 53% reported using parks less frequently due to Covid-19, nearly a quarter of respondents said they used parks more often in the same period. Results across all respondents find that the most important amenities are trails (64%), trees (54%), water-related features (46%), and quiet time (41%). The most significant barriers to park use include available time for recreation due to work (38%) or family (37%) and safety concerns (35%). Physical limitations (16%) and access to parking (14%) or public transportation (13%) also emerge as important barriers. We also find that perceptions of desired amenities and perceived access barriers do differ across different racial, ethnic, and other groupings, with implications for policy and management approaches that could be implemented to lower visitation among some group by, among other things, improving access to the specific amenities desired by groups, and by alleviating notable perceived barriers such as safety concerns. Ensuring that the specific amenities provided by urban parks and greenspace align spatially with the user groups they serve also could ensure greater equity in ecosystem services provision.

HOW WILL CLIMATE CHANGE AND ALTERED PRECIPITATION REGIMES IMPACT SEMI-ARID GRASSLANDS?

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Semi-arid grasslands are water-limited ecosystems with highly variable precipitation regimes both within and among years. The significance of these grasslands for providing ecosystem services at regional scales is well-documented and more recently, the critical role they play in global carbon cycle anomalies has become evident. Driven by a warming atmosphere, the global hydrological cycle is intensifying and precipitation regimes in these grasslands are being altered in myriad ways. These include more extreme individual rainfall events (deluges), shifts in precipitation seasonality, and more intense droughts. All of these are expected to become the “new normal” in the future and thus, there is a need to understand how the functioning of these ecosystems and the services they provide will be affected by climate change.

Based on field experiments conducted in the shortgrass steppe of Colorado, we find that these semi-arid ecosystems are highly sensitive to changes in precipitation event size and pattern, alterations in the seasonal timing of precipitation, and increasing summer drought. This vulnerability to alterations in precipitation regime in semi-arid grasslands is consistent with their high sensitivity to total precipitation amount. These results point to the need for a more comprehensive understanding of how ecosystem responses to precipitation amount are mediated by key attributes of precipitation regimes. For example, increases in event size may lessen the negative impacts of drought and overall, changes in rainfall patterns may matter most in dry years. Mechanistically, we show that changes in precipitation attributes can affect both the timing and depth distribution of soil water availability with important consequences for aboveground productivity and forage availability.

DROUGHT SENSITIVITY ACROSS NORTHEASTERN FORESTS IS RELATED TO THE AGE OF TRANSPIRED WATER

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External stressors are driving changes in the density and composition of forests across the US. Predicting the water yield responses from these stressors is challenging because of our limited knowledge of plant hydraulic function. Recent empirical ecohydrologic observations suggest that trees in mixed-species plots often vary the depth, and therefore the age, of water that is taken up by roots and transpired. We hypothesize that trees reliant on shallow water may be vulnerable to short duration droughts (on the order of days to weeks). In contrast, trees accessing deeper and older water may avoid these short duration droughts but may experience elevated risk from lower frequency precipitation anomalies (occurring over season and years). We studied this concept with a process-based hydrological age-tracking model calibrated for 140 reference condition forests across the US and high-frequency water isotopic measurements collected in the University of Connecticut forest for six tree species. Our analysis demonstrates that forests that are capable of transpiring older water experience less frequent losses in transpiration and follow closely to the global Budkyo model. In contrast, forests reliant on younger water sources deviate sharply from the Budyko model during periods of water limitation. Preliminary high resolution xylem water isotopic measurements of six foundational northeastern US forest trees suggest that a loss of oak (*Quercus* sp.) could have a fundamental impact on water yield. These results can inform forest management and pest control strategies that limit alteration of the hydrologic cycle under climate change.

ECOSYSTEM SERVICES AS A TOOL FOR PROTECTED AREAS INTEGRATED MANAGEMENT: CASE STUDIES FROM THE MEDITERRANEAN - GREECE

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Ecosystem services (ES) approach has been used in many cases for delineating aspects on how natural capital contributes and supports economic development, biodiversity conservation, culture, and human prosperity. However, a holistic assessment of all ES types, based also on ecosystem extent and ecosystem condition (EC), in most cases is missing, especially within protected areas. The scope of the present study, conducted under the LIFE IP 4 NATURA Project, is to provide an integrated approach at large (case-study) scale, at four Natura 2000 protected areas in Greece. Those areas, distributed in four different regions of Greece, include mountains (one on the North and one on the South, on the island of Crete), wetlands and lake, and coastal areas. The goals of the study are: (a) map ecosystems and their extent at different time periods, (b) create ES maps for each area for provisioning, regulating and maintenance and cultural services, (c) identify changes between the year 1945 and today, (d) support natural capital accounting and (e) support decision making. Field surveys on biotic and abiotic characteristics have been performed and stakeholder perception has been incorporated to identify key ES, via relevant workshops. Photointerpretation and remote sensing techniques have been applied to produce the relevant maps for the year 1945. Data set for the statistical agency and local authorities have been analyzed for the ES assessment. Main results include large scale ecosystem types, EC and ES maps for each protected area, ecosystem extent accounting tables (1945 – present) and prioritization of areas of specific importance for EC and ES, at each case-study. Study outcomes provide a robust base line for management and policy decision for an integrated strategic plan, based on each area's specific biotic and abiotic attributes, stakeholders' perception, and local needs. This study can act as a guide on how the ES approach can be used to scientifically support decision making for protected area management, especially at sites where the human – nature interaction is evident and should be supported in the most sustainable manner, following regional, national, and international legislation and related strategies.

ADAPTIVE STRATEGY BIASES IN ENGINEERED ECOSYSTEMS: IMPLICATIONS FOR PLANT COMMUNITY DYNAMICS AND THE PROVISIONING OF ECOSYSTEM SERVICES TO PEOPLE

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Plant communities in green stormwater infrastructure (GSI) such as biofilters play an integral role in ecosystem services provisioning, such that many design manuals now feature plant lists that guide vegetation selection. This study looks at the implications of those lists for biofilter plant communities and their services, focusing on 1) how plants are selected across US climate zones, 2) whether selected plants exhibit adaptive strategy biases (i.e., towards competitive, stress tolerant or ruderal strategies that might impact their services provisioning), and 3) whether human-induced selection or natural climatic processes underly any biases revealed. Our results suggest that biofilter plant strategies are significantly biased towards stress tolerance or competitiveness and away from ruderalness, relative to the broader pool of both native and wetland-adapted native species. These biases appear to reflect human concerns related to water availability and climate (water conservation; $p < 0.05$, irrigation; $p < 0.1$, local climate extremes; $p < 0.1$) rather than strict climatological limits, which would also be evident among native plants (significant relationships between meteorological variables and native plant strategy were not detected). Competitive bias was evident in humid-continental climates and stress tolerant bias in hot coastal/arid climates, with some degree of anti-ruderal bias present across all zones (significant in 5 of 8). The benefits and costs of relaxing these biases is discussed, focusing on the implications for water quality, hydrologic, and cultural services provisioning, and the dynamicity of GSI ecosystems, particularly their capacity to self-repair, a prerequisite for the development of self-sustaining GSI.

MULTIFUNCTIONAL ECOSYSTEMS: NITROGEN MITIGATION BY SHORT ROTATION WOODY CROPS IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY

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The Lower Mississippi Alluvial Valley (LMAV) has marginal lands that are usually less suitable for agricultural production due to seasonal flooding. However, these areas may be managed by planting flood-tolerant short rotation woody crops (SRWCs). More importantly, SRWC plantations have the potential to take up excess nutrients coming from fertilized agricultural land. To examine nutrient mitigation potential, a SRWC plantation was established at the interface between marginal agricultural land and an oxbow of the Yazoo River in the LMAV in 2018. The experimental design contained two unplanted blocks (control) and two planted blocks with 75 individuals each for eastern cottonwood (*Populus deltoides*), black willow (*Salix nigra*), and American sycamore (*Platanus occidentalis*). At the end of growing season in 2020, planted blocks 1 and 2 had 59 and 72 surviving trees for eastern cottonwood, 47 and 63 trees for black willow, and 68 and 70 trees for American sycamore, respectively. Black willow had higher total tree volume (0.152 m³ in block 1 and 0.350 m³ in block 2) than eastern cottonwood (0.010 m³ in block 1 and 0.016 m³ in block 2) and American sycamore (0.003 m³ in block 1 and 0.001 m³ in block 2).

To determine water quality using colorimetry methods, groundwater samples were collected biweekly during the flood-free period in 2020 from 16 shallow groundwater wells installed along an elevational gradient of the plantation. The plantation was successful at removing nutrients in groundwater before discharge to the oxbow. During summer, the plantation mitigated 79% ($\bar{x} = 1.431$ mg/L) in block 1 to 83% ($\bar{x} = 0.444$ mg/L) in block 2 for nitrate, and 75% ($\bar{x} = 0.119$ mg P/L) in block 1 for orthophosphate. During fall and winter, orthophosphate was mitigated by 57% ($\bar{x} = 0.059$ mg/L) in block 1, and total phosphorus was mitigated by 56% ($\bar{x} = 2.300$ mg P/L) in block 2; however, ammonia was not mitigated. In the control blocks, there was no decrease in nutrient concentrations, except total phosphorus. This suggested that nutrient mitigation was mainly due to uptake by SRWC plantation rather than downslope movement of groundwater.

Therefore, instead of abandoning these areas, establishing SRWC plantations on marginal land can mitigate agricultural runoff and thereby, improve water quality of the LMAV. Furthermore, planting SRWCs potentially generates a stream of income for landowners by producing biomass feedstocks needed for bioenergy.

INFLUENCE OF MANURE APPLICATION AND SOIL PHYSICOCHEMICAL PROPERTIES ON LEACHING OF METALS IN PASTURES

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Significant amount of poultry manure produced in the southeastern United States is being applied to pasture lands. Loss of metals from manured pastures through surface and subsurface pathways has long been considered as a major source of non-point source pollution of waterbodies. Subsurface loss of metals is significant and can lead to both declines in crop yield as well as deterioration of water quality. Therefore, to achieve the fundamental goal of sustainable agriculture, it is critical to evaluate the fate and transport of metals through the agricultural systems. In this study, we used rainfall simulations to examine the effect of soil physiochemical properties, especially the soil macropore characteristics, on the flux, fate, and transport of metals. Undisturbed soil cores were collected from Hartsell's fine sandy loam soil with Kentucky 31 tall fescue pasture in Crossville, Alabama. Treatments included surface-applied poultry manure and control (no manure applied). The leachates were collected and analyzed for various heavy and trace metals along with the measurement of levels of metals in soil. In addition to column experiments, X-ray computed tomography (CT) was used to quantify the macropore network connectivity, which is essential to preferential flow. Results indicate that the concentration and loadings of Cu, Mn, K, Mg, and Zn are significantly higher in the leachate of the manure treatment than in control. Results on the effect of soil macropore characteristics on vertical distribution and transport of metals in the vadose zone will be presented.

IMPACT OF NEARBY FALLOWING ON PESTICIDE USE

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The cessation of agricultural production, whether permanent or ephemeral, has risks and opportunities for ecological communities and the ecosystem services they provide. Of particular interest is the influence of fallowed cropland on agricultural pests and pesticides, as idle lands may serve as a source of pests and/or natural enemies that spillover onto neighboring crop fields. Despite the increasing amount fallowed lands driven by abiotic, economic and policy conditions, few studies have investigated how the frequency and duration of fallowing influences agricultural pests or pest control on neighboring cropland. Here we couple field-level data from over 240,000 field-year observations from 2002-2020 in Kern County, CA, USA with remotely sensed metrics of revegetation and panel data models to investigate 1) does fallowing drive insecticide, herbicide or fungicide use on neighboring cropland, 2) is the effect of surrounding fallowing on neighboring cropland moderated by the level of revegetation on the fallowed parcel, and 3) is the effect of surrounding fallowing on pesticide use dependent on the crop type on the neighboring field? Our results suggest very little effect of surrounding fallowing on any type of pesticide in aggregate or for any of the top eight crops by area, even after controlling for a combination of crop-, farmer-, region- and year-specific heterogeneity. While temporary fallowing lasting under one year may lead to a small reduction in pesticide use on neighboring cropland, annual fallowing in general or interacted with quartiles of revegetation has a near-zero effect on pesticide use. Pesticide use decisions are one, albeit one environmentally and socially important, margin by which farmers may respond to changes in landscape characteristics and associated changes in ecosystem service provision. Future studies could advance understanding by evaluating other potential outcomes (e.g., yields) and on-farm decisions (e.g., crop rotations), and by engaging with farmers and other stakeholders to identify social and economic impacts of and responses to widespread fallowing. Nevertheless, our results suggest that large changes in pesticide use on remaining, active crop fields are an unlikely consequence of increased short or long-term fallowing in the diverse croplands of California.

ECOSYSTEM SERVICES AND ENVIRONMENTAL PERCEPTION IN LAGOS IN NORTHEASTERN BRAZIL

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Historically, continental water resources have been used by human populations, being also the habitat of several living organisms. The permanent echoes of life, with an important role in the maintenance of life, among these are globally distributed, which are caused by the socio-economic impacts resulting from different uses. The study of this study analyzed how people perceive and identify the ecosystem services (ES) of these lakes, listing the use and occupation of their environments. Three natural lakes located in Ceará, northeastern Brazil, in different geoenvironmental units were selected for this study: Depression Sertaneja; Pre-Coastal Boards and Coastal Plain. In bibliographic survey of the SE of the investigated lakes and we used qualitative methods to investigate the local ecological knowledge (LEK) residents of their surroundings. These were calculated from the water in terms of the quality of measures: thought, from the quality of the appropriate measures, from a quality measure of the appropriate measures, from a result of total quality for the appropriate water, total turbidity, of total quality for adequate water and the identified ES, we used the salience index in the observations. The other populations identified four cultural services: maintenance of traditional knowledge; creation and maintenance of social relationships; personal satisfaction and highlighting the relationship of "belonging, kinship" with the lake, not recorded until then, as well as the loss of services due to environmental degradation. Local ecological knowledge about the environment is essential to understand how societies make decisions and handle nature and can serve as a basis for environmental planning and for the formulation of public policies for environmental maintenance and conservation.

THE BUZZ ABOUT SOYBEANS: IMPROVING POLLINATION SERVICES AND PRODUCTIVITY IN SOYBEAN CROPPING SYSTEMS

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As one of the most important commodity crops in the US, the expansive acreage of soybeans can provide substantial quantities of pollen and nectar for honeybees and other pollinators when in bloom. However, current management practices rarely consider potential benefits the soybean cropping system can provide to support pollinators, and, conversely, the possible yield benefits to soybean production through bee pollination. To evaluate the benefit honeybees, derive from and soybeans, we monitored 12 apiaries positioned along a gradient of agricultural landscape intensity in central Ohio through the summers of 2019 and 2020. Colony weight data were recorded continuously using automated hive scales to infer periods of nectar flow and dearth in the surrounding landscape. Pollen and nectar collected from study colonies were analyzed to identify floral resources utilized by honeybees. We observed a large weight increase and high proportions of soybean pollen in nectar samples collected in July from apiaries surrounded by highly agricultural landscapes. To evaluate the potential for honeybee pollination to improve soybean production, we installed two honeybee colonies in six soybean fields ranging from 17 – 133 acres in Ohio during soybean bloom in 2020. Again, abundant soybean pollen was detected in honey sampled from colonies situated in large fields, which also gained weight faster through the bloom period compared to those in small fields. Improved pod development was observed in soybean plants near the honeybee colonies and along field edges where wild pollinators were most abundant, although the effect was less pronounced in smaller fields. Our results suggest that soybean bloom plays an important role in summer honeybee productivity, and pollination by bees may improve soybean yield. Future research will focus on farm management strategies such as planting nectar-rich soybean varieties and integrating perennial pollinator habitats in the agricultural landscape to provide season-long floral resources and improve soil health. These strategies are expected to better support pollination services and improve honey production for beekeepers while benefiting soybean crop productivity.

BALANCING ECOSYSTEM SERVICES, ENVIRONMENTAL JUSTICE, AND ECONOMIC PROSPERITY IN ARIZONA

Hebin Lin

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The America the Beautiful Initiative, inaugurated by the President of the United States in January 2021, has achieved early progress across the nation in such focus areas as parks, habitat areas and corridors, trails, outdoor recreation, voluntary conservation groups, and local jobs. This presentation provides an overview of the efforts of the U.S. Bureau of Land Management in Arizona, focusing on the vision and practices of balancing the improvement of ecosystem services, addressing environmental justice concerns, and promoting economic prosperity. Two projects, the Black Canyon Corridor (BCC) Travel Management Plan and the Virgin River Canyon (VRC) Recreation Fee Business Plan, are used to illustrate how the vision is realized in practice, through innovative integration of management frameworks, interdisciplinary scientific inputs, communication flows, conservation and socioeconomic data tools, Geographic Information Systems (GIS) maps and story maps, community outreach, and policy development. The achievements in Arizona reveal three key success factors: (1) the identification of mutual impacts in space and in time between the ecosystems and human activities as a foundation; (2) the development and application of interdisciplinary and visual data tools as a driving force; and (3) the cultivation of a system of feedback for consensus-building among all stakeholders (leaders, managers, subject matter experts, communicators, the public, etc.) as an adaptation mechanism. In summary, the America the Beautiful Initiative, on the one hand, sets forth the challenges of meeting the goal of restoring, connecting, and conserving 30 percent of lands and waters by 2030 for our nation, and, on the other, inspires opportunities for innovative and collective commitments in transforming sustainable development visions into tangible actions. The progress in Arizona serves as a good example for balancing priorities as a valuable input to the process of completing this mission within the decade.

ACCELERATING THE USE AND VALUE OF PARTICIPATORY SCIENCE FOR ECOSYSTEM SERVICES

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Participatory science refers to a range of open engagement methods—such as citizen science, community science, participatory research, community-based monitoring, stakeholder engagement, traditional ecological knowledge, crowdsourcing, and prize competitions—that empower individuals, communities, and organizations to openly collaborate on a wide range of scientific challenges and societal issues. The ubiquity of web applications, mobile devices, low-cost sensors, and other emerging technologies as platforms to conduct these activities is making it more feasible to use these methods efficiently and effectively while accelerating scientific research efforts at local, regional, national, and global scales. Based on reviewing various scientific papers, projects, and tools from around the world, there is growing interest and potential to accelerate the use and value of participatory science for the science and application of ecosystem services. Participatory science methods are often used to: conduct scientific research in a cost-effective way, test ecological and environmental theories and experiments in local communities, identify and address data and knowledge gaps related to natural resources, assess and quantify ecosystem services at different spatial and temporal scales, collect local data and knowledge of ecosystem services, increase local participation and understanding of local ecosystem services, obtain public preferences and perceptions to assess ecosystem services, evaluate nature-based solutions for specific ecosystem services, improve and accelerate large-scale natural resource monitoring and management efforts, and inform local ecological and environmental decision making. However, there are still challenges with leveraging participatory for ecosystem services, such as: Data quality errors and biases from public-generated data from volunteers, lack of formalized practices leading to inconsistencies in methodological protocols, insufficient funding to support long-term community engagement efforts, developing training and capacity building resources to sustain these efforts. The presentation will provide the diverse ways participatory methods were used in the science and application of ecosystem services, the various levels of participation, the goals, and benefits for using these participatory approaches, and the challenges with applying these techniques to the science and applications of ecosystem services.

MONETIZATION OF HYDROLOGICAL ECOSYSTEM SERVICES FOR HYDROPOWER PRODUCTION: TWO STUDY CASES FROM THE TROPICAL ANDES.

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In Latin America, countries relying heavily on hydropower (HP) are also host to highly biodiverse and threatened tropical ecosystems. These ecosystems are a critical part of the global water cycle but also play an important role in regulating water and sediment flows. Cloud forest ecosystems are especially important by often contributing to a positive water balance and efficiently reducing sediment exports that may impact downstream HP generation assets. Given accelerating land-use change, alternative funding for the conservation of those services is needed. One option is the monetization of sediment retention and water flow regulation, which can be paid for by HP companies. This approach may create a financial incentive for the private sector to engage in upstream conservation activities while maintaining existing production capacity and thus decreasing the necessity to build additional HP plants. We tested this idea in two large HP assets (>1,000 MW) in the Eastern Colombia Andes. We developed a spatially explicit, hydro-sedimentological model to represent key processes at a daily temporal scale. A 30-year timeline was simulated to assess for differences in water and sediment flows, between 'Business as Usual' (BAU) and targeted scenarios of Nature-based Solutions (NbS). To monetize these changes, we assessed the impact on energy generation from changes in water flow and the operational costs generated by sediment yields in the reservoirs. Our results showed that the NbS portfolio generates insignificant increases in base flow, not reflected in electricity generation, and the reduction in sediment export would range from 8% to 21%. In financial terms, the cost/benefit ratios of implementing the conservation/restoration portfolio would range between 0.3x and 3.0x. We concluded that there are two primary implementation challenges to consider. First, the size of the NbS portfolio proposed ranges between 50K and 100K hectares to be implemented over 10 to 13 years with funding needs superior to USD 100M. Second, is the competition with grey infrastructure, with both companies on the path of increasing the level of water intakes, which rules out benefits from NbS by expanding reservoir lifespan beyond the timeframe of the project (~34 years). The financial viability of these approaches would be best guaranteed by adopting a landscape approach that would consider multiple ecosystem services and involve other key watershed actors such as water utilities.

