

**2018 ACES**  
A Community on Ecosystem Services  
*Natural Resources Benefitting People*  
Celebrating **10 years** of ACES!

In partnership with  
**ECOSYSTEM MARKETS**  
Making Them Work

**ESP**  
Ecosystem Services Partnership



**Abstract Book**

*Linking Science, Practice, and Decision Making*  
December 3-6, 2018 | Washington, D.C. Area

**UF | IFAS**  
UNIVERSITY of FLORIDA



# Welcome to ACES 2018!

**On the behalf of A Community on Ecosystem Services (ACES) and our partners in Ecosystem Markets and the Ecosystem Services Partnership (ESP), we welcome you to the ACES 2018 Conference!**

This is the 10-year anniversary of the first ACES conference! ACES conferences have been an important venue for sharing state-of-the-art ecosystem services science and practice since ACES was held in Naples, Florida in December 2008. Since then, the conference has been held every other year and has evolved as a critical destination to connect with colleagues and friends with expertise and interest across the wide spectrum of the ecosystem services community.

The focus of ACES 2018 is Natural Resources Benefitting People to emphasize the important connections between nature, science, and people. For this year's conference, we've provided a range of workshops, plenary sessions, and presentations – we anticipate that you will always find something that piques your interest. ACES 2018 will provide a rich venue for synthesizing ecosystem services related research, methods, tools, and policies. There will be more than 400 participants, coming from over 25 countries, including leaders from all levels of government, NGO's, non-profits, academia, and the private business and financial sectors. We encourage each of you to reach out and make a concentrated effort to interact with those who have an expertise different than your own. Take this opportunity to expand your experience and knowledge!

We are very excited to welcome our 13 esteemed 2018 Fellows: graduate students from around the world who will help lead ecosystem services science and practices going forward! Since ACES 2010, ACES Fellows have been chosen from a very competitive (and long!) list of candidates, and each receives partial or full funding to attend ACES. Take the time to read their bios, either online or in this program book, and make a point to stop by their oral or poster presentation. These students represent the future of the ecosystem services community and this is our opportunity to help mentor them along the way!

We wish to thank the supporting and partnering organizations and the Steering and Early Career Advisory Committee members for their outstanding efforts to make ACES 2018 a success. Their insights and support are greatly appreciated, and this conference could not have happened without them. We especially wish to thank the staff of the UF/IFAS Office of Conferences and Institutes for their continued (since 2008) extraordinary efforts in organizing conference logistics and making ACES 2018 possible, and for the strong leadership of Kristin Zupancic in this endeavor. Her exceptional patience with the Planning Committee and her skillsets are remarkable!

We anticipate that ACES 2018 will provide many opportunities to share science advances and state-of-the-art practices within the ecosystem services community. As always, as the week proceeds, remember to attend sessions that are outside of your field, and be sure to network, meet old friends, make new friends, and establish new interdisciplinary relationships.

*Thank you for attending ACES 2018!*

---

**Dianna Hogan, Ph.D.**

*Deputy Regional Director for Science,  
Southeast Region, U.S. Geological Survey  
Planning Committee Chair, ACES 2016, 2018*

**Frank Casey, Ph.D.**

*Economist  
Ecosystem Services Lead  
Science and Decisions Center, U.S. Geological Survey  
Planning Committee Chair, ACES 2012, 2014*

**Chris Hartley, Ph.D.**

*Senior Environmental Markets Analyst  
Office of Environmental Markets  
U.S. Department of Agriculture*

**Shonté Jenkins**

*Science Information Specialist  
Science and Decisions Center, U.S. Geological Survey*

**Marc Russell, Ph.D.**

*Assistant Lab Director, NHEERL  
Matrix Interface, SHC  
U.S. Environmental Protection Agency*

**Carl Shapiro, Ph.D.**

*Director  
Science and Decisions Center, U.S. Geological Survey  
Planning Committee Chair, ACES 2008, 2010*



# Table of Contents

**3** ..... Welcome Letter

**6** ..... Sponsors & Supporting Organizations

**7** ..... Partnering Organizations

**8** ..... Conference Committees

**9** ..... Abstract Compilation

**306** ..... Notes

# Sponsors & Supporting Organizations

Thank you to the organizations that take the extra step to partner with us through financial support.  
This important educational event would not be possible without you!