VALUATION AND MANAGEMENT OF TOXIC HARMFUL ALGAL BLOOMS AT NATIONAL PARKS

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Harmful algal blooms (HABs) are proliferations of microscopic algae and/or cyanobacteria that may produce a wide variety of hazardous toxins. These toxins, along with the algae or bacteria, impair water quality and threaten the health of humans, animals and ecosystems. HABs pose unique risks to our National Parks system where healthy ecosystems and robust recreation are top priorities. 38% of National Park Service lands have experienced a HAB with most events producing toxin levels above the EPA's advisory thresholds for human health. This project builds a set of integrated biophysical and economic models for HABs' effects on ecosystem services on NPS units. The model identifies 10 ecosystem services impacted by HABs which led to changes in recreationist well-being. The models are dynamic and specific with each model characterized by its specific combination of HAB and park type. For each HAB/Park Type combination the model calculates the (per day) value of recreational impacts of a HAB before detection and the (per day) value of impacts of a warning and/or closure. Together, for a single HAB, the model can total the impact, in dollars, to inform dynamic management decisions. Using these models, I conduct case study benefit transfers for specific types of HABs (e.g., cyanoHABs, brown tides) on a variety of NPS park types. Each case study allows for melding the best science with ecosystem service valuation to answer management questions. We have 3 case studies which explore different questions. What is the value of increased monitoring to more quickly identify and manage HABs? Early results from Sleeping Bear Dunes National Lakeshore show identifying a HAB a week earlier can save nearly \$700,000 for a single HAB. What is the value of more accurate toxin information to managers? Early results from St Croix National Scenic River show that having more accurate toxin information can lead to better management decisions that save about \$400,000 over multiple HABs during a single summer. What is the value of increased effectiveness of water quality warnings? Early results from Padre Island National Seashore show that increasing compliance to warnings by 20% can lead to \$200,000 in benefits for a single brown tide HAB event. Together these results show the value of investment in monitoring, research, and cooperation between park managers and HABs researchers.

THE IMPORTANCE OF SHADE TREES IN PROMOTING CARBON STORAGE IN THE COFFEE AGROFOREST SYSTEMS OF PUERTO RICO

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It has been suggested that agroforestry practices may provide a tool to address the various stresses associated with anthropogenic pressures on the environment, from promoting biodiversity to increasing carbon storage in agroecosystems. The purpose of this study is to describe the variation of the carbon (C) stock in the coffee agricultural landscape of the Cordillera Central region of Puerto Rico, exploring the relationship between agroforestry management practices and the farms C stocks distribution. We estimated the total carbon stock for 68 farms distributed throughout the coffee-growing region of Puerto Rico by combining the carbon content in the soil, shade trees and the main crops (coffee, plantain, and citrus). We note that 38 of the farms used in this study incorporated shade trees into the management of their systems, while the subsequent 30 did not. We found that soil organic carbon contributes the greatest amount of C on a per farm basis (~ 70% on average), but this is conditional on the management of the farm, particularly if a farm has shade trees. Farms that included shade trees had larger overall pools of carbon. We note that shade trees account for almost all the variability in C storage in the region, as the other pools of carbon measured in this study were relatively constant. We show how management practices influence the pools of C across the farms studied, as well as the variable impact of including trees in the coffee agroecosystem. This study demonstrates that adopting agroforestry practices in this region's coffee farms would help reduce the carbon footprint and contribute other known benefits that can make agroecosystems more resilient to climate change. As the first study of its kind in Puerto Rico, the information presented here is critical to assist in making decisions regarding the adoption of shade trees in coffee farms in the region.

GETTING OFF THE LADDER: DISENTANGLING WATER QUALITY INDICES TO ENHANCE THE VALUATION OF DIVERGENT ECOSYSTEM SERVICES

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Many economic valuation studies and Federal cost-benefit analyses of water quality build from pioneering work using a “water quality ladder” or single water quality index (WQI) to characterize both current conditions and effects of policies. However, a ladder or index that monotonically combines disparate ecosystem services and is divorced from underlying ecological production functions can result in misguided valuation results and policies. We address this by testing alternative approaches that separate and value changes in distinct ecosystem services stemming from policies with small to moderate changes in water quality. The indices we test are explicitly linked to nutrient loadings in Michigan’s rivers, lakes, and Great Lakes. Our split-sample experiment compares results of contingent valuation surveys for treatments with two versus three quality metrics. The key distinction is that the two-index survey, like many existing studies, aggregates sub-indices for water contact and fish biomass scores into a single WQI, whereas the three-index survey separately utilizes both. Our results suggest changes in water contact attributes (reflecting changes in water safety and clarity) are valued differently from changes in biomass of fish targeted by recreational anglers. Aggregating changes to these two distinct ecosystem services using a single WQI yields consistently lower benefit estimates across a range of underlying changes. In valuation scenarios with small changes in overall water quality, the WQI-based benefit estimates can differ by a factor of 20 from benefits measured by decomposing the index and valuing the disparate sub-indices, differences which might change balance of benefits and costs in regulatory evaluations.

TIME TO TAKE STOCK

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Much of the work on natural capital assessment and accounting has emphasized monetary values rather than changes to state of natural capital assets themselves. Consequently, the distinct features and benefits of effectively measuring changes in natural capital assets are neither adequately surveyed nor widely known. This working paper stakes stock of this work, capturing these features and benefits so they can best complement the ongoing natural capital efforts. Natural capital assessment methods rarely treat stocks of natural capital as assets in a complete way nor do these methods have standardized rules such as those used in financial accounting. As a result, measures of the stocks are generally incomplete, methods inconsistent and results more difficult to compare and consolidate into a single statement for an organization or business unit. In response, *Time to Take Stock* begins working towards a clear, precise, and pragmatic concept of “natural capital accounting,” or “corporate natural capital accounting (CNCA)” when applied to business or public organizations. A sequence of seven steps or “standardization” that are necessary for undertaking CNCA. The seven CNCA standardizations help ensure that CNCA considers all natural capital assets, including ecosystem types (e.g., forests, wetlands, coral reefs) and their components (e.g., timber, soil, water, species, gases, chemicals). Because of the use of classification systems, the seven CNCA standardization also ease measurement of both interactions among components within ecosystems as well as interactions among ecosystems. Moreover, when resources limit measurement to an incomplete set of components (e.g., soil, water), the standardizations provide a framework for incorporating additional data or improving methods at later dates. In total, the application of the seven CNCA standardizations will improve valuation, support better integration of risks into decision making, enhance opportunity identification and improve the interoperability of data.

VALUING ECOSYSTEM SERVICES FROM U.S. CATTLE RANCHES AND FARMS

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The 2017 United States (U.S.) Census of Agriculture estimated over 640,000 beef cattle ranches and farms in the U.S. Societal benefits of beef cattle ranching extend beyond beef production and include less commonly quantified ecosystem services such as wildlife habitat, recreation and open space amenities, spiritual values, and sustaining a way of life. The Sustainable Rangelands Roundtable led an assessment of the economic value of U.S. beef cattle ranching based ecosystem services: 1) forage production, 2) general ecosystem services (estimated from Conservation Reserve Program Grasslands payments), and 3) wildlife recreation. The 2019 effort provided a valuation of ecosystem services associated with privately-owned rangelands and pastures used by U.S. beef cattle ranches and farms – a national value of \$14.8 billion, or \$726.01 per beef cow and \$0.86 per pound of retail beef. State values were also calculated. Results are available at www.sustainable-rangelands.org/wp-content/uploads/2019/11/B-1338-economic-value_web.pdf as a report, *National and State Economic Values of Cattle and Farming Based Ecosystem Services in the U.S.* This publication was based on 2012 Agricultural Census data. The second phase expands findings by using 2017 Agricultural Census data and incorporating ecosystem service values associated with public lands' grazing. U.S. beef producers purchased 8.2 million AUMs on approximately 193 million acres of Bureau of Land Management grazing allotments in 2017. Forest Service grazing is additional. Acreage incorporated in this second valuation will be more than 1.5 times the acres considered in the first part of this study. The value of ecosystem services from combined public and private grazing lands used for beef cattle production likely will be significantly greater than the \$14.8 billion previously calculated. However, this valuation is still conservative, meriting further research, because not all ecosystem services provided by grazing lands used for beef production can be valued at present. Support was provided by the Beef Checkoff.

HOW MOBILE DEVICE DATA CAN INFORM OUTDOOR RECREATION MANAGEMENT

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Effective management of outdoor recreation sites relies on allocating limited maintenance and operations resources to areas of relatively high recreation demand. For recreation sites with limited access points (e.g., Washington State Parks), estimating visitation is accomplished through surveys, vehicle counts, or in-person observation. However, tracking visitation on millions of acres of recreation lands that often have multiple entry points (e.g., many sites managed by the Washington Department of Fish and Wildlife or Washington Department of Natural Resources) is a different challenge altogether. Deploying conventional visitor counts on these “porous” properties requires significant time and resources. Location-enabled mobile device data offers a tractable means of estimating visitation for these lands. Using statewide mobile device location data for the 2019 and 2020 calendar years, we were able to produce monthly visitation estimates for almost all state-managed lands by calibrating statistical models to on-site visitor counts (e.g., campground check-ins, road counters) and other locational data (e.g., site amenities, weather, air quality). This level of spatial and temporal resolution can be particularly useful when attempting to monitor changes in visitation associated with factors such as public health, road work, or changed or expanded visitor amenities.

THE ECOSYSTEM SERVICES BENEFITS OF COMMUNITY-DRIVEN GREEN INFRASTRUCTURE: INSIGHTS FROM THE WATER WISE MODEL IN NEW ORLEANS

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In New Orleans, the Greater Tremé Consortium (Water Wise Tremé), Healthy Community Services (Water Wise 7th Ward), and Upper 9th Ward Bunny Friend Neighborhood Association (Water Wise Upper 9th Ward) in partnership with Water Wise Gulf South (WWGS) have planted over 501 trees and implemented over 151 green infrastructure projects between 2013 and 2021. These projects have added more than 50,603 gallons of stormwater retention capacity to areas of New Orleans which are frequently flooded. Earth Economics (EE) with the Greater Tremé Consortium, Healthy Community Services, and Upper 9th Ward analyzed the value of existing and planned green infrastructure installations to provide data-driven evidence for engagement with the City of New Orleans and prospective funders to increase installations of community-driven solutions. The analysis found that adding green spaces with community-proposed green infrastructure projects will provide an additional \$131,000 to \$848,000 in ecosystem services benefits to the local and regional community, contributing a total yearly benefit value between \$1.3 million and \$17.8 million.

ECOSYSTEMS SERVICES SUPPLY BY AGRICULTURE: USING CHOICE EXPERIMENTS TO ESTIMATE TRADE-OFFS BETWEEN MONETARY AND NON-MONETARY INCENTIVES

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Payments for ecosystems services (ES) have been used worldwide to incentivize land managers to adopt more sustainable land uses and management practices. However, recent empirical evidence shows that land managers preferences towards monetary payments are probably overrated. Public funded access to farm advisory services (knowledge services) appears to be highly valued by farmers because the adoption of more sustainable land management practices to be successful requires intensive knowledge services. Climate change adds complexity to decision-making, due to trade-offs between ES. Hence, land managers, and farmers, need knowledge to support their decisions. Non-market valuation methods, such as Choice Experiments (CE) have been applied to estimate farmers, and other type of land managers, willingness to accept (WTA) monetary compensation to adopt sustainable land managing practices, including conservation agriculture. This paper shows how this method can be used to assess trade-offs between the WTA monetary compensation and the public funded supply of advisory services, accounting additionally for subjective socio-psychologic variables, such as perceptions or emotions. Hence, the paper goals are twofold. It aims at showing that CE can be useful to measure trade-offs between different type of policy incentives and to identify the ones or the mix showing more effective to influence land managers decision-making towards sustainability transitions. Another goal is to provide empirical evidence for policy recommendations on European eco-schemes intended to enhance farmer's supply of ES. The survey was conducted in the Mediterranean Uplands in Portugal. These landscapes are extremely vulnerable to climate change entailing trade-offs between the supply of different ES. A questionnaire was designed to implement CE also collecting farmer's perceptions (latent variables). A total of 253 valid questionnaires were obtained. Data analysis showed farmers are willing to exchange monetary compensations for knowledge services, when more demanding soil conservation practices are at stage. Results also show farmer's perception of higher knowledge needs increases WTA, and that being socially acknowledged reduces WTA. Fire risk perception increases WTA and the perception of collective effort to reduce fire risk at landscape level reduces WTA. The results enable to produce recommendation on more effective incentives mixes beyond simpler ES payments.

TRENDS IN ECOSYSTEM SERVICES ASSESSMENT AND EVALUATION FOR NATIONAL FOREST PLANNING

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The 2012 National Forest Land Management Planning rule directs National Forests and Grasslands to assess and account for ecosystem services when developing management plans. National Forests and Grasslands encompass a spectrum of ecological, social, and cultural communities facing diverse needs, stressors, and risks. Various methods and indicators are used to describe ecosystem services, values and benefits to the communities or user groups identified within National Forest areas of influence.

Several National Forests have completed assessments, Environmental Impact Statements, and final plans under the 2012 Rule, providing examples of how forests from different regions of the country are characterizing ecosystem services and establishing a more transparent foundation for describing benefits people receive from those services. Various classification systems can be adopted, ranging from comprehensive schemes based on the United Nation's Millennium Ecosystem Assessment, to hybrid systems incorporating concepts from systems such as the Montreal Process or USEPA's Ecosystem Services Classification System (2015). Indicators of goods and services include proxies derived from readily available biological or ecological information and monitoring data, or more direct measures of service benefits incorporating geospatial data reflecting beneficiary populations or service use. Values and benefits are characterized using a range of approaches from simple proxies based on resource conditions to more detailed data regarding resource use, prices, and beneficiary demographics. Benefits are presented using overlay maps, tradeoff tables, and qualitative discussions. Services considered include water supply, recreation/cultural experience, air quality, energy/mineral production, health/wellness, forest products, biodiversity, and wildlife. The assessments and analyses reveal the challenges of modeling ecosystem services and benefits when National Forests have limited data, time, and resources.

We will present an overview and insights on the approaches and indicators used to address ecosystem services, beneficiaries and values in National Forest planning efforts, shedding light on potential trends and needs regarding ecosystem service methods and data. Material presented should provide context to help frame discussion about the potential relevance and feasibility of applying new evaluation or analytical methodologies being considered or proposed at this conference and elsewhere.

MEASURING THE IMPACTS OF COASTAL RESTORATION ON PEOPLE: HOW MUCH IS CHANGING, AND FOR WHOM?

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Funders, government agencies, and restoration practitioners are increasingly interested in assessing social and economic (S&E) outcomes of environmental projects, specifically restoration projects and nature-based solutions. While ecological monitoring is common, monitoring ecosystem service (ES) outcomes (the S&E outcomes of natural system changes) is not. Thus, projects are unable to track how they affect wellbeing. Barriers to consistent ES monitoring include lack of standardized metrics and methods. The National Ecosystem Services Partnership (NESP) has been involved in multiple recent projects that aim to advance monitoring of S&E benefits of coastal restoration and nature-based solutions. We (1) reviewed the S&E metrics identified in existing programs, (2) developed conceptual models to link project types to important social and economic outcomes, (2) identified common metrics across similar project types, and (3) synthesized methods for measurement. These measurement methods describe how to track how much ES are changing based on a particular project, and to whom those services are distributed to and accessible for. This presentation will introduce and describe the results of, and resources developed for three such projects. A project to advance standardized S&E monitoring of post-Deepwater Horizon restoration projects in the Gulf of Mexico. Results include tools that enable identification and assessment of S&E outcomes and linked metrics and measurement protocols for over 20 common restoration project types. A project in collaboration with the NOAA Damage Assessment Restoration and Remediation Program to develop methods for assessing the effects of oil spills on ES important to fishers who may be underrepresented in current damage assessment processes. This information could help post-oil spill restoration decisions. And in partnership with the NOAA Office of Coastal Management, creation of an online clearinghouse for identifying common ES outcomes of specific project types and associated resources that could aid in the development of metrics to monitor those outcomes. More consistent monitoring of the S&E outcomes—including distribution of and access to those outcomes—for restoration and nature-based solutions projects will provide important information that can help scientists, funders, and the public fully appreciate and document the ways that these projects affect human wellbeing.

NATIVE CLIMATE SEEING CLIMATE RESILIENCE THROUGH NATIVE AND WESTERN SCIENCE EYES

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“Our ancestors left this land to us, and we are only borrowing it from our children. For this reason, as we make decisions that affect the land, we must consider the consequences those decisions will have for the next seven generations, at least.” (Salish Tribal Elder in the 2022 CSKT Climate Change Plan)

Tribal farmers and ranchers, in the West are increasingly challenged by major climate drivers - heatwaves, extreme winds, droughts, wildfires, and floods. Climate impacts to tribal agriculture include declining snowpack, longer, hotter growing seasons with less spring runoff for irrigating crops, reduced crop yields due to intense heat, more pests, and increased evapotranspiration, degraded range and grasslands for livestock grazing, less frequent and more intense monsoonal rains, and increased frequency and intensity of catastrophic wildfires. Climate resilience is not a new concept to Native and Indigenous communities in North America. They have experienced and adapted to extreme climate shifts for millennia. In doing so they recorded observations from thousands of years living on landscapes transformed both gradually and precipitously by changes in climate. In turn, they passed on to future generations wisdom about how to adapt to these changes through stories, practices, and traditional ecological knowledge (TEK). Western scientists and climate resilience champions have much to learn from TEK if they are willing to “see with both eyes.” One that sees the world through a reductionist lens of data gathered and interpreted by western science and the other through a holistic lens of Indigenous wisdom. Both eyes are needed to envision ways for communities to adapt to a warming world. This presentation will describe approaches to enhancing climate and agricultural resilience by listening, learning, sharing, and applying knowledge derived from both western and Native science and applying this knowledge.

CARBON, COFFEE, AND CLIMATE JUSTICE: RESULTS FROM A 10-YEAR PAYMENT FOR ECOSYSTEM SERVICES (PES) PROJECT IN HAITI

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The overlapping challenges of our changing climate, ecosystem degradation and social inequity can seem insurmountable in pursuit of sustainable economic development. Are there approaches that can make progress across a suite of goals? We believe such an approach exists through an effort between the University of the South (Sewanee), the Haitian non-profit Association Zanmi Agrikol (AZA) and 50 farmers in Haiti’s Central Plateau, a region challenged by decades of deforestation. This partnership has (i) raised household incomes and reduced charcoal-making, (ii) encouraged more climate-resilient agroforestry systems; (iii) provided Sewanee with verified carbon offsets; (iv) trained students in carbon offset verification and in issues of environmental justice. Farmers are provided with trees and technical support from AZA. The carbon sequestered in their trees is quantified through surveys conducted by students and AZA staff. Payments from Sewanee’s Green Fund are made to farmers to offset travel-related CO₂ emissions. The farmers have planted over 12,000 trees that have sequestered >500 metric tons of CO₂-equiv and increased the carbon stored on farms by up to 2000%. In 2019, 120 tons of sequestered CO₂ offset airline emissions from 7 years of project travel between Sewanee and Haiti. Farmers now sell coffee and \$15,000 will be paid to the 50 families for carbon offsets in 2022. Hundreds of Haitian and Sewanee students have participated by conducting surveys and research. This study shows that paying small farmers produces meaningful carbon offsets, incentivizes ecosystem service provision and improves livelihoods. As collaborative partners, universities can play a pivotal role in supporting PES projects that provide transformative educational experiences to advance climate justice, a model that can be adapted and scaled to other situations.

WATER QUALITY OFFSETTING – CHALLENGES AND POTENTIAL FOR ALLOWING ECONOMIC DEVELOPMENT WHILE PROTECTING ECOLOGICAL ASSETS

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Water quality offsetting is one approach to counterbalance the impact of expanded economic development on the regulating ecosystem services which maintain water quality. Offsets aim to reduce water quality pollution through either change in land management practice, or rehabilitation of riparian and aquatic ecosystems. However fundamental knowledge gaps exist when determining the situations in which point source water quality discharges from development can be effectively offset by addressing diffuse source water quality pollution at other locations.

The Great Barrier Reef in Queensland, Australia is the world's largest coral reef ecosystem. However, it is impacted by poor water quality from current and expanding agricultural and industrial development. The Queensland Government recently enacted regulations to allow water quality impacts from such development to be offset through water quality improvement actions elsewhere. The Reef Catchments Science Partnership (the Partnership) was established as a collaboration between the University of Queensland and the Queensland Government to facilitate the implementation of these regulations.

The Partnership reviewed water quality offsets in Queensland and internationally and found it can be difficult to obtain sufficient information on how ecological processes maintain water quality and how water quality may improve from offset activities. For ecosystem rehabilitation, there are substantial challenges in determining the most appropriate type of offset and optimal location and estimating the offsets effectiveness. Despite these challenges, water quality offsets have the potential to allow continued economic development while maintaining or improving water quality and deliver substantial co-benefits. We provide recommendations for when decision makers can have more confidence that water quality offset actions would achieve their desired outcomes, and when additional information would be needed to confirm their effectiveness.

URBAN HEAT ISLANDS AS WINDOWS INTO CLIMATE CHANGE AND ECOSYSTEM SERVICE PROVISIONING BY STREET TREES

Emily K. Meineke, Mark N. Lubell, Alessandro Ossola

Trees provide critical ecosystem services to urban residents, such as local cooling, air purification, and runoff reduction. It has long been appreciated that urban trees are under threat from stressors associated with both urbanization and climate change. What is not known, however, is the extent to which tree species currently planted in urban areas will continue to provide ecosystem services as the climate warms, precipitation shifts, and urbanization intensifies. Here, we propose to apply an experimental framework that harnesses existing urban heat gradients as analogs of future climate conditions to infer how climate change might affect local cooling services provided by popular and commercially important urban trees species. For selected tree species we will assess key metrics describing their capacities to reduce local temperatures, including metrics of growth and shade quality. This work provides a blueprint for determining how escalating heat may affect ecosystem services provided by urban trees across US cities.

MAPPING LIVESTOCK AND POULTRY PRODUCTION BY COUNTY WITH THE USDA CENSUS OF AGRICULTURE

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Livestock and poultry production is a critical part of the agricultural economy of the United States, providing meat, eggs, milk, fur, wool, and leather goods. Such production relies on crop yields, which in turn rely on ecosystem services like fertile soil and pollinators. However, livestock and poultry production may be detrimental to public health, contributing to problems in water and air quality, greenhouse gas emissions, infectious disease outbreaks, and the spread of antibiotic resistance in pathogens. Therefore, understanding the distribution of these facilities is pertinent to the U.S. economy and the health of its people.