---

Ecometric Solutions Group | ESII Tool

Ecotone

The Nature Conservancy

Ramboll Environ

Society of Environmental Toxicology and Chemistry (SETAC)

U.S. Department of Agriculture, Office of Environmental Markets

U. S. Environmental Protection Agency

U.S. Forest Service

U.S. Geological Survey | Science and Decisions Center

University of Florida, Institute of Food & Agricultural Sciences

# Partnering Organizations

Thank you to the organizations whose employees have given so much of their time as members of the ACES 2018 Steering Committee. Their efforts and leadership help make this important educational event successful.

---

Australian National University, Crawford School of Public Policy

College of Charleston, School of Sciences & Mathematics

COMPASS

Duke University, Nicholas Institute for Environmental Policy Solutions

Electric Power Research Institute (EPRI)

Environmental Resources Management (ERM)

Ecosystem Services Partnership

Ernst & Young Global Limited

IUCN Commission on Ecosystem Management

The Nature Conservancy

NOAA National Ocean Service

Resources for the Future

Seale & Associates, Inc.

U.S. Geological Survey | Science and Decisions Center

University of Florida, Institute of Food & Agricultural Sciences

University of Minnesota

Vanderbilt Law School

Willamette Partnership

# Conference Committees

## Planning Committee

---

**Frank Casey**  
USGS Science and  
Decisions Center

**Dianna Hogan**  
*Conference Chair*  
U.S. Geological Survey

**Marc Russell**  
U.S. Environmental  
Protection Agency

**Kristin Zupancic**  
*Conference Coordinator*  
UF/IFAS Office of  
Conferences & Institutes

**Chris Hartley**  
USDA Office of  
Environmental Markets

**Shonté Jenkins**  
USGS Science and  
Decisions Center

**Carl Shapiro**  
USGS Science and  
Decisions Center

## Program Committee

---

**Frank Casey**  
*Committee Co-Chair*  
USGS Science and  
Decisions Center

**Shonté Jenkins**  
*Committee Co-Chair*  
USGS Science and  
Decisions Center

**Marc Russell**  
*Committee Co-Chair*  
U.S. Environmental  
Protection Agency

## Steering Committee

---

**Ken Bagstad**  
U.S. Geological Survey

**Jessica Fox**  
Electric Power  
Research Institute

**Doug MacNair**  
Environmental  
Resource Management

**Paul Sandifer**  
College of Charleston

**Ann Bartuska**  
Resources for the Future

**Erica Goldman**  
National Council for Science  
and the Environment

**Simone Maynard**  
International Union for  
Conservation of Nature

**Darius Semmens**  
U.S. Geological Survey

**Patrick Coady**  
Seale and Associates, Inc.

**Monica Grasso**  
National Oceanic and  
Atmospheric Administration

**Joe Nicolette**  
Environmental Planning  
Specialists, Inc.

**Jeffrey Thomas**  
Puyallup Tribe

**Bobby Cochran**  
Willamette Partnership

**Ariana Sutton-Grier**  
The Nature Conservancy

**Lydia Olander**  
Duke University

**Michael Vardon**  
Australian National  
University

**Robert Costanza**  
Australian National  
University

**Carter Ingram**  
Ernst and Young

**Steve Polasky**  
University of Minnesota

**Margaret Walsh**  
U.S. Department of  
Agriculture

**Rudolf (Dolf) de Groot**  
Wageningen University and  
Research Center

**JB Ruhl**  
Vanderbilt University

**Jon Waterhouse**  
Oregon Health and  
Science University

## Early Career Advisory Committee

---

**Marcello Hernández-Blanco**  
Australian National University

**Solen Le Clec'h**  
Zurich

**Rebecca Runting**  
The University of Queensland, Australia

**Shonté Jenkins**  
*Committee Chair*  
USGS Science and Decisions Center

**Colin Phifer**  
Office of Research and Development  
U.S. Environmental Protection Agency

# Abstract Compilation

Abstracts are sorted alphabetical by presenting author's last name. Presenting author names appear in **bold**.