EnviroAtlas (<https://www.epa.gov/enviroatlas>) introduces a suite of layers mapping livestock and poultry production by county based on the USDA Census of Agriculture (CoA). The new layers help fulfill EnviroAtlas's goal of providing access to geospatial information on ecosystem services while supplementing other layers already within the catalog. As the authoritative source on agricultural facilities, the CoA provides metrics by county, counting any farm selling \$1,000 or more in products annually. Depending on the animal sector, the CoA collects the number of heads present on the farm at the end of the Census year (Inventory) and/or the number of heads sold by the farm during the Census year (Sales). We processed maps for 11 sectors: all cattle, beef cattle, dairy cattle, calves, swine, laying hens, broiler chickens, turkeys, ducks, sheep, and horses. These EnviroAtlas maps display Inventory data for all sectors except calves and broiler chickens, which rely on Sales data. For each sector, the number of heads and the number of operations is reported by county. Also, for all sectors except turkeys, ducks, and horses, operations are further categorized as small, medium, or large, based on the number of heads managed/sold. EnviroAtlas displays the most recent year (2017) with additional years for download (2002, 2007, and 2012).

By providing the CoA data as geospatial layers via EnviroAtlas, users can see the distribution of livestock and poultry in their areas of interest and combine it with demographics or data about other ecosystem services like floodplains, water quality, and air quality. Future research might focus on ways to spatially refine metrics reported by the CoA from the county-scale to finer spatial scales to increase relevance and applicability to specific communities.

ASSESSMENT OF THE AQUATIC ECOSYSTEMS FOR IMPROVED ECOSYSTEM SERVICES PROVISION IN KANO, NORTH-WESTERN NIGERIA

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Aquatic ecosystems are significant for providing numerous ecosystem services that benefit man all over the world but these resources are threatened by reduction in quantity and pollution. This consequently leads to human health conditions, poor crop production and loss of aquatic biodiversity. This has reduced the ability and capability of this resource to provide the necessary services hence this study aims at mapping and assessing the aquatic ecosystems in Kano with a view to improving their viability for the people of Kano state, Nigeria. The study performed a supervised classification on the LANDSAT 8 image of Kano state to locate the larger aquatic ecosystems like rivers and dams. For the others, the direct digitization technique using latest Google Earth Image (version 10.7) and National Space Research Development Agency (NASRDA) land use map of the state was used. The study found out that rivers and streams, reservoirs and ditches have area coverage of 117km², 346km² and 8km² which represent 22.7, 67.2 and 1.2 % of the land area covered by the aquatic ecosystems respectively. The results also showed that most of these ecosystems occur on an average altitude of between 430-460m above mean sealevel. The number of rivers and streams that occur in Kano is more than 50, 17 major reservoir and 78 for ponds. The results concluded that these ecosystems are threatened by contamination, poor management, waste disposal, high levels of siltation and sedimentation, among others which limits their ability to provide the necessary ecosystem service. Therefore the study recommends immediate intervention of the authorities in curtailing these threats and introduces necessary policies to boost their services production.

ESTIMATING THE ECONOMIC VALUE OF ECOSYSTEM SERVICES FROM GREAT LAKES COASTAL WETLANDS FOR RESTORATION DECISION-MAKING

Lou Nadeau

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The freshwater wetlands of the Great Lakes play a critical role in the lacustrine ecosystems of the region. They provide numerous services including fish and wildlife habitat, water quality improvements, erosion protection, stormwater and flood storage, and recreation opportunities. Human activities along the shores of Lake Erie and Huron impact coastal wetland habitat areas and reduce their ability to provide valuable ecosystem services. Of all the Great Lakes, Lake Erie supports the largest population and experiences the greatest stress from urbanization, industrialization, and agriculture. This presentation will discuss work performed by Eastern Research Group, Inc. (ERG) to develop an approach for valuing ecosystem services from coastal wetlands using existing valuation literature combined with detailed ecosystem modeling. The project focused on freshwater coastal wetlands from Saginaw Bay to the western Lake Erie. ERG used the Natural Capital Project InVEST modeling tool to assess how changes in ecosystem health would translate into ecosystem functioning. Along with that detailed modeling, ERG performed a series of stakeholder meetings to gauge interest in which ecosystem services were most important. Finally, ERG applied benefit transfer method to place economic values on the changes in ecosystem functions derived from the modelling. The result was a set monetary values of specific ecosystem services for 598 polygons over the project area. These detailed data can be used in setting restoration priorities. This presentation will discuss the process used in developing the project, detailed information on the outcomes from the project, and a discussion of how these results can be used in decision-making.

THE EFFECTS OF LIVESTOCK GRAZING ON SOIL HEALTH AND CARBON IN SEMI-ARID RANGELANDS

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Currently, there is growing interest in working landscapes sequestering soil organic carbon (SOC) to mitigate climate change. In Utah, where rangelands comprise 80% of the state's land area, livestock grazing has led to a loss of SOC across 17% of the state's vital agroecosystem under public ownership. Because SOC is also the primary indicator of soil health, such loss both lowers soil quality and reduces global climate resilience. A management strategy with the potential to balance grazing and SOC sequestration is the implementation of grazing practices that minimize livestock's physical impacts on rangelands and rangeland processes. There is currently wide-spread doubt, however, about whether such methods will be effective in semi-arid rangelands. We thus examined how the presence, duration, and timing of grazing can meet this goal in northeastern UT. We measured infiltration, bulk density, and SOC stocks in riparian and upland areas. In riparian areas, we found infiltration was fastest, bulk density lowest, and SOC stocks highest in both enclosures with no grazing and in pastures that were grazed for short durations. This was likely due to the absence of, or relatively short amount of time, livestock were present. Reduced disturbance minimizes the extent of soil compaction, enabling water to enter the soil and – in part – fuel the microbial communities responsible for processing and storing SOC. In upland areas, infiltration, bulk density, and SOC stocks were highly variable. On average, bulk density was lowest in pastures grazed for short-durations relative to long and in pastures grazed late in the season relative to early. The low bulk density in late-grazed pastures is likely due to low soil water content when livestock were present. Wet soil will compress more than dry when exposed to livestock traffic. Finally, SOC stocks were, on average, highest in upland pastures grazed for short-durations relative to long. As in riparian areas, this is likely due to the short amount of time livestock were present on the pastures. These results suggest that reducing the duration of livestock grazing and shifting its timing are effective strategies to improve soil health and increase SOC stocks. If so, with the evolution of C markets, focusing on managing grazing duration and timing may provide a model to recapture lost SOC. This could offer producers a source of funding that supports both rural communities and rangeland stewardship.

HOW TO MAP WHAT MATTERS: ENVIROATLAS

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Effective input to environmental decision making requires access to relevant, appropriate, and vetted data. The EnviroAtlas, one of several related tools developed by USEPA, is a portal containing a wealth of geospatial data, easy-to-use tools, and other resources useful to decision-making within an ecosystem services framework. An Interactive Map provides a mechanism for data discovery and analysis and an Eco-Health Relationship Browser provides an interactive mechanism for a user to explore scientific evidence showing the linkages between ecosystems, ecosystem services, and human health outcomes. The data contained within EnviroAtlas are consistently derived across the nation. Many of the data layers are partially derived from satellite imagery for which each data point represents a 30 by 30-meter grid cell on the ground. Higher resolution data, with each pixel representing a 1 by 1-meter grid cell, are available for featured locations across the US. Other data layers are derived from the US Census data including a population density layer that intelligently downscales population counts from Census geography to 30-meter pixels. Spatially explicit population data can help lead to a better understanding of the ecosystem service production/beneficiary dynamic.

This presentation will briefly introduce EnviroAtlas but will mainly focus on how it has evolved since the last ACES meeting. It will cover several examples of new data, tools, and outreach materials including education modules. One of the tools to be presented allows the users to calculate ecosystem services metrics for any geography of interest. The presentation will also cover how the EnviroAtlas can be used in conjunction with the other tools in this session.

FEATURES OF DIVERSE AND PRODUCTIVE AGRICULTURAL SYSTEMS: BIOPHYSICAL AND HUMAN DIMENSIONS OF CROP PRODUCTION IN US COUNTIES

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A growing body of literature suggests that diversification of agricultural systems benefits crop yields by supporting ecosystem services. However, across broader areas in which crop fields are embedded, diversification may also impact farm management strategies, access to governmental resources, and interactions across farms. Some of these human factors may alter the crop yield benefits of diversification observed at larger scales, while some point to potential challenges to diversification. However, little is known about what distinguishes diversifying and simplifying agricultural systems, or what distinguishes diverse and productive agricultural systems from those that are not diverse but still productive. Our research aims to elucidate the barriers and bridges to diversification of agricultural systems and the impact of biophysical, social, economic, and farm management factors on the benefits diversification provides to crop yields across landscapes. We present preliminary results from semi-structured interviews with agricultural professionals and farmers from U.S. counties that have recently diversified or simplified, and the results of an archetype analysis of U.S. County diversity-productivity character that point to potential limitations and challenges to diversification of agricultural systems resulting from a complex interplay of biophysical, regulatory, and economic considerations. These findings may support identification of strategic locations in which to target agricultural diversification efforts and regulatory pathways towards encouraging diversification.

HOW TO MODEL WHAT MATTERS: FECS AND THE ECOSERVICE MODELS LIBRARY

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In an ideal world, there would be ample time and money to measure all final ecosystem goods and services (FECS) that matter in each scenario. In the real world, time and money are often limited. After using the FECS Community Scoping Tool and the FECS Metric report to identify the FECS and metrics that matter the most in each scenario, it may not be feasible to measure them all so modeling may be a useful alternative. The FECS Voltron includes the EcoService Models Library (ESML, <https://esml.epa.gov/>) to help users find models to estimate the production of ecosystem goods and services. The ESML is a database containing descriptions of over 250 ecological models, their variables, and the source documents that describe them. Relationships potentially described as “ecological models” can vary widely in complexity, presentation, and subject matter. Some are elaborate simulation tools with software, manuals, and websites; others are simple equations not found beyond the pages of a journal article. Typically, an “ecological” model can draw from a single discipline (e.g., a predator-prey interaction in ecology) or many (e.g., including physical-chemical-biological, and potentially social-political-economic, elements). This presentation will include a demonstration of the ESML using the scenario of a community planning beneficial reuse of a capped landfill site. Models were found using the common language of the FECS Voltron, the National Ecosystem Services Classification System (NESCS Plus), as well as several of the 20 other ESML filters. Models were compared and evaluated for applicability to this case study using a variety of detailed descriptors that help users understand the modeling approach, environmental context, level of effort and expertise required, and the level of uncertainty in the produced results. The ESML also features Variable Relationship Diagrams, which are available for each model in ESML. These Variable Relationship Diagrams are conceptual models that show the inputs required to run each model (referred to as “Predictor Variables”) and the outputs you get from running the model (“Response Variables”) as well as arrows that show the logic and interrelationships of the variables. Additionally, where potentially appropriate, ESML includes links to EnviroAtlas data layers that could be potentially useful as model inputs. For the landfill case study, the Ecosystem Services Identification and Inventory (ESII) Tool, Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Carbon, InVEST Pollination, and Grassland Bird models were used to compare a native grassland revegetation scenario vs. the status quo to estimate differences in several different ecosystem services (e.g., erosion control, pollinators, birds, carbon storage).

ECOSYSTEM SERVICES AND OFFSHORE OIL & GAS AND WIND STRUCTURES

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When conducting commissioning/decommissioning studies (of oil & gas or wind structures), it is critical that we consider long-term provision of ecosystem services by the structures, considering all technically feasible options that could maximize these services while managing site risks. Subsea structure has been documented to provide significant ecosystem services including, but not limited to fish and benthos production/refuge, marine mammal feeding, and regional biological connectivity. With many species on decline in the face of climate change, commercial fishing pressures, and reduction in natural reef areas, offshore infrastructure can function as de facto marine protected areas. This session will explore the evolution of assessment approaches, use cases, and regulatory frameworks associated with ecosystem service value as they have been integrated into offshore energy infrastructure commissioning and decommissioning decision-making. Incorporating the flow of ecosystem services over time is critical when considering commissioning and decommissioning alternatives, primarily because the decisions will directly and indirectly affect future generations. Using ecosystem service value alongside site risk mitigation metrics in decision-making can provide the greatest overall benefit to society, government, and operators, both current and future, addressing the core concerns of sustainable development. Through a combination of case studies, literature review, and subject matter expert experience, we will discuss win-win solutions for the public, operators, and the government in various global contexts and areas to improve existing processes. The approaches discussed in this session will support operators, regulators, and other stakeholders in making decisions that maximize the flow of ecosystem service benefits while managing site risks.

The topics discussed by panelists will include, but are not limited to:

Joseph Nicolette – Incorporating Ecosystem Service Valuation into Offshore Structure Decommissioning Decision-Making.

Mark Rockel - Incorporation of Natural Resource Economics for Ecosystem Service Valuation.

Paul Krause – Legislation Focusing on Ecosystem Services and Offshore Structure Management.

Larry Johnson - Offshore Commissioning, Decommissioning and Doing the Right Thing – Operator Perspective; and

Kristen Strellec - Big Picture of Ecosystem Services and Incorporation into BOEM's Strategy and Framework.

PRIVATE LAND CONSERVATION: A PUBLIC-PRIVATE PATHWAY TO PRESIDENT BIDEN'S 30 BY 30 CONSERVATION GOAL

Joseph Nicolette¹, Dr. Peter Kareiva², Mark Bailey³, Dr. Mark Rockel¹, Dr. Lydia Olander⁴/Katie Warnell⁴, and Justin Heitmann⁵

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Through a combination of literature review, field data collection, analysis, and economic valuation we demonstrate the public interest value of conservation easements on private property. Understanding the public interest value of these properties is important to a variety of stakeholders, including policymakers, private landowners, land trusts and other conservation organizations, and environmental economists. The session will begin with a 20-minute video demonstrating the concepts to be discussed by the panelists. The Institute for Research on the Economics of Taxation (IRET) assessment of the need for private property conservation asserts that land conservation will ultimately boil down to rewarding the private landowner who conserves the public interest. Why? Our panelists will answer this question as the potential public benefits of conservation easements on private property are enormous. The panelists will discuss data-driven approaches for assessing how conservation easements' natural characteristics and ecosystem services relate to their public economic interest values. Assessing private land conservation to maximize public interest values illustrates how public-private partnerships can pave the way to achieving President Biden's 30 by 30 goal for land conservation. The discussion will include, but not be limited to importance of Private Land Conservation in Meeting 30 by 30 Goals, Field Data Collection to Support Land Conservation, Land Conservation Economic Valuation and Methodology, GIS Ecosystems Service Mapping and Connectivity, and High-Resolution Drone Data Collection. Public interest values are comprised of active and passive uses, and private versus public conserved properties can have distinct contributions to land conservation goals and public interest value. Demonstrating the public interest value of land conservation should encourage the adoption and continued incentivization of conservation easements. The applications of these approaches are consistent with federal policies surrounding the value of actions that affect the environment such as land preservation and conservation, as well as actions that negatively impact the environment. As such, these methodologies provide a practical framework from which to understand the public interest value of conservation easements.

CROSS-SECTOR WATER COLLABORATIVES: A CRITICAL ECOSYSTEM MANAGEMENT TOOL IN A RAPIDLY CHANGING WORLD

Ethan Brown, Nicole Maness, Emerson Ringger, and Sara O'Brien
Willamette Partnership, Portland, Oregon

The purpose of this oral presentation is to share the authors' experience with agriculture-utility water partnerships and other cross-sector collaboratives as a key tool in modernizing water management in the increasingly challenging environment facing local- and state-level decision makers. These challenges include failing infrastructure, climate disasters, environmental justice and equity concerns, and a policy and funding environment that sometimes creates perverse incentives that undermine provision of ecosystem services.

The presentation will outline some benefits and challenges of cross-sector water collaboratives and examples of collaboratives that are helping local partners navigate these challenges. Results, conclusions, and recommendations will highlight a set of enabling conditions that the authors believe could better support emerging partnerships and institutionalize and scale cross-sector collaboration.

The authors share a combined 40+ years of experience in designing and operating ecosystem services markets and will frame the work discussed here as a next phase of evolution in ecosystem services implementation.

IMPACTS OF LAND OWNERSHIP AND FOREST FRAGMENTATION ON FORESTLAND'S WATER-RELATED ECOSYSTEM SERVICES PROVISION AND DYNAMICS IN KENTUCKY

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Ecosystem services assessment is critical for sustainable land management decision-making. However, ecosystem service responses to land ownership fragmentation have rarely been incorporated into landscape management decision-making contexts.

One challenging factor is lack of information on how to create incentives for landowners to participate in conservation efforts that would decelerate loss of ecosystems to development. This study uses InVEST ecosystem services valuation tool to assess and quantify water-related ecosystem services in 2001 and 2011 and how these changed between the period in Kentucky. This study provides new insights on integrating ecosystem service information into landscape planning by illustrating significant changes in ecosystem service values among different landowner types.

The net ecological and economic consequences of forestland cover transition in Kentucky were assessed. Details of how each landowner type was influenced, and the driving factors were analyzed. Results show that the total value of water-related ecosystem services was \$746 million in 2011, which was a decrease of \$19 million from 2001 level.

Family-owned forestland contributed 75% of the total loss. Family-owned forestland presented the highest mean value of water retention and the lowest mean value for soil, nitrogen, and phosphorus retention. All landowner groups experienced a noticeable loss in water-related ecosystem services values.

Land ownership and forest fragmentation exerted significant impacts on ecosystem service provision and change. Integrating land ownership into ecosystem service assessment may improve the landscape and regional planning through which to promote scientifically sound decision making by natural resource management agencies.

UNDERSTANDING ECOSYSTEM SERVICES BENEFITS PROVIDED BY GEOGRAPHICALLY ISOLATED WETLANDS

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Geographically isolated wetlands (GIWs) are widespread in many agricultural regions, but their role in mitigating non-point source water pollution is poorly understood and they lack the legal protections of riparian and floodplain wetlands. Our long-term goal is to provide the scientific foundation needed to establish conservation incentive programs for GIWs based on quantification of ecosystem services. We are investigating these issues in an ongoing study in southwest Georgia, a karstic region with numerous GIWs and intensive irrigated row crop agriculture. The agricultural GIWs in the study are on working farms and are compared to reference wetlands with forested watersheds. Rain gauges, water level loggers, and sediment traps were installed in each wetland and samples are collected regularly for water quality analysis. We are using these data to model hydrologic and sediment dynamics of the contributing area of each wetland in the Soil Water Assessment Tool (SWAT). We also collected long cores from each wetland, which were analyzed using paleolimnological techniques to quantitatively reconstruct sediment and nutrient dynamics throughout the 50- 100-year period of agricultural expansion. Our results provide strong evidence that GIWs are providing substantial ecosystem services through the storage of sediment, carbon, and phosphorus. We show through three independent methods (sediment traps, SWAT modeling, and paleolimnology) that sediment storage rates are much higher for agricultural wetlands than the reference forested wetlands and are like or higher than sediment storage by other aquatic systems. Paleolimnological analysis also demonstrated that GIWs are storing large amounts of carbon and phosphorus, though nitrogen storage rates were relatively low. Future work will investigate nitrogen removal in GIWs through measurement of denitrification rates. The goal of this study is to identify management practices, such as maintaining vegetated buffers or improving wetland connectivity, that improve GIW health and function for water quality with minimal impact on agricultural productivity. Local agricultural stakeholders are engaged in research activities. The collaborative process of discovering the presence and value of GIWs on working farms will be documented in video format for wider distribution.

HOW DO WE MAKE BENEFIT-COST ANALYSIS WORK FOR NATURE-BASED SOLUTIONS?

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Benefit cost analysis (BCA) is used in a range of federal decision-making processes – from assessing new regulations, to designing new water infrastructure, to selecting who to fund in grant programs. It has been a challenge to incorporate impacts to and benefits from nature into federal decision making through inclusion of ecosystem services, despite compelling evidence that assuming ecosystem services have no value can lead to bad decisions. In part, this is due to difficulties quantifying and monetizing these services. While the academic literature on methods is robust and there is consensus and clarity on methods that can be used for many services, for other services there is less clarity. Even when methods are available, we are not seeing uptake by many agencies and others struggle to find acceptable and feasible approaches. This session will bring together experts, mostly from the federal agencies, to present on the main challenges they face and tee up some ideas for possible solutions. These challenges are due to numerous factors including real or perceived limitations or constraints in policy or agency authority, insufficient plug and play models and tools for non-experts, and stove-piping in federal agencies limiting sharing of existing models and expertise. This panel presentations will be followed by a directed dialog with the presenters and audience to brainstorm solutions including key research or tool building that would support use of ecosystem services in BCA. This session would benefit agency staff who are faced with BCA challenges, academics interested in working on solutions to valuation and monetization challenges, and anyone who wants to understand and help to solve the complex challenges of moving ecosystem services into decision making.

Confirmed session moderator and panelists:

Dr. Lydia Olander, Nicholas Institute, Duke University

Dr. Ariana Sutton-Grier, Ecosystems Mission Area, U.S. Geological Survey

Dr. Matthew Oreska, Natural Resources Division, Office of Management and Budget

Dr. Todd Bridges, Engineering Research and Development Center, US Army Corps of Engineers

Dr. Kate Quigley, Office of Science and Technology, National Oceanic and Atmospheric Administration

Dr. Jennifer Helgeson, Applied Economics Office of the Engineering Laboratory at the National Institute of Standards and Technology

TRACKING BENEFITS OF NATURAL AND WORKING LANDS OVER TIME

Katie Warnell, Sara Mason, and Lydia Olander

Nicholas Institute and National Ecosystem Services Partnership, Duke University

Natural and working lands (NWL) encompass everything from pristine wilderness to industrial agricultural lands, including wetlands, coastal areas, grasslands, working forests, rangelands, and urban greenspace. They provide benefits (ecosystem services) such as air filtration, flood and fire risk reduction, supply of forest products, and provision of wildlife and biodiversity. These benefits support and enhance food security, wealth, health, happiness, and ability to withstand climate impacts. Understanding the status and trends in these benefits, and the trade-offs in benefits given different land use choices, is important for decision making. In the United States, a growing number of states are developing NWL action plans to track progress toward state goals on biodiversity and climate. Nationally, as part of America the Beautiful, the US government is developing a Conservation and Stewardship Atlas that will track the status and trends of NWL, and the benefits that these lands provide to citizens. A presidential executive order released on Earth Day 2022 acknowledged the benefits provided by NWL and called for the development of a national assessment of the condition of nature in the US. To support these efforts, we gathered existing data sets on the benefits provided by NWL across the US that could potentially be used to track their status and trends over time and evaluated their suitability for this purpose using 5 key criteria. The project also identified which benefits were not included due to missing or insufficient data. 137 datasets were reviewed and assessed, 37 of which were deemed suitable and ready to use in national analysis and tools. Ongoing funding will be essential for datasets to be updated regularly over time. Most datasets are limited to conterminous U.S. omitting important and unique benefits provided by NWL in AK, HI, and US territories. Data were not available for benefits related to human health and greenspace exposure, pest and disease regulation, and cultural ecosystem services. Getting a version 1.0 of a national status and trends assessment off the ground is well within reach, and there are tangible, concrete steps that can get us there.

COASTAL ECOSYSTEM ACCOUNTING FOR HAWAI'I

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This project applies natural capital accounting to systematically assess coastal ecosystems' contribution to the Hawaiian economy and engage with decision makers to catalyze transformative change in conservation and economic policy. Less than 5% of Hawaiian coastal waters are under some form of management, and most of the coastline is impacted by climate change, land use, and resource harvest levels that threaten coastal functioning. Hawai'i's reliance on coasts for wellbeing and revenue, sustainability-driven policy environment, and blend of worldviews make the state a uniquely powerful place to demonstrate and refine the science of coastal natural capital accounting and to engage with decision-makers. Moreover, the state's pathway using accounts to inform coastal policy can serve as an example for Pacific island neighbors.

An ecosystem account begins with synthesizing information about the extent, condition, and use of the natural environment of the landscape and seascape, focusing on locally relevant biophysical metrics of natural capital assets and ecosystem services. The process is designed to provide an evidence base for understanding and mapping natural capital, evaluating its status and trends, and exploring its relationship with priority economic sectors and livelihoods.

Building the accounts involves compiling time series data for land and coastal habitats. We rely on USGS LCMAP for terrestrial layers, and an state-wide data collaborative for benthic layers. Secondly, we are synthesizing existing data for relevant conditions such as fish stocks, coral cover, and water quality. Third, we are quantifying use with a focus on fisheries, recreation, tourism, and shoreline protection, using a combination of ecosystem service models, surveys, and secondary data. When feasible and appropriate, we are valuing and monetizing these ecosystem services using both standard non-market valuation techniques, as well inclusive valuation methods appropriate for the Hawaiian context and worldview. Finally, the project will conduct pilot policy analysis, using the accounts to compare policy options and highlight trade-offs from development and conservation strategies. Outputs are targeted to existing community, state, and federal partners, who engage via an advisory group.

EXPERIENCES FROM STATE-LEVEL NATURAL CAPITAL ACCOUNTING IN HAWAII

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Freshwater on islands is a scarce resource prone to overuse and inadequate management due to its public goods nature. The Hawaii state Water Code articulates an obligation to protect water as a resource as well as the public trust uses of water. In practice, private commercial uses have often been granted at the expense of the public, in part because public uses are undocumented. Climate change adds to the complexity and uncertainty of the management problem. A systems-scale perspective of water management could enhance water managers' ability to fulfill regulatory mandates and adapt to environmental change.

One issue is that agencies and counties each collect freshwater data according to their individual mandates and jurisdictions, with little coordination and sharing. This project builds water accounts based on the UN System of Ecological and Economic Accounts – Water framework as a mechanism for compiling a comprehensive and systematic database on water supply, use, and quality. In partnership with potential users and providers of data, we developed reporting protocols and accounting tables that are consistent with national level methods. We inventoried and assessed the stocks and flows of freshwater within and between natural systems and the human economy for two islands, O'ahu and Maui. We also explored available information on water quality and emissions.

The supply and use tables illustrate some vulnerabilities in the island freshwater system. For instance, over 99% of water for domestic purposes is derived from groundwater. The accounts also reveal some opportunities for improving freshwater security, for instance increasing reuse of treated wastewater. The effort identified key data gaps, and overlap where multiple agencies were collecting the same information. Much of the information in the accounts was known by individual water authorities, though centralizing and graphically presenting the system-wide information in a cross-agency workshop stimulated conversations about data sharing and monitoring to fill gaps. The relevance of water accounts for guiding local water management would be enhanced by matching the scale of the accounts to the scale of decision-making. For instance, the resolution of the supply data should be at the aquifer scale to compare to future projections under climate change. In sum, island-scale water accounts have potential to inform water planning, but local scale management will require local scale accounts.

RELATIONAL VALUES IN EMPIRICAL RESEARCH: A SYSTEMATIC REVIEW

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The concept of relational values of nature (RVs) refers to the values, principles, and preferences derivative of relationships among people and nature. In the past five years, empirical research involving RVs has gained traction in sustainability science, as RVs have the potential to articulate a nuanced understanding of why and how people value nature, beyond the dichotomy of intrinsic or instrumental values of nature. To fill this gap, we performed a systematic literature review of relational values research. We analyze 72 peer-review publications to summarize the state of current research identify opportunities for future research and theoretical development. In our analysis, we code what authors identify as RVs, along with descriptive elements of studies (e.g., study location, participant attributes.) Authors most frequently report identity (individual and cultural), social cohesion, livelihoods, connection to place/human-nature connection, and religion as RVs. Empirical scholarship investigating RVs has increased considerably since 2017 and exhibits substantial diversity: in discipline (from marine science to economics); in geographical location (throughout six continents); and in participants and data collection methods (from 2-person interview samples to 2,203 participant surveys to 14 participatory videos). We recommend that future studies make concerted efforts to consider key conceptual characteristics of RVs (non-substitutability, values of/about relationships, not solely instrumental) to differentiate RVs more clearly from other environmental values. We also suggest that RV scholarship would benefit from increased attention to how relational values, a concept that arose originally from philosophy, can be relevant to environmental management.

LAND REPURPOSING IN THE SOUTHERN CENTRAL VALLEY, CALIFORNIA: STAKEHOLDER PERSPECTIVES AND RECOMMENDATIONS

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Global agricultural production must increase substantially to meet future food needs. Yet, croplands and rangelands around the world, and the people who depend on them, are under increasing stress from variable climates, pests, and policy pressures. For example, climate change-driven droughts are forcing governments around the world to implement policies restricting groundwater pumping. Such policies can cause extensive agricultural land retirement. California exemplifies this phenomenon, passing the 2014 Sustainable Groundwater Management Act (SGMA) during the historic 2011-2017 drought. Reaching the mandated water balance under SGMA is projected to require the retirement of up to 315,000 hectares (ha) (780,000 acres) in one of the world's most productive agricultural landscapes. Widespread land retirement has the potential to be socially and economically disruptive. Yet, it also presents an opportunity to promote habitat restoration, ecosystem service provision, and endangered species protection. Thus, as SGMA water restrictions are currently being rolled out, it is important to understand how to maximize the benefits and minimize the harms of land retirement to the broader agro-social-economic system. To better understand the challenges and opportunities of land retirement in the Southern Central Valley, California, we conducted 23 key informant interviews with key stakeholders in conservation, agriculture, and water sectors throughout the region. The hour-long key informant interviews were open-ended and focused on 5 main topics: 1. Impacts of SGMA, 2. Impacts of increased land retirement, 3. Types of land retired and land use options on retired agricultural land, 4. Impacts of retired land on neighboring farmed parcels, and 5. Policy and/or management recommendations. Preliminary results highlight the nuanced perspectives of how SGMA and land retirement are impacting agricultural production and conservation efforts. Key informants identified potential multi-benefit land uses of repurposed land including water banking, solar generation, habitat restoration, livestock grazing, among others. Results also suggest a current window of opportunity to shape the effects of and adaptation to widespread land repurposing. To promote beneficial ecosystem services and habitat restoration, we recommend that landowners receive financial incentives to repurpose their agricultural land for habitat restoration to make up for lost income.

ESTIMATING ECOSYSTEM SERVICE PROVISION TO EVALUATE AND SUPPORT ECOSYSTEM-BASED ADAPTATION MEASURES IN GUATEMALA

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The Regional Office for Mexico, Central America, and the Caribbean of the International Union for Conservation of Nature (ORMACC-IUCN) has been implementing the Green Climate Fund project "Protecting ecosystems and livelihoods in the highlands of Guatemala through better watershed management".

The aim of this presentation is firstly to briefly present the project, which aims to reduce the impacts of climate change on the hydrological cycle in target highland watersheds in the Altiplano of Guatemala through improved land use practices.

Secondly, the presentation will present results of an ecosystem service assessment carried out with the Natural Capital Project's InVEST tool. InVEST was used to estimate the impact of a series of forest landscape restoration (FLR) actions on (1) seasonal water yield, (2) erosion control, and (3) sediment retention. The impact estimates of the FLR actions on these ecosystem services were developed under different climate change scenarios (Shared Socioeconomic Pathway (SSP) scenarios SSP1-2.6, SSP2-4.5 and SSP3-7.0), to assess the potential future impact of these Ecosystem-based Adaptation (EbA) measures. Although FLR actions do have a positive impact on the provision of ecosystem services, there is spatial variation as well as differences according to the climate change scenario considered. The spatial results will be used to show expected future impacts of the project, and to identify potential areas for restoration that have not yet been restored. This presentation will thus illustrate the use of ecosystem service assessments using different climate change scenarios to estimate potential future impact and identify key areas for restoration, in support implementation of EbA projects.

ASSESSING EFFECTIVENESS OF FINANCIAL AND BEHAVIORAL INTERVENTIONS AT PROMOTING VOLUNTARY CONSERVATION ADOPTION IN AGRI-ENVIRONMENTS: A GLOBAL REVIEW

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While implementing conservation practices on private farms and forests can produce substantial environmental benefits, these practices are not being adopted widely enough to result in measurable improvements at regional scales. Researchers have investigated the production and program factors influencing producer choices to voluntarily adopt these practices. However, existing reviews have disagreed about many findings, raising questions about review methods, including omitted variable bias. Further, applying lessons from past work to promote adoption is difficult because many reviews have investigated dispositional variables that practitioners and policymakers cannot directly observe or influence. We conducted a new review of 146 empirical studies that tested effects of different interventions on conservation adoption, with the aim to produce robust and directly applicable findings. We developed a meta-regression of quantitative studies from diverse disciplines that filtered by study quality (i.e., use of randomization and clear analysis reporting), which we then synthesized with a thematic analysis of qualitative studies on producer perspectives about conservation practices. We find that, of the interventions assessed, financial incentives show the most robust evidence of having a significant positive effect on producers' conservation adoption. Additionally, we find that limiting included studies to those with randomized study designs and clear analysis reporting, which few previous reviews have done, substantially improved model fit and identified financial incentives and regional effects as significant variables. The thematic review of qualitative studies revealed that peer groups may be successful in reinforcing adoption behaviors due to homophily effects and that financial incentives not only offset implementation costs but also mitigate perceived risks of adoption. Given problems we encountered in testing hypotheses about the magnitude of variability explained by intervention types and practice characteristics, we provide recommendations for future research design, including better pairing of qualitative and quantitative data over time.

MICROBIAL RESPONSES TO ENVIRONMENTAL PERTURBATIONS THAT AFFECT PHOSPHORUS AVAILABILITY AND RETENTION IN SOIL

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The fate and transport of phosphorus (P) in agroecosystems has implications for fertilizer application rates and crop yields, legacy-P accumulation, and eutrophication and is controlled by biotic and abiotic processes that affect the partitioning of P to different dissolved and solid-associated fractions. These processes are influenced by environmental factors such as moisture, redox potential, and pH and are poorly understood, particularly for microbial reactions affecting P speciation. Our work is focused on elucidating the most significant microbial reactions affecting P in agroecosystems and their dependencies on environmental perturbations. To accomplish this, we are conducting a multipronged approach of benchtop microcosm tests that allow controlled and homogeneous experiments, data mining of published metatranscriptomic results following relevant perturbations, and field monitoring at established agricultural monitoring sites. Microcosm experiments have looked at effects of variable saturation on P dissolution and partitioning in biotic and abiotic anaerobic conditions. These tests have shown significantly enhanced dissolved P in saturation biotic conditions relative to abiotic and unsaturated conditions. While dissolved ferrous iron also increased during these tests, consistent with the reductive dissolution of iron under anaerobic conditions and the release of iron-associated P, characterization of P speciation showed an increase in iron-associated P and a decrease of residual organic P that accounted for the observed increase in dissolved P. Abiotic conditions did not induce a change in dissolved P under saturated anaerobic conditions. Mining of metatranscriptomic data has drawn from studies that amended organics, moisture, and carbon dioxide relative to benchmark conditions. These prior studies focused on changes in expression of genes involved in nitrogen and carbon processing, but they did not look at P-associated transcripts. Our preliminary findings are showing upregulation of genes involved in polyphosphate accumulation and hydrolysis, and we are currently evaluating different "housekeeping" genes to normalize transcript abundance, since each of these perturbations stimulated overall transcript abundance that confounds differential comparisons without normalization. These efforts will be integrated to show the principle microbial pathways contributing to changes in P speciation and availability under an array of environmental determinants.

WHERE TO START WITH FINAL ECOSYSTEM GOODS AND SERVICES (FEGS): CLASSIFICATION AND METRICS

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Final ecosystem goods and services (FEGS) are the subset of ecosystem services directly benefiting people. We developed a classification system to organize and categorize the full range of FEGS provided by ecosystems. The National Ecosystem Goods and Services Classification System (NESCO Plus -- <https://www.epa.gov/eco-research/national-ecosystem-services-classification-system-nescs-plus>) has two primary structural dimensions. The first is a hierarchical representation of ecosystem classes. The second lists the ways in which people use and appreciate ecosystems. This listing is provided as a hierarchical listing of beneficiaries, or as a hierarchical listing of uses and users. The system also identifies the broad ecosystem features, or attributes, used or appreciated by each beneficiary or use and user combination. This system provides a complete internally consistent scheme for representing ecosystem goods and services.

A classification system is a vital structural and organizational element, but practical guidance benefits from the specification of metrics of FEGS. This specification provides guidance to ecological monitoring and modeling programs and encourages the development of information for communications and benefits analysis. In response to this requirement, we propose FEGS metrics for seven different ecosystems and dozens of different ways in which we benefit from ecosystems. This broad-based effort incorporated both natural and social science perspectives. The method used to generate the hypotheses starts by identifying beneficiaries for each ecosystem. Based on literature reviews, group discussion and common sense we identify broad attributes that matter directly to beneficiaries and then specific metrics of those attributes. Each of these key steps is consistent with the specifications of NESCO Plus. We examine the availability of data, particularly spatial explicit data available over large regions, and identify gaps in the existing capacity to quantify FEGS metrics. The result (<https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs-metrics-report>) is the provision of a consistent approach to positing FEGS metrics, the identification of metrics for further evaluation, and greater interdisciplinary competence. The findings and conclusions in this report (presentation) have not been formally disseminated by the U.S. EPA and should not be construed to represent any agency determination or policy.

ELICITING CULTURAL SERVICES THROUGH VIRTUAL EXPERIENCES WITH GREEN STORMWATER INFRASTRUCTURE

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Urban nature, including green stormwater infrastructure such as bioretention cells (BRCs), has become the principal form of nature-based experience available to many. Connection to nature has positive effects on physical and mental health outcomes, making it critical for human wellbeing. Even so, the cultural services that foster it (for instance aesthetics) are only infrequently the design focus of engineers. The National Academy of Engineering recognizes this oversight in their infrastructure grand challenge, arguing we must rethink infrastructure design, “with clear vision for the aesthetic values that go beyond mere function and contribute to the joy of living”. This study aims to do exactly this for stormwater BRCs, focusing on their most visually obvious design feature, vegetation. Because cultural services are perceptual, achieving this goal requires community input, and a combination of social science and engineering approaches. Here we describe new techniques for engaging communities with BRC design through virtual reality (VR) experiences. Results from human subject’s survey work conducted on site at two BRCs are compared to results from a pilot study eliciting virtual perceptions of the same two infrastructure elements to determine whether simulated infrastructure can accurately capture real-world perceptions. Perceptions of these systems were benchmarked relative to other landscape features, situating our results in context. Aesthetic perceptions of virtual and real BRC elements were not significantly different for either BRC evaluated. However, aesthetic scores elicited using VR were always slightly higher (2-6%), consistent with the presence of a small VR-associated “wow factor”. Compared with other landscapes, BRCs were preferred to paved areas, comparable or preferred to mowed grass and grass with trees and viewed less favorably than shrubs and trees. Perceptions of the VR interface were generally positive, with some nausea reported by a fraction of participants.

Our results suggests that VR simulations may prove a useful tool for eliciting greenspace perceptions and bringing community voices into green infrastructure design. This would improve the capacity of such infrastructure to meet diverse community needs and potentially their ability to connect people to nature.

ECONOMICS OF VALUING PUBLIC INTEREST

Mark Rockel

Montrose Environmental, Sandy Springs, GA, USA

The primary reason real estate appraisers and environmentalists arrive at different value opinions of wetlands and other natural resource assets is because the two parties are often solving different valuation problems. Specifically, an analysis of the methods used by the two reveals that real estate appraisers typically appraise the *market value* of a specified private interest in a natural area, whereas environmentalists typically consider the *total economic value* of a natural area, irrespective of interest. This can lead to decisions about land use which can be incompatible with public interest value.

The Institute for Research on the Economics of Taxation (IRET) assessment of the need for private property conservation asserts that land conservation will ultimately boil down to rewarding the private landowner who conserves the public interest. Why? Because private lands provide habitat for 95 percent of the federally listed species in the United, and thus, the potential public benefits of conservation easements on private property are enormous. Therefore, a defensible and transparent process that identifies this public interest value in a consistent manner would enable ranking of parcels to prioritize for public acquisition, private conservation, or even commercial use.

The public interest value is derived by summing the willingness to pay for the parcel across the individual members of the public. The public interest value is the more accurate representation of the value to the public of donating or transferring the property to provide public recreation opportunities and to fulfill the public's desires for preserving natural areas for the enjoyment of others, including future generations. This public interest value must be estimated by means other than a market appraisal. Furthermore, this public interest value represents the public's total willingness to pay for the property and would be the public's highest offer price for the property were the public to act as a single agent. We discuss the various economic methods available to estimate the public's willingness to pay and provide case examples and results.

ECOSYSTEM SERVICES, LAND CONSERVATION, AND PUBLIC INTEREST VALUE – A VIDEO

Michael Rockel

Montrose Environmental, Sandy Springs, GA, USA

The video starts by defining for the audience what ecosystem services are and provides examples of those services that audience members may interact with daily. It then transitions into defining public interest benefits and an approach to value them, willingness-to-pay (WTP). The subset of public interest values considered are rationalized and explained. Federal agencies that incorporate these values are identified and studies explicating using ecosystem values are noted. Rationale for why land conservation and specifically conservation easements as a land conservation mechanism are introduced and supported. The methodology for valuing public interest benefit will be illustrated and additional clarity into willingness-to-pay (WTP) and its coupling with benefit transfer to produce public interest benefit values will be provided.

IDENTIFYING NATURE-DEPRIVED COMMUNITIES

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As a component of the Biden-Harris administration Executive Order 14008, the Secretaries of the Interior, Agriculture, and Commerce, and the Chair of the Council on Environmental Quality submitted a 2021 report, “*Conserving and Restoring America the Beautiful*,” which recommends a ten-year initiative in support of locally led efforts to conserve and restore America’s lands and waters. One of the six early focus areas of the initiative is to “create more parks and safe outdoor opportunities in nature-deprived communities” and specifically to “support locally led conservation and park projects in communities that disproportionately lack access to nature and its benefits.” A broad and diverse body of scientific literature has identified public access to parks and green and blue spaces as a critical nature-based solution to people’s mental and physical health challenges and to mitigating the impacts of a changing climate, such as extreme heat and storm water flooding. The burdens associated with lack of access to nature do not fall evenly on all Americans. For example, an estimated 100 million Americans do not have an accessible park within a ten-minute walk of their home. Creating and improving access to parks and green and blue spaces in nature-deprived communities furthers the *Justice40 Initiative*, established in Section 223 of Executive Order 14008. Federal investment in the development of parks and green and blue spaces in nature-deprived communities promotes nature-based solutions to help reduce the unequal burdens of legacy pollution and climate change impacts. These investments, such as planting trees in nature-deprived communities, contribute to the delivery of 40 percent of the overall benefits of climate, clean energy and other Federal investments flowing toward disadvantaged communities, consistent with the goal of the *Justice40 Initiative*. This presentation will document the process and methods for developing a spatial definition and national threshold index for identifying nature-deprived communities and tracking their progress using publicly available datasets. Ultimately progress (results) will be measured by how well Federal agencies collaborate to support local leaders’ efforts to improve access, conserve, expand, create, and steward parks and green and blue spaces for the people who live in nature-deprived communities. It is intended that this information will be tracked in the American Conservation and Stewardship Atlas, the beginnings of which will be presented at this session.