## **FUNCTIONAL GREEN: AN ECOSYSTEM SERVICE PERFORMANCE METRIC FOR LANDSCAPE REGULATION**

***Pamela Abee-Taulli***

Environmental Review Specialist Senior, Development Services Department, City of Austin, TX, USA

Urban landscapes displace natural ones. But increasingly, urbanites are demanding that nature be re-integrated into cities; and ecosystem service (ES) is a useful tool for accomplishing that goal. Human habitation unavoidably supplants the natural environment. As a response, government entities provide nature in the public realm. But to integrate nature into private development requires a regulatory framework, which generally takes the form of a landscape ordinance.

The first landscape ordinance in the City of Austin was passed in 1979, revised in 1982, and goals are environmental, financial, and aesthetic. A prescriptive code written for a suburban development type, the ordinance establishes vegetative treatments for predictable parts of a commercial site, such as parking lots. However, Austin is in the process of rewriting the land development code to encourage compact and dense development, which has little to no room for landscape.

In response, we are developing Functional Green, a landscape regulation that uses ES as the performance metric to get the biggest ecological benefit out of the smallest space. The goal is to allow site-design flexibility for densely developed sites, while also requiring projects to provide a quantity of ES commensurate with that required for less dense sites under the standard landscape code.

City of Austin staff with landscape, green stormwater infrastructure, biology and other environmental expertise worked with a consultant, Heather Venhause of Regenerative Environmental Design (RED), to select a set of landscape elements appropriate for both dense urban sites and the local climate. Venhause's team researched over 120 studies to identify the ecological and economic benefits of these elements in Austin's climate. The result is a location-specific, ES scoring system that is applied similarly to other scored, performance-based landscape regulation systems such as Berlin's Biotope Area Factor, Seattle's Green Factor, and Washington DC's Green Area Ratio.

Functional Green pushes developers to maximize ES value as they contrive to get the most points out of the least space. Moreover, it incentivizes assessment of the existing site conditions at the beginning of the development and design process, particularly as existing, well established trees have the highest point value in the system, due to their ecological worth in central Texas' increasing temperature and droughts. Success will depend on two factors: the development community's willingness to embrace a different development and review paradigm, one that involves landscape architects from the beginning of site and building design; and City's willingness to review green features across disciplines for their multiple environmental benefits.

## CULTURAL ECOSYSTEM SERVICES AND CORAL REEFS IN WEST HAWAI'I

*Alison Adams<sup>1,2</sup>, Rachelle K. Gould<sup>1,2</sup>, Jill Brooks<sup>3</sup>*

<sup>1</sup>Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA

<sup>2</sup>Gund Institute for Environment, University of Vermont, Burlington, VT, USA

<sup>3</sup>Department of Geography, University of Vermont, Burlington, VT USA

Cultural ecosystem services (CES), or the non-material benefits people get from nature such as aesthetics and cultural heritage, are fundamental drivers of human well-being. CES are also linked to individuals' likelihood of engaging in pro-environmental behaviors. In short, CES influence the well-being of both people and planet. However, despite their importance, CES are the least-studied of all ecosystem services, and the link between ecological condition—in flux in many places due to climate change and other factors—and CES is even less explored. Coral reefs provide a good case study of these effects, since changes in these ecosystems can happen on short timescales and are easily visible to non-scientists. Using a single-question survey inspired by freelisting techniques, we surveyed individuals on reef beaches in West Hawai'i to assess (1) the CES provided by reefs to Native Hawaiians and non-Native resident Hawaiians, and (2) whether reef condition affects participants' responses. We asked each respondent one of two questions: "What do coral reefs mean to you?" or "Do coral reefs affect your well-being, and if so, how?" We also gathered basic information about participants' demographics and reason for being at the beach.

We discuss differences between respondents with different identities, and the effect of reef condition on survey responses. We also discuss the different kinds of responses elicited by the two questions, which may inform how researchers seek to elicit such information in the future. Although we did not ask specifically about changes in the reefs, mention of pressures on the reef was commonly included in participants' responses about the meaning of reefs or the impact of reefs on their well-being, suggesting that there is widespread concern about how changes in reef health are affecting these values.

As the environment changes, both material and non-material benefits are affected. However, assessing non-material benefits often requires time-consuming analyses of complex qualitative information. Freelisting can provide rich qualitative information for larger sample sizes and in shorter time. Our findings suggest that environmental change affects CES in critical ways; to support efforts to both adapt to and mitigate the effects of climate change on culture, we recommend further study of these effects in other ecosystems and cultural contexts.

## **ECOSYSTEM SERVICE BENEFITS PROVIDED BY FLORIDA WILDLIFE: ECONOMIC AND SOCIAL VALUES**

***Damian Adams<sup>1</sup>, Shelly A. Johnson<sup>1</sup>, Holly K. Ober<sup>2</sup>***

<sup>1</sup>School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

<sup>2</sup>Department of Wildlife Ecology and Conservation, North Florida Research and Education Center, University of Florida, Quincy, FL USA

This study investigated the public's preference for wildlife habitat management within the native range of the longleaf pine ecosystem in Florida, USA, which is a global biodiversity hotspot on the North American coastal plain. A survey was distributed and statistical methods were used to quantitatively assess preferences for wildlife habitat management and ecosystem services. A comprehensive evaluation was conducted on 10 wildlife species and 8 wildlife-related ecosystem services (i.e., direct use, indirect use, and non-use benefits) that these species provide. This filled a gap in knowledge on how the association between specific wildlife species and ecosystem service benefits alters the public's preferences for wildlife habitat management from their original perspectives. Specific objectives included: 1) quantify the public's preference for habitat management among wildlife species within the study system, 2) determine if communicating associations between wildlife species and the ecosystem services they provide change the public's preference for wildlife habitat management, and 3) quantify the public's preference for wildlife-related ecosystem services. Results showed that indirect-use ecosystem services and non-use ecosystem services had a more positive influence on the public's preferences for habitat management than direct-use ecosystem services. Furthermore, providing information on ecosystem service benefits associated with wildlife species can change the public's preference. In order to align public preference, policy, and wildlife habitat management goals, it is important to comprehensively address deficiencies in science, policy, and management at an ecosystem scale. Communicating the full suite of benefits these species provide can help align public support with conservation and habitat management goals.

## **FORESTLAND OWNERS' WILLINGNESS TO PARTICIPATE IN CARBON MARKETS**

*Mustapha Alhassan<sup>1</sup> and Marzieh Motallebi<sup>2</sup>*

<sup>1</sup>U.S. Geological Survey, Science and Decisions Center, Energy and Minerals, Reston, VA, USA

<sup>2</sup>Clemson University, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC, USA

Forests perform myriads of ecological functions including carbon sequestration, nutrient cycling, maintenance of wildlife habitat, and improvement of air and water quality. In particular, carbon sequestration through recommended forest management practices is a forest ecosystem service that helps mitigate climate change and its impacts. It is also an emerging opportunity for forestland owners to generate and sell carbon credits in carbon markets. Therefore, understanding forestland owners' perceptions and willingness to participate in carbon markets is an important component of evaluation of carbon management approaches. In our research, we estimate South Carolina private forestland owners' willingness to supply carbon credits in the California Cap-and-Trade program using a contingent valuation approach. To estimate minimum amounts forestland owners are willing to accept to participate in a carbon market, we used a random utility model. The random utility model helps us to examine variations in willingness to accept across characteristics of the forestland owners and their forestlands. We also investigate forestland owners' motives for owning forestlands and how information itself and source of information about global climate change affect their willingness to participate in a carbon market.