REVIEW OF EPA RESOURCES FOR NATURAL CAPITAL ACCOUNTING

Marc J. Russell¹, Anne Neale¹, Paul Ringold¹, Patricia Murphy¹, and Joel Corona²

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Natural Capital Accounting is the systematic tracking of ecosystem asset’s extent, condition, capacity, and production and use of beneficial services through time. In most cases the goal is to generate national scale accounts on an annual basis so that people can be aware of nature’s wealth and these accounts can be compared to other national economic indicators and accounts. To facilitate those comparisons, natural capital accounts need to follow statistical standards and recognized accounting frameworks such as that presented by the recently accepted UN’s System of Environmental-Economic Accounting – Ecosystem Accounts (SEEA-EA).

The United States has not yet embarked on the regular development of national scale natural capital accounts, but many federal agencies regularly generate or use national datasets such as national surveys, monitoring efforts and remotely sensed data, which can be used for accounting purposes. The U.S. Environmental Protection Agency has many datasets that are publicly available at national scales that can be considered for their use in national accounts. Datasets useful for inclusion in national accounts may include biophysical and economic data from EPA’s EnviroAtlas, those used by models such as Benefits Mapping and Analysis Program (BenMap), or other resources such as the Report on the Environment, National Aquatic Resource Surveys, and Air and Water Quality monitoring. Here we assess these EPA resources for data that might be used within a national capital framework, and specifically for ecosystem accounts. Previous comparisons of existing data to final ecosystem goods and service endpoints yielded mixed results, with many metrics are only useful as proxies for what is directly beneficial to humans. Many existing datasets consist of indicators of ecosystem services, function, or condition, but are not direct measures, or are only available where high resolution spatial data is available, such as in large metropolitan areas, but not in more rural places. A crosswalk of the existing data to the proposed list of Ecosystem Services in the SEEA-EA is a first step to gauge how utilizable EPA’s data are for application to ecosystem accounts. Here we report on datasets that work for populating the various tables needed for natural capital accounting in the U.S. and highlight gaps that could be filled by new research or data gathering efforts.

NATURAL CAPITAL ACCOUNTING AS A MONITORING TOOL FOR DECISION MAKING

Marc J. Russell.

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Natural Capital Accounting is the systematic tracking of ecosystem assets through time. In most cases the goal is to generate annual ecosystem based national scale accounts so that people can be aware of nature's wealth. These natural capital accounts are comparable to other national economic indicators and accounts. To facilitate those comparisons, natural capital accounts follow statistical standards and recognized accounting frameworks such as those in the recently accepted UN's System of Environmental-Economic Accounting – Ecosystem Accounts (SEEA-EA).

The framework and standardization of natural capital accounting offer decision makers a valuable tool for monitoring impacts of their decisions. These accounts are designed to track changes in ecosystem extent, condition, capacity, supply and use, as well as translation of disparate units into a common "currency". Each one of these accounting tables offers the user useful information on the status and trends of ecosystems of interest. What is tracked in accounts is flexible, allowing users to track things as simple as the area of wetlands in a region, for example, or as complex as the amount of wild rice harvested from a specific lake by a specific group. As well as tracking measures of ecosystem condition that might be proxies for supply and use of ecosystem goods and services, accounts can also track the capacity of ecosystems to continue to produce those goods or services into the future.

The United States (US) will soon embark on the regular development of natural capital accounts. Many federal agencies generate or use national datasets such as national surveys, monitoring efforts and remotely sensed data, which can be used for accounting purposes. Pilot accounts at national and regional scales, as well as urban areas, have been completed for select ecosystem components like extent, quality, and functions such as pollination, air pollution removal, etc. Here we present background on SEEA-EA with highlights from existing work on US ecosystem service accounts as a demonstration of their potential utility for decision makers. National scale environmental-economic accounting approaches could be beneficial for local and regional decision makers monitoring status changes in ecosystems due to specific interventions. While accounting systems may not currently be a part of environmental managers' toolboxes, they may become more widely accepted and used within the US over the next decade.

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EFFECTS OF CLIMATE CHANGE ON ECOSYSTEM SERVICES IN SOUTHERN CALIFORNIA

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Public lands in southern California are unique in that they contain a Mediterranean-type climate region that is dominated by chaparral vegetation but also have forested woodlands and alpine environments at higher elevations. These landscapes provide a variety of goods and services (e.g., water supply, carbon sequestration, etc.) that directly and indirectly benefits individuals and nearby communities, otherwise referred to as ecosystem services. However, climate change is expected to affect the production and availability of these ecosystem services that communities benefit from. Because of these changes to the landscape, public land managers have an interest in designing adaptation strategies to plan for resilient landscapes that sustain the provision of ecosystem services. This study's aims included 1) documenting the perspectives of federal public land managers, 2) compiling the best-available science and data regarding current and future conditions of ecosystem services in southern California, and 3) formulating strategies to adapt to a changing climate.

The area of the study includes the Angeles, Cleveland, Los Padres, and San Bernardino National Forests (managed by the U.S. Forest Service) and the Santa Monica National Recreation Area (managed by the National Park Service). Key ecosystem services examined in this study were identified through a series of semi-structured interviews with staff at each national forest and the national park unit. Ecosystem services identified as crucial and common across the study area included carbon sequestration, cultural and heritage values, grazing, recreation, soil erosion control, air quality, water quantity, and water quality. Existing data sources were used to estimate the current quantity and future projections of ecosystem services supplied on the landscape. Finally, a series of workshops with Forest Service and National Park Service staff were conducted to formulate adaptation strategies given climate sensitivities and vulnerabilities.

The provision of ecosystem services to the communities of arid southern California is expected to change due to climate change. Through increasing temperatures, higher frequencies, and intensities of wildfires, and changing precipitation patterns, the quantity of water provided risks declining, along with the quality of the water provided. Though higher temperatures and carbon fertilization might make rangeland more productive, other ecosystem services may be more severely affected by grazing. Cultural ecosystem services that provide a core sense of place and contribute to the diverse communities of southern California also face threats from worsening drought conditions and wildfire risks, resulting in higher costs for protecting these invaluable resources. These impacts are exacerbated by increasing populations in the area. The adaptation strategies identified in the study highlight the most effective approaches to mitigating the negative impacts of climate change to the provision of ecosystem services in the region.

NATURE'S BENEFITS EDUCATIONAL CARD GAME

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Taking care of nature benefits you! It is important for students to understand the dependence of their own future health and well-being on the sustainability of ecosystems and the services they provide, as well as how human actions can impact the availability of these benefits, to be better equipped as future decision-makers. Through gameplay, the concepts associated with stewardship of natural resources can be taught and reinforced in a fun and engaging way.

The Nature's Benefits Card Game, suitable for use with grades 6-12, can serve to supplement and reinforce environmental science instruction on core science standards and curricula, with a particular focus on the concepts of ecosystem services and sustainability. The game uses the EPA's National Ecosystem Services Classification System Plus (NESCS Plus) as its scientific foundation, leveraging ecosystem services attributes and natural resource users described in the related Final Ecosystem Goods and Services (FEGS) Scoping Tool.

The objective of the Nature's Benefit Card Game is to take concepts of stewardship from the abstract to the concrete by providing realistic connections that students can make between ecosystems, natural resources, and people. During gameplay, each student plays a role as a decision-maker who scores points when they successfully create "chains" of three cards that match 1) ecosystems to 2) the natural resources they provide to 3) the people who benefit from those resources. For more advanced students, additional card types can be played that protect or disrupt these chains through natural disasters, human activities, or sustainable management. Incorporating these cards leads players to make choices about how to manage ecosystems in a way that balances both short-term interests and long-term sustainability. Two game play options, competitive versus cooperative play, create different incentives for players, which lead to different strategies and teach different lessons.

The game is available as a physical card deck, attainable as a printable pdf, with game instructions and lesson plans based on the North Carolina science educational standards (<https://www.epa.gov/eco-research/natures-benefits-card-game>). The game can provide an additional option for educators and outreach coordinators to meet environmental education needs, as a fun way of reinforcing taught curricula, and communicating the benefits of environmental protection and sustainable use of natural resources.

RELEVANT LANDSCAPE METRICS TO SUPPORT THE DEVELOPMENT OF A LANDSCAPE CARBON MARKET

Gregg Simonds and Eric Sant

President Open Range Consulting, Park City, UT

The markets for carbon sequestration and other ecosystems services have been hampered by not having relevant metrics that both the buyer and seller of credits can trust. We at Open Range Consulting (ORC) have published, patented and applied our remote sensing technologies that produce exceptionally and uniquely accurate maps of ground cover conditions.

We have mapped over 70 million acres of the Western U.S. environmental types; high mountains, deserts, annual grasses, prairie, and riparian landscapes. Our customers have been highly experienced on-the-ground managers, like ranchers, who can validate the relevancy of the maps we produce. Our maps and products have been used for water quality, endangered species habitat and wilderness value analysis, and fire mitigation and grazing planning. These products have been used by ranchers, farmers, public land management agencies, NGOs, DOD, and mining companies. Recently, we were able to make high correlations between soil sampling analysis for attributes, like organic carbon, to satellite acquired spectral reflectance. This breakthrough technology holds the promise of mapping soil health attributes throughout entire landscapes at 10-meter resolution, update this information and detect the change over time. Having precise, accurate, timely and cost-effective information of ground cover conditions and soil health attributes will allow for markets to be developed based on landscape relevant information. Having environmental credits markets will provide the necessary incentives for those in agriculture to adapt their practices to reflect the values of environmental health.

BE SEAGRASS SAFE

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Seagrasses are completely submerged grass-like plants in coastal areas. They help maintain water clarity by trapping sediments in the water column and provide food and shelter for many species of marine life. Because of their underground root system, damage to seagrass meadows can be detrimental. If the damage is too extensive or repeated, the seagrass meadows may not recover. Recovery can take months or even years. Unfortunately, studies estimate that over 30,000 acres of seagrass throughout Florida have been damaged or "scarred" by boat propellers. In response, summer staff engaged with boaters launching at coastal ramps in Hernando and Citrus counties during the peak summer boating season in 2019 and 2021. Users were provided educational information about seagrass, propeller scarring, and preventative scarring behaviors that one can quickly adopt. Incentives, such as drybags, stickers, and keychains, were distributed to boaters in exchange for their contact information. "Seagrass Safe Boating" signs were also installed at each boat ramp. Social media, including Snapchat geofilters, were additional ways of engaging with boaters at the ramps. During this educational campaign, staff engaged with 1,100 boaters, of which 726 provided their contact information. The end-of-season follow-up surveys indicated that 99% of respondents implemented at least one preventative scarring behavior during their boating adventure, 64% shared information about seagrass scarring with others, and 86% were more aware of seagrass importance and personal stewardship. Studies indicate that people are more likely to change behaviors when signing pledges, such as during our Seagrass Safe campaign. Education is vital in preserving our natural resources and coastal ecosystems and is less costly than restoration.

FROM CARBON TO THE COSMOS- HOW NATIONAL MARINE SANCTUARIES EVALUATE AND INCORPORATE ECOSYSTEM SERVICES INTO MEANINGFUL DECISION-MAKING

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Many ecosystems service (ES) frameworks assume a one-way relationship between humans and nature, in which humans consume services. But, at the heart of many cultures is a creation story describing the unbreakable bond between humans and their environment. It extends well beyond simple dependence on natural resources and describes the interdependence and reciprocal relationship between people and place for mutual health and wellbeing. A panel of natural and social scientists, cultural heritage practitioners, and a marine sanctuary manager will discuss the role of ecosystem services (ES) in decision making and evaluating the performance of national marine sanctuaries, the approach used, and the unique role culture plays in the evaluation of ES and meaningful decision-making by leadership. The panelists will discuss their experiences mixing western science with other knowledge systems in understanding these services. We define ES in a slightly more specific way than some other practitioners. In the sanctuary's context, ES are the benefits people obtain from nature through use, consumption, enjoyment, and/or simply knowing these resources exist. We convene expert workshops to conduct periodic assessments of the status and trends of sanctuary resources, and the ES they provide. We consider numerous forms of knowledge as a basis for judgment in rating resources and ES status and trends. Use of the word "knowledge" here has been carefully considered and comes from the most fundamental meaning of science, which derives from the Latin "scire," to know or understand. Knowledge in this sense would include what many call "best available science," or the most reliable and relevant information that can be obtained to inform a decision. It can include established, or widely agreed-on facts or ideas derived from rigorous experimentation, hypothesis testing, observation, or experience; it may be available in peer-reviewed or gray literature, or as expert, local, or traditional knowledge. This panel asks natural and social scientists, cultural heritage practitioners, and marine sanctuary managers to consider the policy, legal, and societal benefits of "braiding" modern and traditional knowledge to enhance our understanding of the relationships between people and places of marine sanctuaries, and to improve deliberations and the application of co-management frameworks. What legal frameworks guide the integration of traditional and modern knowledge systems in your work? What are the challenges in improving inclusivity of cultures given the mandates? How have you incorporated science into the evaluation of ecosystem services and what have you seen as primary challenges? What benefits to your discipline would arise from the braiding of modern and indigenous knowledge?

#FINANCE4NATURE: IDENTIFYING, QUANTIFYING AND BRIDGING THE GLOBAL BIODIVERSITY FINANCE GAP

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Nature loss poses a grave risk to the global economy and societies. Loss of ecosystem services could result in a decline in global GDP by an estimated \$2.7 trillion by 2030. Biodiversity harmful subsidies create avoidable, potentially unintended costs to nature of more than \$1 trillion per year. Global public investment in biodiversity is approximately \$152 billion and the estimated investment need is approximately \$800 billion per year. The biodiversity finance gap can be narrowed or closed by mobilizing additional financial resources, realigning current expenditures, improving the effectiveness of existing and future programs and policies, and by avoiding biodiversity harmful policies. UNDP BIOFIN exists to demonstrate how nature positive economies can work for people and planet. BIOFIN was initiated ten years ago at the CBD COP 11 in response to the urgent global need to divert more finance from all possible sources towards global and national biodiversity goals. Now present in 40 countries, BIOFIN is working with governments, civil-society, vulnerable communities, and the private sector to catalyse investments in nature. BIOFIN found public biodiversity investments are increasing and are increasing with GDP; funds allocated to biodiversity protection and management help reduce the number of threatened species and the rate of biodiversity loss; population growth and poor governance are associated with lower financial support for biodiversity and an increase in threatened species. BIOFIN has identified hundreds of finance solutions that can help protect the future of the planet and our economies. Biodiversity finance solutions in participating countries have resulted in, for example: \$1 million of forest carbon sequestration in Kazakhstan; \$2.8 million for bird conservation in Indonesia; \$40 million to expand the protected areas system in Philippines; more than \$1 million per year in additional protected areas fees in Botswana; and hundreds of thousands of dollars generated in build back better crowdfunding campaigns for protected areas in Belize, Costa Rica, Ecuador, Philippines and Thailand. Results highlight the importance of connecting biodiversity budget expenditures to biodiversity outcomes and results. They point to fruitful points of intervention for innovative finance solutions in biodiversity protection and management; policies and programs, mechanisms and actions that can help countries deliver better biodiversity management and protection.

CONSIDERING ECOSYSTEM SERVICE BENEFITS OF REGIONAL HABITAT RESTORATION FOR MONARCH BUTTERFLIES

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The monarch butterfly (*Danaus plexippus*) population of eastern North America has experienced substantial population declines over the last two decades. Previous research has established habitat restoration goals and found that a significant portion must occur on agricultural land in their core breeding area, the Upper Midwestern United States. We explore the potential to pair habitat restoration with ecosystem service provision by creating continuous riparian buffer strips throughout the region. Using a sophisticated geospatial analysis, we consider several buffer-width scenarios in terms of the amount of habitat created and the crop pollination and water quality regulation services provided. We compare the conservative economic value of these ecosystem services with the lost value of crops for each scenario. Results suggest that riparian buffers could be used to meet 10-43% of the total monarch habitat restoration target with moderate management. The value of water quality and pollination benefits provided by buffers is estimated to exceed costs only for our narrowest buffer scenario, with a cost-benefit ratio of 1:2. Larger buffer widths provide more monarch habitat, but at substantial additional cost to farmers while ecosystem service benefits remain approximately the same. The restoration of narrow multi-functional riparian corridors thus has the potential to be a win-win scenario, adding habitat while also providing a variety of other valuable benefits to farmers and downstream communities. This suggests the potential to leverage monarch habitat restoration efforts for the benefit of a wider variety of species and broader coalition of beneficiaries.

ASSESSING SELECTED PHYSICAL AND SOCIOECONOMIC EXPLANATORY FACTORS, URBAN HEAT, AND ECOSYSTEM SERVICES IN MIAMI METROPOLITAN AREA

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High temperatures and urban heat islands can affect ecosystem services. This is an issue that is especially important in urban areas where an abundance of pavement and buildings rather than tree cover affect temperatures. The objective of this study is to investigate the relationship between various explanatory factors and land surface temperature and the effect of land surface temperature on ecosystem services. Physical explanatory factors include tree canopy cover, precipitation, greenhouse gasses, normalized vegetation index (NDVI), impervious surfaces, and distance to coast and roads. Socioeconomic factors assessed include population density and median income. Statistical tests such as Geographically Weighted Regression and Linear Regression are being used to determine relationships with temperature and ecosystem services. Land surface temperatures (LST) are calculated using google earth engine. MODIS imagery between 2002 and 2021 separated by wet season and dry season was used. The data was separated into Day and Night within the wet and dry seasons. Land surface temperature results are compared with explanatory factors affecting the LST to determine their impact on ecosystem services. The hypothesis is that physical factors such as tree canopy and NDVI result in reduced temperatures and increased ecosystem services. Factors such as population density and greenhouse gasses raise temperatures and reduce ecosystem services.

Results will impact understanding of human health in urban areas. Additional issues include assessing changes in temperature and ecosystem services for different temporal settings.

APPLYING NATURAL CAPITAL ACCOUNTS IN THE EUROPEAN UNION AND THE UNITED STATES: A SYNTHESIS

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During the past decade, significant advances have been made in beginning development of natural capital accounts in the European Union and in the United States. Although there appears to be great value in enhancing development of these accounts, there are only limited applications of NCA to policy and decision making. To advance and synthesize NCA applications, scientists from the US and the EU are convening a working group to plan, focus, and advance these efforts beginning in Fall 2022. Initial discussions will address current efforts, opportunities for synthesis, and development of a common strategy for advancing NCA applications. The ACES session will report on progress made, opportunities and challenges identified, and invite participation in continuing EU/US efforts to partner in strategic NCA applications development. Participants in the session will be from the Joint Research Centre, European Space Agency, the Directorate-General – Environment from Europe and USGS, NASA, EPA, NOAA, the State Department, and universities/NGOs from the United States.

THE FINAL ECOSYSTEM GOODS AND SERVICES (FEGS) VOLTRON: THE POWER OF TOOLS TOGETHER

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Effective environmental decision making requires consideration of ecosystem services to ensure the aspects of the environment that stakeholders rely upon and enjoy, continue to exist, and function as needed. Many researchers and organizations have developed decision support tools to facilitate this inclusion. An array of tools exist that address different aspects of decision making and different types of decisions. But decision support tools must balance specificity and transferability and managers often need multiple tools to meet their needs. Moving from one tool to another, however, can become a challenge unto itself. The USEPA has developed a set of tools that all use the National Ecosystem Services Classification System (NESCO) Plus framework to simplify the application of multiple tools in a single decision process. The FEGS Metrics Report provides guidance on how to measure and monitor services, while the Final Ecosystem Goods and Services (FEGS) Community Scoping Tool helps prioritize services for monitoring. These services and metrics can then be mapped with EnviroAtlas or modeled using entries in the EcoService Models Library. Each of these tools is valuable on their own, but together they are more than the sum of their parts. Other speakers in the session are discussing each of the tools; this presentation builds upon them and discusses an example of how these tools can be used together.

ANALYZING ECOSYSTEM BENEFITS OF MANGROVE RESTORATION IN LIBERIA

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Mangrove ecosystems provide habitat for numerous species and are a source of important ecosystem services for coastal communities. Yet, over the last few decades, they have been subject to extensive degradation and deforestation worldwide. Recent estimates derived from the analysis of satellite images shows that between 2000 and 2021, Liberia lost approximately 26% of its mangrove ecosystems. In 2021, in the revised Nationally Determined Contributions (NDC) to the United Nations Framework Convention on Climate Change, Liberia formally recognized that protection and restoration of mangrove ecosystems is critically important for adaptation and mitigation, among other benefits. To support Liberia in reaching its NDC, we estimated the costs and benefits of restoring mangrove ecosystems in Liberia. We utilized results generated through the System of Environmental Economic Accounting—Ecosystem Accounting (SEEA EA) which has been implemented in the coastal zone of Liberia. First, using a time series of ecosystem extent maps, and applying a set of prioritization criteria, we identified viable areas for restoration within a focal pilot zone near a coastal town called Owensgrove. Second, we estimated the costs of restoring these areas using input costs of restoration (e.g., labor costs associated with hydrological restoration, costs of seedlings, planting, equipment, maintenance, and travel to restoration sites). To compare restoration costs with potential benefits, we assessed ecosystem services benefits provided by mangrove ecosystems, such as climate regulation, provisioning services and coastal protection. Finally, considering that restoration of mangrove ecosystems requires a long timeframe, we calculated the net present value using a 20-year time horizon and an appropriate discount rate. The results of the analysis suggest that mangrove restoration is a cost-effective approach to regain lost and degraded mangrove ecosystems along coastal areas of Liberia. This work provides an essential foundation for scaling up restoration of mangrove ecosystems across Liberia. It also demonstrates the utility of SEEA EA outputs in informing these restoration efforts, in response to the United Nations Decade on Ecosystem Restoration's rallying call to action that began in 2021.

AN OPEN-SOURCE GIS TOOL TO ASSESS SOCIAL VALUES FOR CULTURAL ECOSYSTEM SERVICES

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Increasing the use of open-source, GIS software for ecosystem service assessments is important to addressing shortcomings in accounting for perceived values of ecosystem services. Challenges in completing these assessments are compounded when simultaneously considering both 1) non-material, cultural services as opposed to more tangible provisioning, regulating, and supporting services and 2) their social values, which are notably more difficult to measure than ecological or economic values. Valuing nature involves numerous methods based on input from heterogeneous stakeholder groups, which produces results that are presented in inconsistent formats and contexts that are not readily comparable. Social values incorporate a broader perspective of value based on a wide array of cultural experiences and research disciplines, which can be better considered using open-source, GIS tools.

Open-source solutions can eliminate proprietary GIS software licensing costs and avoid impacts of proprietary software changes on dependent applications. A wider net can be cast into the potential user community, and development resources can be focused on new capabilities or improving the user experience rather than simply adapting existing functionality to new software releases. Although open-source software comes with its own set of challenges (e.g., steep learning curves, lack of technical support, dependence on unpaid contributors), they can be minimized by narrowly tailoring a GIS application to focus the user experience on a very specific set of tasks while still providing flexibility to define parameters and the capability to be applied anywhere a user can acquire appropriate input data.

Beginning with the 4.x versions of Social Values for Ecosystem Services (SolVES; <https://solves.cr.usgs.gov>), an open-source, GIS-based tool is available for generating quantitative, spatially explicit models of social values attributed to cultural ecosystem services, such as aesthetics and recreation. Developed for QGIS with Python and a spatially enabled PostgreSQL database, SolVES models the relationship between data representing the location and types of perceived values (e.g., from public participation GIS surveys, visitor surveys, geotagged social media) and environmental data. Its design supports application in any biophysical or social context for which users can provide data and assists efforts to incorporate social-values information into larger ecosystem service assessments.

ANTICIPATING THE IMPACTS OF CLIMATE CHANGE ON FOREST AND RANGELAND RESOURCES WITH LANDSCAPE-SCALE DEMOGRAPHIC MODELS

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Environmental change is altering the structure of dry forests in the western US, including pinyon-juniper (P-J) woodlands, impacting critical ecosystem services such as carbon storage, forage production, and wildlife habitat. Anticipating where P-J woodlands may continue to expand or contract in the future remains a substantial challenge for managers. Demographic models are a powerful tool to anticipate future forest structure based on changing survival, reproduction, and growth rates. However, collecting demographic data at management relevant spatiotemporal scales is often logistically infeasible. Our goal is to anticipate changes in P-J woodlands in response to environmental change at landscape to regional scales using novel approaches that integrate remote sensing, field data, and statistical inference to quantify tree demographic rates and their drivers. Results indicate that warming and drying conditions are leading to population vulnerability, with increased mortality, declining recruitment, and the decline of P-J woodlands in many locations. We find that as much as 50% of the pinyon pine populations in the warmest and driest locations are declining. However, management actions such as tree thinning could mitigate the direct impacts of a warming and drying climate in some cases. Building on these results, we are working to scale up our approach using 70-years of regional aerial imagery. These data will allow us to understand the dynamics and long-term demography of dry forests at unprecedented spatiotemporal scales and help identify and manage dry forests that are currently under stress and at risk from changing climate and increased environmental pressures.

NCA-ES AND DEPARTMENT OF THE INTERIOR DECISION-MAKING

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The concepts of ecosystem services (ES) and natural capital accounting (NCA) can play an important role in providing information to Department of the Interior (DOI) decision makers that can affect resource management decisions. The set of information generated by via the ES and NCA frameworks can help make tradeoffs more explicit, rigorous, and comparable over time. However, developing information that is consistent with those frameworks can be challenging because data is often limited and there is not a consistent understanding within DOI of the meaning of the concepts. In addition, the advantages of presenting information that could inform a decision using the ES and NCA frameworks may not be readily apparent to decision makers. This presentation will discuss the efforts by the DOI to implement ES and NCA, and how those frameworks can better inform DOI decision-making beyond approaches that do not rely on ES or NCA. The presentation will discuss: DOI efforts to implement the ES framework that were initiated in 2015 and restarted in 2021; data gaps that limit the application of ES and NCA frameworks; development and implementation of consistent data standards; how data collection might be undertaken; and DOI's role in OSTP's NCA strategy plan efforts.

ECO-FIP: AN ENHANCED METHOD FOR EVALUATING LARGE-SCALE, MULTI-OBJECTIVE FLOODPLAIN RESTORATION OPPORTUNITIES

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There is a growing need for rigorous yet efficient approaches for rapidly evaluating multi-benefit floodplain restoration projects at sufficient pace and scale to address the magnitude of today's natural resource and infrastructure challenges. In settings like California's Central Valley, the convergence of water scarcity, competing land use priorities, climate change and aging flood infrastructure requires urgent solutions for sustaining populations of threatened species such as salmon while addressing flood risk and securing water supply for agriculture. EcoFIP (Ecological Floodplain Inundation Potential) is a methodology and toolbox that facilitates multiple levels of identification, screening, and evaluation of potentially suitable multi-objective floodplain restoration projects. EcoFIP leverages Eco hydraulic modeling, soils characteristics and groundwater data to estimate uplift or impacts to ecosystem services resulting from physical alterations to river corridors (e.g., floodplain lowering, levee setbacks) and changes in flow conditions (e.g., climate change, reservoir reoperation). EcoFIP generates outputs such as acre-days of inundated floodplain area, acre-days of suitable floodplain habitat for salmonids and other species, and potential groundwater recharge volumes summarized over a range of water years. EcoFIP can estimate habitat benefits at multiple scales (e.g., river reach, parcels, or model pixels) enabling evaluation of the ecological characteristics of any boundary of interest for various historical or potential flow regimes. EcoFIP solves the problem of needing to run computationally intensive hydraulic simulations that are often infeasible when evaluating for ecological outcomes of different long-term hydrologic scenarios. This presentation will describe a pilot application of EcoFIP being performed along a 50-mile reach of the Upper San Joaquin River between Friant Dam and Chowchilla Bifurcation Structure in support of the California Department of Water Resources' Central Valley Flood Protection Plan and Conservation Strategy. The pilot study is assessing floodplain inundation, salmonid habitat suitability, and groundwater recharge at multiple spatial scales for current and future flow regimes with the goal of identifying potential multi-objective floodplain restoration sites that provide high-quality salmonid habitat and maximize groundwater recharge from floodplain inundation.

EXCEEDING EXTREME DROUGHT THRESHOLDS MAGNIFIES PRODUCTIVITY LOSSES IN GRASSLANDS GLOBALLY

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Drought events are intensifying globally due to climate change. However, because extreme droughts are by definition rare, we have limited understanding of their impacts in ecosystem functioning. We conducted a coordinated, globally distributed experiment aimed at imposing a historically, and thus statistically extreme, single year drought (i.e., 1-in-100 yr threshold of historical occurrence) at 75 grassland and 26 shrubland sites spanning six continents. At all sites, we measured annual aboveground net primary production (ANPP), a fundamental component of the global carbon, as a metric of drought-induced loss of ecosystem functioning. The experimental drought was imposed passively and year-round, using shelters covered with strips of plastic to intercept a fixed percentage of rainfall. Due to this passive approach of rainfall manipulation, the experimental droughts imposed exceeded the extreme threshold when ambient or below-average (42 sites), while 58 sites experienced less severe, historically nominal drought because ambient rainfall was above-average during the year of the treatment. When drought was extreme, aboveground net primary production (ANPP) was reduced by an average of 34%. This loss in ANPP was a ~1.5-fold greater than that observed for those sites experiencing less severe drought (20% reduction), or from reported reductions in ANPP from recent meta-analyses of drought experiments. Consistent with past observations, shrublands were more resistant to extreme drought than grasslands (25% vs. 36% reduction in ANPP, respectively). However, we observed striking variation in ANPP response to extreme drought, ranging from near-catastrophic (>80%) loss in ANPP to complete drought resistance (no change in ANPP), despite utilizing a standardized experimental design. Across the diverse array of sites, when both extreme and nominal droughts were considered, drought severity explained 42% of the variation in ANPP responses among ecosystems, particularly those that were more grass-dominated, whereas other ecological variables, such as soil texture, climate, and species richness, did not explain additional variation in ANPP response to either extreme or nominal drought or both combined. Although ecosystem responses were highly varied, our estimates of ANPP loss to extreme drought greatly exceed those previously reported, which has important consequences for grassland ecosystem services.

LEVERAGING CONSERVATION FINANCE AND PARTNERSHIPS WITH ECOSYSTEM SERVICES

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Nature's benefits, also known as ecosystem services, are the benefits people, see, feel, hear, and rely on in their daily lives. They include clean air, water quality and flow, carbon sequestration, cultural heritage, pollination, recreational opportunities, wood products, increased physical and psychological wellness, and more. Effective management of these public benefits has become increasingly complex in recent years given population growth, development pressures and climate change. Given these challenges, the U.S. Forest Service (USFS) is working in partnership with diverse stakeholders to enhance the pace, scale, and effectiveness of conservation. These efforts have intensified under the Biden Administration's conservation and climate change focus. This presentation will share how a nature's benefits framework can be a tool for increasing the pace and scale of ecological restoration on public lands through innovative financing and partnerships.

Although the USFS is successfully implementing ecological restoration activities, the demand for nature's benefits requires a shared stewardship approach. In the Pacific Northwest and Southwest, we see millions of acres in need of management without enough federal funds available to get the job done. Promising efforts include completed Memorandums of Understanding between the U.S. Forest Service and the states of CA and OR, and the ability to fully utilize land management authorities to collectively implement cross-boundary restoration. As a result, we are working at larger scales and using new tools to mitigate impacts from fire and overgrown vegetation on water quality, greenhouse gas emissions, and recreation.

Communicating the value nature's benefits bring to households, agriculture, and industrial sectors can incentivize beneficiaries to act. Innovative financing offered by conservation finance partners who work with private investors can increase the pace of landscape and watershed-scale restoration. This can meet beneficiary and partner interests as well as corporate social responsibility goals. Highlighting the "bounty" of natural resources from our National Forests, and the public's dependency on them, against the backdrop of a warming climate, is a great educator and influencer as we seek to sustain these resources in perpetuity. This session will include examples of conservation finance pilots that use ecosystem service valuation as a basis for shared restoration investments across sectors.

PROTECTING RANGELANDS IN A CHANGING CLIMATE: USING A HERITAGE CATTLE BREED TO MAINTAIN ECOSYSTEM FUNCTION UNDER LIVESTOCK PRODUCTION

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Recent and long-term climatic trends suggest the Colorado Plateau, USA is undergoing more frequent and extended periods of drought and heat, reducing the quality and quantity of available forage in the rangelands that dominate this region. These climatic changes raise two important concerns for livestock producers: a) how to feed cattle under decreased forage production and b) how to maintain range condition under livestock grazing. To better maintain ecosystem function under livestock production, we propose the use of Raramuri Criollo cattle, a heritage breed adapted to the arid rangelands of Mexico, as an alternative to conventional breeds such as Red Angus. Criollo cows are 300-500 lbs. lighter than Red Angus cows, and previous studies in the Chihuahuan Desert have shown that they range farther from water, eat a broader diet containing more shrubs, and navigate more rugged terrain than conventional breeds. We are determining if these behaviors also occur on the Colorado Plateau at the Dugout Ranch, located in San Juan County, UT, and hypothesize that these behaviors will effectively increase the quantity and quality of forage available and lessen impacts on range condition for Criollo in comparison to Red Angus. We are tracking the movement of 20 Red Angus and 20 Criollo cow-calf pairs using GPS collars and pedometers. We are also examining diet composition through fecal DNA metabarcoding which, when coupled with field and remotely sensed data on community cover and composition, will allow us to determine diet selectivity and landscape-level forage availability. In addition, we are examining the impact of Criollo and Red Angus on ecosystem services such as erosion susceptibility and biological soil crust cover. Finally, we will use beef production metrics such as body condition scores and pounds calf crop weaned to quantify the economic feasibility of producing Criollo cattle on the Colorado Plateau in comparison to Red Angus. The results of this study, which is still in its early stages, could provide opportunity for ranchers on the Colorado Plateau to implement adaptive solutions to current and future challenges posed by a changing climate.

IMPACT AND VALUE OF DUNG BEETLES IN CENTRAL FLORIDA RANGELANDS

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Only recently have the potential values of supporting and regulating ecosystem services, necessary to sustain extractive and cultural services, been recognized. These values are difficult to calculate because these services do not have 'market values. Despite the pivotal and underpinning role that non pollinating insects play in the overall functioning and stability of ecosystems, they have received comparatively scant attention in comparison to other taxa in terms of ecosystem service provision. We focus on dung removal by dung beetles and how this ecosystem service can be factored into pasture rotation management in terms of minimizing rotation days, increase year-round production and increase the long-term health of the pasture ecosystems. We developed an agro-economic model to assess the economic value of the dung degradation ecosystem service under a high and low dung beetle abundance scenario. Using the results from a dung decay regression model we calculated the amount of avoided forage lost under each dung beetle abundance scenarios. Dung beetle degradation action accounted for a 38.9% reduction in forage loss in managed lands with lower dung beetle abundance versus 57.6% in a natural land use with higher dung beetle abundance. This translated into a potential \$918,337 annual saving to landowners in ranches and other lands that contain a lower abundance of dung beetles and a potential saving of \$1,360, 250 annually under a higher abundance scenario in natural lands. Our study provides useful insights to understand the situation of decomposition ecosystem services and their impact on agricultural productivity at regional levels. Our analysis shows the economic contribution of one group of decomposers within agricultural production, revealing the high productive potential of dung beetles in the Southeast US. It is becoming increasing apparent that the increasing use of veterinary medicines which impedes ecosystem functioning by the disruption of dung beetle lifecycles and therefore dung removal activity in US grasslands will have a measurable economic impact on productivity.

NAVAJO RESOURCE MONITORING IN THE GLEN CANYON ADAPTIVE MANGEMENT PROGRAM: USING ECOSYSTEM SERVICE FRAMEWORKS TO INFORM ADAPTIVE MANAGEMENT

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The Navajo Nation is collaborating with the Glen Canyon Dam Adaptive Management Program (GCDAMP) to create a resource monitoring program based on traditional cultural values and knowledge to direct management decisions of Glen Canyon Dam operations. The Tribe has participated in the management and protection of the Grand Canyon since the early 1990's through the GCDAMP, largely with an archeological focus. The Grand Canyon region contains vast resources which the Navajo people depend on for sustaining life and cultural continuity, so access to and education on culturally significant resources within the Canyon is vital to strengthening and reviving traditional practices and knowledge. In 2022, the Navajo people continue to be concerned with the health of the Colorado River ecosystem and after years of challenges related to invasive species, hydropower generation constraints, and climate change, it is important as ever to carefully consider participation in the program. We believe that successful participation lies in how we translate and communicate complexities of entire ecosystems to a management product that facilitates procedural inclusion, sensitivity of traditional practices, and socio-ecological knowledge. These products will expand beyond the limiting field of archaeology to encompass entire ecosystems through an Ecosystem Services (ES) framework. The mechanism for measuring these resources will be built through interdisciplinary collaborations to create an integrative database system through a comprehensive ethnographic study and regional community based participatory research. The research will be represented by mapping spatial relationships linking resources to story and place. The monitoring framework developed will achieve the following goals: 1) establish inter-agency guidelines, 2) direct future agency research and management efforts, 3) create a knowledge base to educate tribal members, researchers, and the public, and 4) support tribal members' physical and spiritual connection to the lands and maintain associated cultural practices to promote well-being. This framework will be used to identify and recommend critical resource connections and thresholds that are impacting values held throughout the Navajo Nation for future management protocols and decision-making strategies. New adaptive management strategies look to embrace complex systems thinking and incorporate traditional knowledge for decision making.

GREEN INFRASTRUCTURE AND ECOSYSTEM SERVICES AT TWO METROPOLITAN AREAS OF GREECE

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Green infrastructure in major cities provides solutions for e.g., regulating local climate, pollution, floods and wind impact, biodiversity maintenance, supports comfort conditions for visitors and local citizens and provides recreation opportunities and aesthetics. The scope of the present study, conducted for the LIFE IP 4 NATURA Project, is to assess how green infrastructure provides ecosystem services (ES) at the two largest metropolitan areas in Greece, i.e., Athens, and Thessaloniki. The goals of the study are: (a) map and assess urban and peri-urban green space and areas, (b) identify and map climatic conditions at the local scale, (c) analyze population density, (d) map and assess actual and potential supply of ecosystem services and (e) support decision making for urban planning and eco-smart solutions for current and future management plans and development goals. Landsat Thermal Infrared Sensor (TIRS) imagery has been used to retrieve land surface temperature, using a Google Earth Engine processing chain. Green space and tree canopy information was extracted based on visual assessment and re-analysis of Copernicus HRL Forest 2018 forest layer; statistical analysis methods on multispectral High Resolution satellite data were used to calculate final values. Population density data (100m scale) for 2020, were extracted from the Global High Resolution Population Denominators Project. Population characteristics data were extracted from the Hellenic Statistical Authority database. ES identification and assessment is based on literature review, field surveys using the MAES_GR platform and on spatiotemporal analysis of climatic data and comfort condition thresholds. Main results include: (a) green infrastructure maps for Athens and Thessaloniki metropolitan areas, (b) green area per citizen maps, (c) comfort conditions maps and (d) actual and potential supply maps for provisioning, regulating and maintenance and cultural ES. The study outcomes provide input for scientifically informed decision making on urban space planning under management and climatic scenarios, using green infrastructure as a core element that provides a variety of crucial ES and simultaneously support sustainable development goals and integrated solutions for future urban expansion.

UPDATING LAND TRUST CONSERVATION STRATEGIES FOR CLIMATE CHANGE RESILIENCE

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Lowcountry Land Trust (LLT) works with private landowners to conserve land across the South Carolina coastal plain. Traditionally LLT has done conservation easements on working lands (farms and forestry) but has recently recognized the need to expand conservation targets to include a climate change component. To do this, a GIS analysis was performed using The Nature Conservancy's *Resilient and Connected Landscapes* data layer. The goal of this analysis was to identify areas of land that would be considered resilient due to their predicted ability to support species and ecosystems as climate changes over time.

Using this dataset, we visually examined the South Carolina coastal plan to look for clustered areas classified as medium and high resilience. The dataset considers resilience as land with geographic variability and microclimates that allows ecosystems to continue and withstand climate change over time. For each clustered area, we created statistics about land cover, conservation status, and susceptibility to sea level rise. Interviews with LLT field staff were conducted to gain insights into the threats, opportunities, and strategies for conservation for each region.

We identified 24 high resilience zones within the coastal plain and created preliminary conservation area targets and strategies for each. To explain and share our results, we also created a booklet covering the entire project, what the data are, how to use it, and a two-page visual dashboard for each zone.

Incorporating the results of our resilience analysis into our conservation strategy has met with mixed success. There are multiple, often competing, interests. For example, LLT has historically worked with farming and forestry lands, which don't typically have the high biodiversity that enhances resilience. We also typically partner with private landowners on conservation easements. This can lead to a juxtaposition between developing terms that incorporate these resilience principles and attempting to address the landowner often wanting to preserve maximum future flexibility. Another challenge we have found is the tension between conservation efforts on large acreage tracts, versus a focus on smaller but higher impact areas. Our Board of Trustees is excited about this work and views it as cutting edge for a land trust, hopefully leading to more consideration of climate change in our land conservation efforts.

DETERMINANTS OF FARMERS' WILLINGNESS TO ACCEPT CARBON PAYMENTS FOR SWITCHING TO CONSERVATION MANAGEMENT PRACTICES

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The technical potential of agricultural soil carbon sequestration in reducing greenhouse gases and mitigating the impacts of climate change is widely recognized. However, adoption of conservation management practices that can sequester carbon on agricultural soil is not widespread as a carbon market program. Carbon market programs are voluntary mechanisms that could incentivize farmers' adoption of practices that can sequester carbon. There is limited knowledge of whether current adopters and non-adopters of conservation practices respond similarly to carbon market programs. Knowing the determinants of farmers' willingness to accept (WTA) carbon payments is important to inform policy making for climate-smart agriculture. This study investigates how farmers respond to voluntary financial incentives for agricultural soil carbon sequestration. The data for the analysis are collected through a mail-in survey of row crop producers in South Dakota, conducted during spring 2022. The study employs Discrete Choice Experiment and Random Parameter Logit model to estimate farmers' preferences and WTA carbon market payments. Our study shows that farmers' WTA carbon payments vary based on their adoption status. Similarly, attitudes towards climate change and adverse experience with weather events influence farmers' WTA carbon payments. The findings suggest that carbon market program designs should consider differences in farmers' adoption status for various practices. Study's findings imply that since attitudes and experience play a great role in influencing adoption behavior towards conservation management practices, there need to be more awareness, outreach, and extension activities to farmers in the context of climate change.

OPTIMIZED MANAGEMENT STRATEGIES TO SUPPORT BIOENERGY FEEDSTOCK YIELD AND ECOSYSTEM SERVICES IN DEGRADED FOREST ECOSYSTEMS

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Managing forest ecosystems for multiple ecosystem services is exceedingly difficult and land managers currently do not have the proper tools at their disposal to optimize these goals. It is a central aim of the Eco-Opt (Ecosystem Service Optimization) project to co-develop tools with forest managers that can be added to their current toolbox to ensure forest health in the context of multiple demands on forest ecosystems. Our overall goal is to understand the impacts of extracting biomass energy feedstocks from degraded forests on other ecosystem services and to co-develop decision-making tools with land managers for optimizing biomass extraction without compromising ecosystem services. We used US Forest Service Forest Inventory and Analysis (FIA) data and the Forest Vegetation Simulator to model the bioenergy potential of feedstocks derived from silvicultural systems designed to restore degraded forests in the northeastern US. The bioenergy feedstock potential was evaluated in the context of other ecosystem service objectives such as enhancing carbon sequestration and storage and producing high-value forest products such as sawlogs. In addition, we used forest structural information from the FIA data and model outcomes to conduct a novel investigation of the potential impacts of bioenergy feedstock extraction on climate regulating services related to biophysical changes linked to land surface temperature and albedo. We will present the outcomes of this work and demonstrate the related user-friendly tool developed using R Shiny to compare outcomes under different landowner objectives (e.g., bioenergy feedstock volume vs. maximizing carbon sequestration).

MEASURING NATURE-BASED RECREATION USING HUMAN MOBILITY DATA

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Parks provide cultural ecosystem services; participating in nature-based recreation improves human health and well-being, increases social cohesion, and supports local economies. However, nature-based recreation is not always equitably distributed. To better manage recreation on public lands and address social inequity to support conservation initiatives, such as America the Beautiful, collecting visitor data is fundamental. However, compiling these data across time and space is often challenging. This presentation will introduce a method to measure nature-based recreation consistently. Visitor counts and profiles were estimated based on cellular device locations for the top 50 most visited US National Park Service (NPS) units in 2018 and 2019. We examined the correlation between NPS data (NPS STATS) and anonymized and aggregated human mobility data purchased from AirSage Inc. We also applied a mixed effect model to account for month and clustering by park unit. Visitor origin information based on home Census Block Group was used to estimate travel distance and demographic characteristics. Cellular device-based visitation counts were generally well-correlated with the NPS STATS counts, with a correlation greater than 0.8 for most parks. Regression results showed that park attributes, such as population center (urban vs. non-urban), recognition from non-local communities (iconic vs. local), and porousness level of park boundary (high vs. low), played a role in the relationships between cellular device and NPS counts. Human mobility data tended to better predict NPS STATS' measures for non-urban iconic parks and large parks with low porosity. Origin information based on Census demographics indicated that only 9% of park visitors were African American while they make up around 13% of the general population. Demographics varied by park attributes. Human mobility data provide an alternative and reliable approach to collect visitor information across large temporal and spatial scales. Visitors profile information can be used to promote equitable access. This method could be considered for recreation accounting for the United Nations System of Integrated Environmental Accounting – Experimental Ecosystem Accounts (SEEA EA) framework. Future research should consider taking advantages of this alternative approach to understand visitation and address social inequity of recreational access.

ECOLOGICAL BUSINESS PROFILE: A PRACTICAL APPROACH TO ESTABLISHING ENVIRONMENTAL MARKETS IN SOUTH CAROLINA

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Environmental market mechanisms can be a catalyst to leverage funding for environmental conservation. This mechanism intends to have a continuous flow of financial resources to fuel programs towards strategic key conservation areas and practices. By providing incentives to landowners, they would be able to transition in adopting sustainable management practices. In South Carolina, forestry remains to be the biggest industry and its contribution to state economy reaches about \$21 billion annually. Forest is also the predominant land cover in the state wherein 52% of which are privately owned. Various funding mechanisms, both from federal and state agencies, are present to assist forestland owners in sustainably managing their forests and avoid its conversion to other land use. However, majority of these funding mechanisms are thematic and specific to the type of practice to be adopted. This leads the landowners to pattern their adoption of practices to follow the thematic funding guidelines rather than a holistic land management. Moreover, technical expertise is oftentimes needed to prepare the necessary documents to access these funds. These conditions pose a challenge in developing a workable environmental market such as the Payment for Ecosystem Services (PES). To develop an environmental market that is holistic, ecosystem service-centered, and watershed-oriented, we develop a PES framework in Edisto River Basin, SC using an Ecological Business Portfolio (EBP). The EBP outlines the sustainable practices that landowners will be adopting, the potential costs for doing so, and the possible changes in ecosystem services that the sustainable practice will deliver estimated through ecosystem service-based models. Since we are in the preliminary stages of this effort, we partnered with forestland owners who are willing to develop the EBP for their land. Based on the results of InVEST modeling, projected ecosystem services change in their land would contribute into improvement which justifies the cost for implementing their EBPs. Furthermore, initial comments from landowners about the EBP mentions that the holistic planning nature of the EBP works like a masterplan for them to follow and ensure that the practices that they adopt improves the ecosystem services provided by their land.

BAYESIAN INFORMATION CRITERION APPROACHES TO VALUING THE ENVIRONMENT: AN APPLICATION TO THE BOUNDARY WATERS CANOE AREA WILDERNESS

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Bayesian estimation methods are widely but narrowly used in environmental economics. Broader uses of the Bayesian information criteria (BIC) is common in the ecological literature but have not been applied to efforts to value environment. This analysis utilizes BIC to evaluate a wide range of models and to utilize BIC derived evidence ratios to formally calculate the likelihood that each model is closest to the correct one. Because this approach is independent of distributions and parametrization it can be applied in virtually any circumstance to assess model fit. The Boundary Waters Canoe Area (BWCA) Wilderness is one of the most visited and largest wilderness areas within the U.S. According to the USDA Forest Service (2017) it has an approximate size of 1 million acres, and annual visitation of about 250,000 people. The BWCA is lightly studied from a resource non-market valuation point of view.

The BWCA is now a place of considerable policy concern. Its proximity to potential mining activities warrants additional investigation of its recreational value. This provides measures of visitor valuation of trips to the BWCA. It utilizes a count demand system approach to individually assess the value of the 71 sites. Measures of consumer surplus for each site are computed using a Bayesian estimation approach to find distributions for said consumer valuation in each trailhead, to better represent the variable nature of these measures.

The analysis also utilizes Bayesian model averaging to explore what the average of differently specified parametric models suggest. Rather than simply picking a best model the use of weights allows BIC's associated with various models to be used to calculate a weight of the likelihood of each model and used to weight the different benefit estimates in a meaningful manner. The composite benefit estimates are robust to model misspecification to a degree that individual models cannot be.

DETERMINANTS OF LANDOWNER PARTICIPATION IN PROGRAMS TO DELIVER NATURAL INFRASTRUCTURE AS A WATERSHED SERVICE: A REVIEW

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To better understand landowner participation dynamics in payments for ecosystem services (PES) programs, this analysis seeks to identify and summarize generalizable lessons on the determinants of landowner participation from case studies in the scientific literature. The project aims to identify the key determinants of landowner participation in various PES programs globally and in the United States, and based on this synthesis, provide recommendations for the design of novel PES programs, such as those that aim to deliver natural infrastructure as part of a payments for watershed services (PWS) program. Conclusions were drawn based on a multi-stage qualitative approach that included a systematic search of the scientific literature on PES, PWS or similar programs, and coding and content analysis of a representative subset of this literature (n=49). The analysis found that the factors that maximize landowner participation in the programs studied depend on the ecosystem service targeted, program scale, and whether the program was implemented. For PWS programs, economic factors were unable to fully explain participation decisions, even though payment amount had a positive effect on enrollment. Participation was motivated to a large degree by environmental concerns and natural resource interests only in PWS and programs that aim to deliver wetland-, pollination- or other historically less targeted ecosystem services.

RETHINKING SOCIAL VULNERABILITY INDICES: SEPARATING HOUSEHOLD SUSCEPTIBILITY TO FLOOD-INDUCED HARM FROM EXPOSURE RISK

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Mitigating flood risk through ecosystem restoration and altering the built environment is a challenging goal facing many communities. To allocate scarce mitigation resources, federal agencies, such as the US Army Corps of Engineers, may compare project net benefits using property value protected or lives saved. What is not typically quantitatively measured is how ecosystem service or other benefits can be adjusted to incorporate equity concerns, since property value per affected person will typically be lower in disadvantaged communities relative to privileged ones. Multiple social vulnerability indices have been proposed that combine diverse socio-demographic variables to characterize disproportionate exposure to risk and disproportionate harm that can occur in vulnerable groups. However, distinguishing sources of harm is important because it will lead to different analytic needs and policy prescriptions. If harm is due to disproportionate exposure, modelers can use physical flood models alone to compare flood risk and address these environmental justice concerns. However, if social factors are magnifying the effect of physical exposure, a more complex calculation is needed. We used literature evidence to design a new social vulnerability index that isolates *social susceptibility*, or the potential for excess harm, after controlling for risk exposure levels. This index characterizes the influence of socio-demographic factors on adverse outcomes, separate from the risk due to location and building quality. The index can be combined with flood risk model outputs, without double-counting the exposure factors that are already included. We used studies that controlled for exposure when analyzing contributors to social harms from flooding, such as unemployment, loss of income, and health outcomes but not building damage or disaster declarations. We applied decision science techniques for index creation to avoid common problems with social vulnerability indices when many indicators are summed and assumed to be compensatory. Summing many indicators can result in the low scores on less important indicators offsetting the high scores on more fundamental vulnerability indicators, thereby obscuring signals. The index was designed for prioritizing national flood risk mitigation projects, but some issues apply to addressing equity in any decision context.

BROADENING BENEFITS AND ANTICIPATING TRADEOFFS BY USING AN ECOSYSTEM SERVICES FRAMEWORK IN USACE PLANNING

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We addressed the question, does comprehensively analyzing ecosystem services improve social benefits sufficiently to compensate for any extra effort? Recent research testing whether ecosystem service assessment improves decisions or conservation credit markets finds mixed results. This work tested a new (proposed) ecosystem goods and services (EGS) analysis framework, co-developed by researchers from academia and the US Army Corps of Engineers (USACE), to advance this debate. USACE planning methods are particularly relevant to understanding the outcomes of EGS analysis, given that their policies determine the projects or project elements that can receive federal cost share funding through their programs.

To create a test comparing benefits to effort, we analyzed a multi-objective river restoration project in the Meramec River, Missouri (USA), planned jointly by the USACE and the US Environmental Protection Agency (US EPA). We compared the decision steps and outcomes of the current planning process to a hypothetical alternative EGS-informed scoping process, using available documents and publications. The EGS framework differs from current planning in multiple ways including evaluating all potential EGS benefits, regardless of mission goals or project authorities. Further, it asks for explicit causal relationships between biophysical changes and social benefits created, rather than leaving connections and assumptions implicit.

From our test, we conclude that although the EGS Framework may modestly increase time costs during scoping, the real-world outcomes of the case study suggest that these up-front costs might have prevented costs incurred later. The case study project planners were forced to make major project changes late in the planning process to address stakeholder concerns. The EGS Framework might have avoided this outcome because it elevates stakeholder concerns that fall outside of project authorities or regulation early in the planning process. Use of the framework might also have avoided some EGS incompatibilities created from the sequential decision making to first reduce toxic contaminants before engaging the USACE on improving habitat goals. However, analysis alone does not ensure change. Effective use of the information produced by this or other EGS Frameworks will require some procedural changes, cross-agency collaboration, and engagement with local partners during all planning phases.

SEA LEVEL RISE DRIVES HABITAT AND CARBON LOSS IN THE U.S. MID-ATLANTIC COASTAL ZONE

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The “blue carbon” stored in coastal wetland soils has received significant attention as a potential climate mitigation strategy, but coastal wetlands are at risk of loss due to sea level rise (SLR). Research has focused on the potential for inland migration of coastal wetlands to minimize wetland loss, but generally does not consider the terrestrial habitat losses and potential carbon emissions associated with inland migration. To investigate the overall impact of SLR on coastal zone habitats and carbon fluxes, we developed a spatial model for habitat and carbon changes caused by SLR, building on the InVEST Coastal Blue Carbon model, and ran it for six mid-Atlantic states (NC, VA, MD, DE, NJ, and NY) likely to face coastal habitat loss over the next century due to low tidal ranges and sediment supply.

Our primary model projection, using an intermediate SLR scenario (1.2 m by 2104) predicts loss of 83% of coastal marshes and 26% of seagrass beds in the study area. In addition, 270,000 hectares of forest and forested wetlands in low-lying coastal areas will convert to coastal marshes. These habitat changes cause the study area to shift from a carbon sink to a carbon source in the next century, primarily due to carbon emissions from lost coastal marshes and tree mortality in forested areas converted to marsh. Key uncertainties (and areas where additional research is needed) include land availability for inland marsh migration, the proportion of stored carbon emitted from lost habitats, and methane emissions from freshwater wetlands.

Given the potential for large-scale habitat and carbon loss due to SLR, the vulnerability and long-term sustainability of coastal zone habitats should be considered in conservation, restoration, and coastal planning decisions. While blue carbon may not be a viable climate mitigation strategy in some places, coastal habitats are important to conserve for the many other benefits they provide.

UPDATING REGIONAL ECOSYSTEM ACCOUNTS FOR THE U.S. SOUTHEAST

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Ecosystem accounts provide a standardized way to track the extent and condition of ecosystems and the flows of services they provide to people and the economy. An initial set of pilot ecosystem accounts for the southeastern United States was published in 2020 and contained metrics related to six ecosystem characteristics and services: wild pollinator habitat, water purification, air purification, bird species richness, carbon storage, and recreational birding. Data included in the pilot accounts spanned the years 2001 to 2011 for a subset of metrics and 2010 to 2015 for the remaining metrics, and only included two or three timepoints for each metric. This limited the accounts’ usefulness for observing temporal trends in ecosystem condition and ecosystem service flows.

Since the pilot accounts were compiled, many of the data sources used to calculate the metrics have been updated, and new datasets have been released. This enabled a recent update of the pilot ecosystem accounts for the southeastern United States, including the addition of new timepoints for many metrics and the expansion of the accounts to include new metrics more relevant to the final ecosystem services used by people. The updated accounts span the years 2001 to 2019, with up to six timepoints for each metric.

Being able to quantify the flow of a service to people, rather than an ecosystem characteristic that supports provision of the service, makes the information in the accounts more relevant to a broader audience. The improved temporal resolution in the updated pilot accounts facilitates more accurate interpretation of changes in each metric. An apparent trend across just two or three timepoints may prove to be noise when additional timepoints are added, or a trend may only become apparent when metrics are available every 2-3 years, instead of every 5. Therefore, the updated pilot accounts are an important step toward illustrating the value of ecosystem accounts and to regular implementation and use of natural capital accounting in the US.

GEOSPATIAL APPLICATIONS IN LAND CONSERVATION CONNECTIVITY

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Land conservation provides many benefits to people, ecosystems, and species; these benefits are enhanced when conservation lands are spatially connected to facilitate organism movement and ecosystem processes occurring across larger areas. Spatial data on ecosystem services has been developed for a broad geographic area of the southeastern United States to support pilot ecosystem accounts, and several organizations have identified key connectivity corridors. In this presentation, we will combine these data to assess the status of land conservation in the Southeast in terms of its connectivity and the benefits it provides, as well as potential opportunities for future conservation to enhance connectivity and co-benefits, with a focus on the role of privately conserved land.

NATURAL CAPITAL ACCOUNTING FOR THE USDA FOREST SERVICE

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This paper develops methods for constructing asset accounts for ecosystem services from forests consistent with standards in the UN System of Environmental-Economic Accounting (SEEA). We develop accounts for ecosystem extent, ecosystem condition, and ecosystem services. The accounts and models are developed around a case study on US national forests, where critical tradeoffs exist between provision of economic products (e.g., timber, fodder, water) and other ecosystem services (e.g., carbon storage, water quality regulation, recreation). This work overcomes past data limitations by paring recently developed US ecosystem accounts with long-term plot-level data on forest ecosystem services. Building on the growing natural capital accounting literature (Bagstad et al. 2021), we use SEEA standards to formulate regional natural capital accounts across national forests using USFS Forest Inventory and Analysis (FIA) data and other corporate Forest Service data. As in other national accounting systems, time series data are needed to measure the flow of services and calculate relative value shares for built capital, labor, and natural capital. In the case of ecosystem services, time series data are also needed to calculate the landscape capacity to reliably produce ecosystem services (Hein et al. 2016). FIA data include forest and vegetation extent, volume, ownership, and removal rates on all US lands, dating back to 1930. We anticipate using FIA data to create natural capital accounts for timber provisioning, grazed biomass, crop pollination, water supply, and climate regulation (carbon sequestration).

As of this year, federal accounting standards separate public lands into working, conservation, and operational lands. This has implications for natural capital valuation, since technologies to optimize one or more services from the capital are relevant for operational and working lands. Acknowledging the complexity of this, the Federal Accounting Standards Advisory Board agreed to continue discussing the possibility of reporting the valuation of public lands, while continuing to report acreage across the three categories as a proxy for value. We anticipate using these methods to quantify impacts from timber harvests, fuels management for wildfire, and natural climate solutions.

NOVEL APPROACHES TO ACCOUNT FOR ECOSYSTEM SERVICES BENEFITS IN NATIONAL FOREST PLANNING

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A shared understanding of the benefits and tradeoffs to people from alternative land management strategies is critical to successful decision-making for managing public lands and fostering shared stewardship. This study describes an approach for identifying and monitoring the types of resource benefits and tradeoffs considered in National Forest planning in the United States under the 2012 Planning Rule and demonstrates the use of tools for conceptualizing the production of ecosystem services and benefits from alternative land management strategies. Efforts to apply these tools through workshops and engagement exercises provide opportunities to explore and highlight measures, indicators, and data sources for characterizing benefits and tradeoffs in collaborative environments involving interdisciplinary planning teams. Conceptual modeling tools are applied to case studies examining the social and economic benefits of recreation on the Ashley National Forest and more broadly how to address ecosystem services in pre-planning on the Bridger-Teton National Forest. The case studies illustrate how these types of tools facilitate dialog for planning teams to discuss alternatives and key ecosystem service outcomes, create easy to interpret visuals that map details in plans, and provide a basis for selecting ecosystem service (socio-economic) metrics. These metrics can be used to enhance environmental impact analysis and help satisfy the goals of the National Environmental Policy Act (NEPA), the 2012 Planning Rule, and shared stewardship initiatives. The systematic consideration of ecosystem services outcomes and metrics supported by this approach enhanced dialog between members of the Forest planning team, allowed for a more transparent process in identification of key linkages and outcomes, and identified impacts and outcomes that may not have been apparent to the sociologist who is lacking the resource specific expertise of these participants. As a result, the use of the Ecosystem Service Conceptual Model (ESCM) process may result in reduced time for internal reviews and greater comprehension of anticipated outcomes and impacts of proposed management in the plan revision Environmental Impact Statement amongst the planning team.

VALUING WILD SALMON RECOVERY IN OREGON'S MOST URBANIZED WATERSHED

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We estimate the public benefits associated with conservation of wild salmon and steelhead in the Willamette watershed of western Oregon. Willamette Spring Chinook and Winter Steelhead are the only remaining wild native anadromous salmonids in the basin and are both currently listed as Threatened under the Endangered Species Act. Using choice experiment survey methodology administered via a repeat contact mail survey, we examine Oregonians' willingness-to-pay higher taxes to support recovered fish populations, at different abundance levels and recovery timelines. We estimate non-market benefits of hundreds of millions of dollars per year associated with increasing fish populations from 20,000 returns per year to 70,000. According to a recent recovery plan, this increase would drastically reduce extinction risk and allow de-listing. The public appears to apply an extremely low discount rate to future recovery benefits, implying support for multidecadal conservation efforts to reach a recovery goal. We also find evidence that the public would likely support reducing hatchery salmon and steelhead releases currently providing increased angler opportunities if this were required for recovery. Our results can be used by policymakers to gauge public support for various policies and watershed programs designed to improve salmon and steelhead conditions. *The views expressed in this abstract are those of the author(s) and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.*

VALUE OF IMPROVED INFORMATION FOR OYSTER AQUACULTURE ADAPTATIONS TO THE ECONOMIC RISKS OF CLIMATE CHANGE

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Climate change implications for locally provided ecosystem services are less understood than broad patterns of change, both to scientists and to those whose livelihoods directly depend on natural systems. Aquaculture growers are an example of an ecosystem-dependent business sector that will need to understand risks from ocean acidification, temperature increases, and other water quality changes to adapt to effects of climate change. Oyster aquaculture is being promoted in the US since it provides numerous ecosystem services by relieving pressure on the wild-catch fishery, producing food, supporting commercial and recreational fish, and improving water quality.

Our research uses coupled biophysical and economic models to assess potential cost-effectiveness of climate change adaptations for future growers of the eastern oyster (*Crassostrea virginica*) in Chesapeake Bay. We connect climate, hydrodynamic, and biogeochemical models to project future water quality conditions. We then add bioenergetic oyster growth and oyster mortality models that respond to those conditions to project growth and mortality. Finally, we develop a stochastic dynamic programming economic model that predicts optimal grower adaptation choices through time, after incorporating uncertainty. Models were assembled for bottom culture and water column culture operations and for small and large operations, to capture a range of economic impacts across representative growers.

Our results suggest that projected increases in future water temperatures will improve average oyster growth conditions in this mid-latitude estuary through mid-century, although this benefit could be offset by even small changes in average mortality. Sea level rise will increase background salinity which has some benefits but could also elevate disease rates in mesohaline areas of the estuary. In addition, episodic low salinity pulses due to spring rain events, which may become more common in the future, can also increase mortality. In general, salinity excursions and increased temperatures appear to create more risk than future ocean acidification in the Chesapeake Bay. Output of the stochastic dynamic programming model is used to quantify the value of improved information, including near-term forecasts, where value is measured as increases in expected net profit as growers adapt using improved information.

A METHOD TO ASSESS AND VALUE FLOODPLAIN ATTENUATION SERVICES IN THE SCHUYKILL WATERSHED

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Floodplains provide flood mitigation services by retaining floodwater and thereby reducing the impact of flood damages to property in adjacent areas during storm events. This study used geospatial tools to assess the extent and depth of flooding during representative storm events in the upper and lower Schuylkill River Watershed, as it currently exists (baseline) and under a counterfactual scenario with minimal to no floodplain storage. This analysis used flood frequency estimates of stage for the annual exceedance probabilities of 50-, 20-, 10-, 4-, 2-, 1-percent, which correspond to the 2-, 5-, 10-, 25-, 50-, and 100-year return recurrence intervals respectively, floodplain profiles derived from Height Above Nearest Drainage (HAND) grids, and floodplain geomorphic measurements from the United States Geological Survey (USGS) Floodplain and Channel Evaluation Tool (FACET) to develop an estimated depth grid for the baseline and counterfactual scenarios for each flood recurrence interval. Then Federal Emergency Management Agency (FEMA) Hazus model damage-depth curves and property values were used to estimate the severity of property damage and estimate associated monetary losses that would occur in interest under minimal to no floodplain storage for each flood recurrence interval compared to those incurred under current floodplain storage capacity. This represents the ecosystem services value of the floodplain flood attenuation through a damage avoided method. Results indicate elimination of the floodplain contributes to higher building damages and monetary losses, underscoring the importance of floodplains in mitigating damages from floods. Results from this study could serve as a tool to highlight flood risk in the Schuylkill watershed and beyond.

HOUSING MARKET CAPITALIZATION OF FRESHWAER LAKE FISHERIES: EVIDENCE FROM ONEIDA LAKE, NY

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Human societies benefit from ecosystem services generated by freshwater lake fisheries in numerous ways, from biodiversity, ecosystem health, to recreational opportunities. Quantifying the economic benefits of fish populations is essential for fish and water management.

In the literature, the travel cost method is widely used to quantify the economic benefits of lake recreational fishing. Considering the difficulty in sampling and survey collection, the travel cost model is often stationary, and difficult to capture fish stock dynamics in a single travel cost model. Perhaps more importantly, lake recreational fishery is used by two types of users: anglers who travel to specific access points and nearby homeowners who access the lake from their property. Travel cost surveys usually focus on the former, thus potentially omitting willingness-to-pay from homeowners who could have systematically different preferences towards sports fishing than anglers traveling from off-site.

Developing in parallel, the economic literature has long established the link between lake environmental quality and its capitalization effect on the housing market. In this paper, we build on that insight and quantify the economic benefits of freshwater lake fish species using the hedonic method. Our empirical framework identifies the capitalization effect of fish populations on the change in housing price premiums between lakefront and non-lake-front properties in response to fish population changes. The intuition here is that lakefront properties would be affected the most by changes in fish abundance because of their right of ways to angling, boating, or visiting.

To do so, we leverage annual observations on fish species abundance in Lake Oneida, proxied by gill-net catch rates, gathered by Cornell Biological Field Station. Combining that with arms-length housing market transaction data and water quality monitoring data, we find statistically significant capitalization effects for increasing abundance of walleye and white perch. A one-standard-deviation in the abundance of walleye, the most sought-after sports fish at Oneida, increases housing prices by 10%. We find negative effects for the abundance of yellow perch on housing prices, likely reflecting food chain dynamics between walleye and yellow perch abundance. The capitalization effect is the largest for lakefront properties and smaller and mostly statistically insignificant for properties second row and further away. The aggregated capitalized value for a one-standard-deviation increase in walleye abundance is \$48.8 million.

This study complements and extends the existing revealed-preference method in several aspects. First, we quantify homeowners' revealed preference towards lake fishery, especially those who live close to the recreation site. Our estimate is complementary to the preferences estimated from the travel cost approach, which focuses on anglers *traveling* to specific recreational sites. Second, utilizing long-term observations on species abundance, our paper provides one of the first estimates of the marginal value of varying fishery resource conditions. These complements existing studies using repeated travel cost surveys, offering insights on lake species conservation and management. Lastly, our results are useful in communicating the economic value generated by recreational fishing, especially from homeowners, which could bring significant impacts on ecosystem management decisions.

HOW DO SOCIAL FACTORS INFLUENCE COASTAL CULTURAL ECOSYSTEM SERVICES? A CASE STUDY IN THE ST. LOUIS RIVER ESTUARY

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Under the U.S. EPA's Great Lakes Restoration Initiative (GLRI), one of many initiatives to clean up U.S. coasts, \$3.8 billion have been spent since 2010, although few studies have assessed the equity or human well-being impacts of these investments. Cultural ecosystem services (CES) are the intangible benefits arising from interaction between people and nature, and their assessment could help fill that need. However, the application of CES to inform and evaluate decisions has been limited in part because studies have focused primarily on environmental influences on CES delivery rather than social influences, even though social factors are widely acknowledged to impact CES. To address this, we share our mixed methods study design to explore how social factors (demographics, identity, sociohistorical context) influence CES experiences in a case study of the St. Louis River estuary of Lake Superior. The area includes Duluth, Minnesota, Superior, Wisconsin, and the traditional and reservation lands of the Fond du Lac Band of Lake Superior Chippewa. The area is the focus of ongoing sediment remediation and habitat restoration under GLRI. Community and Indigenous advisory groups were convened to help guide study methods, recruit participants, and help interpret and share results. Our approach includes a survey of diverse community members to test associations between sociodemographic (age, race, and income) and participants' CES experiences. This will be followed by semi-structured interviews with a subset of survey participants from diverse backgrounds to help explain observed sociodemographic trends and qualitatively explore how identity and sociohistorical context influence CES experiences. Social and environmental factors are entangled, so we will also evaluate environmental factors. We will test for associations between reported CES experiences and access, amenities, habitat type, and ecosystem condition, based on local knowledge and existing datasets. This study will help expand the application of CES to guide equitable decision-making in diverse communities. Results will help identify management interventions to increase the supply, quality, and equity of CES benefits. Results will be specific to the case study but may be transferrable to other Great Lakes coastal social-ecological systems and will provide a holistic framework for researchers to measure and understand CES elsewhere.

ASSESSING THE CONTRIBUTION OF ECOSYSTEMS TO OCEAN-DEPENDENT INDUSTRIES

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NOAA has spent many years developing better measures of the contribution of the oceans to U.S. Gross Domestic Product (GDP). This includes the Marine Economy Satellite Account (MESA)—developed in collaboration with the US BEA—and the Economics: National Ocean Watch (ENOW). These efforts are a substantive improvement in our ability to understand how marine and coastal environments contribute to society. However, conventional measures of a country's economic performance, such as GDP, do not fully account for information about the natural assets that support economic activity. Assessing the contribution of ecosystems to different sectors of the economy would enable the U.S. to track progress in marine conservation activities, identify areas for improvement, highlight trade-offs that may exist related to resources use, and consistently track the health and the capacity of the marine ecosystems to provide goods and services to society.

Two approaches can be taken to identify and track the flow of ecosystem services to ocean-dependent industries. The first is to start with specific ecosystem services and determine what economic activities they support. The second approach is to start with an economic activity and determine which ecosystem services support it. We will show how MESA contributes to the second approach and can be used as a building block for creating supply and use tables for ecosystem services that support ocean industries. We have identified commercial fisheries and offshore minerals as industries for pilot studies based on their heavy dependence on, and clear linkage to natural inputs; the likely availability of data; and these industries' ability to serve as examples for future cases. For each of these industries we will determine the type of marine-based ecosystem services that contribute to the industry.

This project will provide primary evidence for government agencies, private sectors, NGOs, and the public to understand, monitor, value, and promote the marine economy and offshore mineral industries; for policy makers to measure the initiatives and policies performance on sustainable ocean and coastal management; and for businesses and R&D researchers to make more informed decisions on investing in this important part of the nation's natural and economic assets.

EFFECT OF NATIVE GRASS BUFFER STRIPS ON NATIVE POLLINATOR SPECIES IN PIVOT IRRIGATED CORN

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Many farmers in New Mexico are limited by the allotted water each growing season, forcing them to work a fraction of their land. A new practice, developed and tested in Iowa, inserted native grass strips in sprinkler irrigated crops. Strips of native grasses, or flowers, were planted intermittently with the cash crop. These management practices reduce water use and benefit ecosystem services (i.e., soil health, erosion control, pest management, etc.). Insect pollinators are a significant component of these ecosystem services. However, little information is available about pollinators in this system. Our study evaluates the impact of buffer strips on pollinators, specifically native bees, for this system in New Mexico. Specifically, field plots consisted of corn (the primary cash crop) as the control, interplanted with a native grass mix. The corn monoculture was planted on 3.88498 Hectares, 1.29499 hectares of grass. The corn/native grass intercropped plots were planted on 1.94249 hectares of the center irrigated pivot. Bees were sampled during the growing season in 2020 and 2022. Sampling consisted of colored bee bowls distributed in the inner, middle, and outer sections of each subplot to test for bee species diversity and quantity. Multiple colors (white, blue, and yellow) were used in this experiment to maximize species recovered because of coloration on attractiveness to various bee species. Bowls were set for 24 hours; then, contents were collected, stored in 70% ethanol, and taken to the laboratory for identification. We collected approximately 6,800 individual bees distributed among 35 genera, the majority being small bees belonging to the genera *Perdita* and *Lasioglossum*. Preliminary results suggest higher diversity and quantity of native bees in the buffer strip system than in the control system. Samples collected from the control plot typically contained up to 15 bees, while bees from the buffer plots contained up to 50 bees. This cropping system not only has the benefit of increasing beneficial insect populations, which will more effectively pollinate insect-pollinated crops but also reduce water usage. These native grasses also have the potential to be cut, baled, and sold to increase profits.

SUSTAINING RURAL LIVELIHOODS, LIVESTOCK GRAZING, AND SAGE-GROUSE HABITAT IN WESTERN SAGEBRUSH SYSTEMS

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Natural landscapes in the North American West provide ecosystem services that support rural economies through livestock grazing. External threats that disturb the landscape therefore affect rural economics. Federal policy and management aimed at preventing disturbance to natural landscapes also influence rural economics, as well as affect rural societal values. Policies that preserve both ecosystem services and socio-economic values require a paradigm that explicitly models the relationship among social, economic, and ecological values as a complex system that dynamically interacts. The overarching goal of our research is to examine whether socio-economic and ecological values are inextricably linked in natural landscapes. Specifically, we will examine the hypothesis that socio-economic values in rural communities are tied to ecological values of resistance (ability of a system to buffer against disturbance) and resilience (ability of a system to rebound after a disturbance; R&R). To achieve this goal, we will develop a cohesive framework to examine how rangeland management affects ecosystem health, rangeland productivity, and rural social well-being across an R&R gradient. Given the unprecedented conservation effort of sagebrush (*Artemisia* spp.) obligate species, we focus on the sagebrush ecosystem of western North America. In this first phase of our study, our scope focuses on developing ecological models that link livestock grazing with greater sage-grouse (*Centrocercus urophasianus*) population dynamics. Greater sage-grouse are an indicator species of sagebrush ecosystem health. We developed dynamic spatial-temporal models of sage-grouse demography using data from 38 field studies across their range. We supplement these data with region-wide sage-grouse lek data to obtain broad spatio-temporal inference. Importantly, we identify external threats and disturbances that impact sage-grouse population dynamics, and how these threats vary in space and time. Future phases of our research will use these results to quantify economic tradeoffs, feedback loops, and threshold effects of grazing strategies, and how those strategies affect sagebrush habitat and sage-grouse population dynamics and assess the sociological R&R of rural communities to changes in policy regarding grazing strategies and sage-grouse conservation.

AMERICAN CONSERVATION AND STEWARDSHIP ATLAS UPDATE

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An American Conservation and Stewardship Atlas is being developed to track progress towards goals of the America the Beautiful initiative, a locally led and voluntary nationwide effort that aims to conserve, connect, and restore 30 percent of America's lands and waters by 2030. The Atlas is intended to be an accessible, updated, and comprehensive tool through which to measure the progress of conservation, stewardship, and restoration efforts. Atlas development is an interagency effort, co-led by the Interior Department's U.S. Geological Survey, the Department of Agriculture, the Department of Commerce's National Oceanic and Atmospheric Administration, and the Council on Environmental Quality. On behalf of the interagency effort, we will provide an update on Atlas development.

HOW MARGINALIZED GROUPS USE NATURE IN CANADA

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Nature contributes to human well-being, especially what is often called cultural ecosystem services contribute to people's physical and mental health, but also allow people to build relational values between human and nature. These experiences and values build a basis for environmental decision-making. In large-scale ecosystem service assessments, it has been proven hard to find good indicators for less tangible contributions of nature. So far, indicators have often been very general and not differentiating between different groups in society.

The scope of this research is to analyze how marginalized groups are using nature in their free time on a national and provincial level. For this, we analyze a representative dataset (n=20,000) provided by Statistics Canada which included questions on eleven activities in nature, demographic, and socio-economic status of respondents. We analyze the data along income gradients and the self-identifying as belonging to different marginalized groups (Indigenous, immigrants, people with disability, people of color) and compare it with the average Canadian behavior.

We find that income plays a significant role on people's activity level in nature – with increasing income people are more active in nature. However, the highest income group (more than 125,000CAD per year/ family) interacts less with nature. Hiking is the most popular activity across all groups, while activities in winter and where specific equipment is required (e.g., snowmobiling) are less popular. Self-identified Indigenous people engage more than other communities in foraging and hunting activities which we connect to a different cultural value of these activities compared to settler or immigrant cultures.

In conclusion, the data mirrors the social reality in that marginalized groups have less interactions with nature. Every marginalized group in the dataset probably has own reasons and challenges for their reduced activities with nature. To overcome existing social and environmental injustices, policy must reduce the barriers of access to the marginalized groups. For large-scale ecosystem services assessments in Canada, the dataset provides a sound basis to be more nuanced on cultural ecosystem services and nature's non-material contributions to people's well-being.

ADDITIONALITY AND THE ADOPTION OF RIPARIAN BUFFERS IN THE FACE OF URBANIZATION

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Governments invest heavily in agricultural conservation programs designed to reduce non-point source pollution and enhance environmental benefits. These programs provide financial assistance to farmers to facilitate the adoption of Best Management Practices (BMPs). The assumption is that farmers are unwilling to voluntarily adopt given the costs, so governments must provide payments. However, previous research has shown that voluntary adoption does occur thus reducing the additional impact (additionality) of conservation payments. Many explanations have been given for reduced additionality, but one that has not been explored is urban sprawl. As urbanization increases, non-farm households interact with agricultural operations with increasing frequency. This puts pressure on farms to adapt to the environmental preferences of non-farm households, which implies that farms in more urban areas may voluntarily adopt BMPs. We combine survey data on the BMP adoptions Pennsylvania farmers with a statewide database of the locations of single-family homes to examine how increased development pressures have impacted the additionality of government conservation payments. In this paper, we focus specifically on the extensive margin adoption of riparian buffer strips. Because government payments and adoption are not randomly assigned, we use a nearest-neighbor matching econometric model to identify the additionality effect. We then interact our variable on additionality with our farm-level measure of urbanization to estimate the moderating effect of urban sprawl on the additionality of government conservation payments. Our results demonstrate that relative to farms in the lowest category of urban pressure – farms with a surrounding density of one house per twenty acres or less – those in the highest group – farms with a surrounding density one house per ten acres or more – see additionality fall by 0.12 percentage points, relative to a base of 85%. Given the limited resources available to most governments to meet conservation needs, our results suggest that a more targeted approach to the distribution of these funds may be warranted. Specifically, moving resources away from urban-fringe areas and targeting them toward more rural farms may improve the additionality of those payments. Whether this is optimal from an environmental perspective will depend on the characteristics of the farming operations.

THE ECOSYSTEM SERVICES GRADIENT: AN INTEGRATED APPROACH FOR IDENTIFYING BENEFITS OF RESTORATION

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Ecosystem restoration aims to recover ecological integrity and biodiversity of degraded ecosystems while providing the ecosystem services that humans want and need. To effectively achieve this, resource managers need methods to assess what levels of restored biological condition are needed to achieve desired beneficial uses; identify ecosystems of high potential value where restoration might be targeted; and communicate the potential benefits of restoration to inspire action and gain public support. The Ecosystem Services Gradient (ESG) framework parallels the Biological Condition Gradient (BCG) as a way of visualizing current conditions within the context of the full range of potential biological condition, from highest quality to highly degraded. The steps to building and using an ESG include: i) identifying relevant ecosystem services for the specific management context, ii) identifying metrics and indicators describing ecosystem services provisioning, iii) using monitoring data and production function models to quantitatively describe levels of ecosystem services production along a gradient of changing condition, and iv) evaluating potential co-occurring benefits or tradeoffs across ecosystem services under different levels of biological condition. A BCG and complementary ESG were developed for Massachusetts Bay embayment to help support setting restoration targets and form a basis for implementing restoration projects toward achieving those targets. An understanding of historical changes in biological condition, as well as associated loss or gain in ecosystem services, can help to identify restoration targets that are reasonable within the context of what might be possible, and that achieve desired levels of benefit. Historical trends in habitat acres and associated ecosystem services provisioning were used to understand the range of potential condition and benefits. Discussions about historic losses of coastal habitats and their benefits, described by the BCG and ESG, are helping to support restoration target setting for Massachusetts Bays embayment to restore seagrass, prevent further losses of salt marsh and tidal flats, and maintain and restore valuable ecosystem services. A paired BCG and ESG approach can be used to help support an understanding of local loss or gain in habitats and associated beneficial uses to communities, prioritize and compare alternative restoration options, and to communicate and track potential benefits of restoration.

NATURE-BASED SOLUTIONS AS A METHOD TO RELIEVE THE PRESSURE ON THE FOOD-ENERGY-WATER NEXUS IN CITIES: EXEMPLIFIED THROUGH ECOSYSTEM SERVICE ASSESSMENT

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Food, energy, and water are three vital resources for humankind. An increasing world population is projected to increase food requirements, impact water availability, and cause energy risks, especially in urban areas. Nature-based solutions (NBS) have been identified as key concepts to defuse the expected tensions within the food-energy-water nexus due to their multiple benefits. This integrated approach addresses societal challenges and offers a promising contribution to how to enhance the availability and quality of resources for productive purposes and human consumption, while simultaneously striving to preserve the intrinsic value of the ecosystems. This research offers lessons learned from the real-life case studies in the project running within the Belmont Forum support project CRUNCH 'Climate - Resilient - Urban - Nexus - Choices'. Four main solutions were proposed and implemented: (i) permeable pavements; (ii) plant microbial fuel cells; (iii) bio-filtration basins and (iv) rain gardens. The results show that NBS provides physical contributions to the urban environment in the way of drought protection, water purification, energy generation, and food production. The pavement that is made of waste compression molding displays higher temperatures of 0.2–0.5 °C than at the surface. For pollutant removal, SS, COD, and mental have the best removal rate with a value between 47% - 81%. Rapid power production is achieved in the plant microbial fuel cells, with an average open-circuit voltage of 567 mV. Chinese celery (*Apium graveolens*) and canna lily (*Canna indica*) perform best and may be suitable plants in rain gardens. Additionally, a case-based quantitative ecosystem service assessment of the presented NBS was performed to demonstrate how different NBS can deliver monetary benefits to the environment. The analysis shows the highest value is for pollination (2.14 million per year). Sediment retention (0.88 million per year) ranks second and carbon storage contributes the least (0.37 million per year). The research concludes that a nexus thinking of the multipurpose design of NBS should be given a higher priority.

WATER STORAGE STRATEGIES IN FLORIDA'S NORTHERN EVERGLADES

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The Greater Everglades is a vast subtropical ecosystem characterized by hydrologic variations due to alternating wet and dry seasons resulting from annual rainfall patterns. Water levels within the region are managed by the South Florida Water Management District to aid in ecosystem restoration initiatives, protect communities from flooding, and meet the region's water supply demands. Under higher than "average" wet seasons and water levels, excess water can be captured and stored throughout the regional water management system where storage is available.

Since 2005, the district has been working with a coalition of state and local agencies, environmental organizations, ranchers, and researchers to enhance opportunities for storing excess surface water on private and public lands. The District's Dispersed Water Management (DWM) Program encourages private property owners to detain, retain, or accept regional runoff for storage on their land rather than drain it. Managing water on these lands reduces the amount of water delivered to Lake Okeechobee and discharged to coastal estuaries during the wet season; it allows for groundwater recharge and rehydration of drained systems, improves water quality, and incentivizes landowners to provide greater environmental stewardship. In addition, the program helps in sustaining the local economy through cost-share cooperative projects, easements, or payment for environmental services to landowners. The vast majority of the DWM projects are in the Northern Everglades where payment for environmental services partnerships between water managers and private landowners were established in 2011. These partnerships have made thousands of acre-feet of water retention and storage available throughout the greater Everglades system. Currently, two types of DWM projects exist, Passive Projects which store on-site rainfall, and Active Projects which are capable of pumping water from the regional system for storage or nutrient attenuation. Collectively, these projects can store nearly 80,000 ac-ft of water retention on local private lands. The objective of this presentation is to highlight the benefits of public-private partnerships to achieve environmental restoration goals, maintain regional flood protection, and incentivize private engagement for water conservation and ecosystem sustainability.

DEMAND FOR ECOSYSTEM SERVICES: EVIDENCE FROM THE ENVIRONMENTAL QUALITY INCENTIVES PROGRAM

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The USDA administers several conservation programs to address farming and ranching related environmental issues. Existing research focuses on farmers' participation decision and adoption of various conservation practices (see e.g., Boyer et al. 2016; Cooper 2003; McLean-Meynsse et al. 1994; Mezzatesta et al. 2013). A few recent studies evaluate the environmental benefits delivered by the programs, such as improvement in local water quality (Kaspar et al. 2007, Liu et al. 2022), and adjustments in agricultural production from the implementation of conservation practices (Fleming et al. 2018; Zhang 2018). However, we lack quantitative evidence on the demand for ecosystem services supported by conservation programs in rural areas (Ryberg et al. 1991). At the same time, improvement in environmental amenities, especially water quality, has been shown to positively impact local housing markets or land prices (Leggett and Bockstael 2000, Walsh et al. 2011). Therefore, changes in rural property price provide a rare opportunity to assess the demand for ecosystem services improved through conservation programs.

In this research, we estimate econometrically the demand for ecosystem services supported by the Environmental Quality Incentive Program (EQIP) using individual property transaction data in rural U.S. Our preliminary results suggest that the implementation of EQIP has a significantly positive impact on rural housing markets. We also examine the ecosystem service channels through which EQIP affects housing price, including water quality, air quality, and wildlife habitats. Furthermore, we demonstrate significant heterogeneity in the demand for ecosystem services across counties with different socioeconomic characteristics. Quantitative assessment of the monetary benefits of agricultural conservation programs is important for evaluating the overall efficiency of the programs. Our results have important policy implications for the assessment of conservation programs: we compare the economic benefits of EQIP through housing markets and its costs and highlight the positive effects of the program on rural economy.

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