From data of 784 private forestland owners' responses, our estimated average willingness to accept in order to supply carbon credits to the California carbon market is \$67 per acre per year. Given \$11 per ton of carbon dioxide (CO<sub>2</sub>) as the lowest price of carbon credit at the time our survey was conducted, and a worst-case scenario of 55 tons per acre (110,000 pounds/acre) of minimum carbon storage of forestland in South Carolina, forestland owners can earn a minimum of \$605 per acre in revenue to participate in California's carbon market. The significant difference between \$67 and \$605 may be due to lack of forestland owners' knowledge of how the carbon market in California works.

The findings of this research suggest that most forestland owners lack information about carbon markets and benefits of forest ecosystems; additional outreach and education could improve forestland owners' participation in environmental quality improvement programs.

## **LEVERAGING EXISTING DATA IN THE RIVERINE ENVIRONMENTAL FLOW DECISION SUPPORT SYSTEM (REFDSS) TO ESTIMATE SEDIMENT RETENTION SERVICES PROVIDED BY FRESHWATER MUSSELS IN THE UPPER DELAWARE RIVER BASIN**

**Zachary H. Ancona<sup>1</sup>, Darius J. Semmens<sup>1</sup>, Ken J. Bagstad<sup>1</sup>, Chris Huber<sup>2</sup>, Heather Galbraith<sup>3</sup> and Dan Spooner<sup>3</sup>**

<sup>1</sup>United States Geological Survey, Lakewood, CO, USA

<sup>2</sup>Fort Collins Science Center, Fort Collins, CO, USA

<sup>3</sup>Leetown Science Center, Wellsboro, PA, USA

Freshwater mussels are found throughout North America in streams, lakes, and rivers. As filter feeders, they provide water filtration, an important ecosystem service. Their water-filtration activities capture, transform, and remove materials (e.g., sediment and nutrients) that would otherwise be transported downstream and can impose significant costs on water utilities, fisheries, recreational users and others. By expanding the knowledge of how freshwater mussels filter water in the Upper Delaware River, estimates of mussels' filtering capabilities can be extrapolated to other areas that share economic and ecological similarities, but may differ in mussel biomass distribution and water quality, such as in the Susquehanna River.

In this study, the USGS is developing a predictive freshwater mussel model (FMM) that links river flow data to biofiltration and nutrient retention efficiencies for freshwater mussels based on field data from 11 sites throughout the Upper Delaware River Basin residing within the Riverine Environmental Flow Decision Support System (REFDSS) tool. Flow-release values for the Delaware River reside within the Operational Analysis and Simulation System (OASIS) model, a reservoir operations and flow-routing model. These flow-release values enable estimation of depth and velocity, creating a unique discharge value raster for each of the 11 river segments given a specific flow-release scenario. Other inputs to the FMM include a mussel biomass layer created from site-specific mussel density heat maps, combined with conservative estimates of average mussel weight. To determine nutrient retention services for freshwater mussels we use a filtration rate that can adjust for mussel size and river velocity. Using these inputs, we are able to calculate per-pixel biophysical estimates of sediment and nutrient retention given the presence of freshwater mussels, which we monetized using watershed-specific estimates of the value of sediment retention. The sediment retention services provided by freshwater mussels are further leveraged using SPARROW model outputs that track the source of nitrogen and phosphorous (i.e., fertilizer from corn-soy-alfalfa, municipal point sources, atmospheric nitrogen deposition, manure, developed land, or other fertilizers) which show the value of downstream nutrient reduction while providing landowners with information on their environmental impact.

Our results highlight the relative value and importance of *in situ* soil conservation versus in-stream filtration by way of freshwater mussels. This information provides quantitative estimates of sediment retention provided by mussels, including monetary values that can be used as a reference for management decisions in the Delaware and nearby rivers.

## **MOVING WELL-BEING AHEAD: VALUE OF POTENTIAL AND REALIZED ECOSYSTEM SERVICES IN SOUTHERN ONTARIO, CANADA**

*Tariq Aziz and Philippe Van Cappellen*

Department of Earth and Environmental Sciences and Water Institute, University of Waterloo, ON, Canada

The services an ecosystem can generate at fullest capacity are called potential ecosystem services; the used portion of potential ecosystem services is known as realized ecosystem services. Because of their contribution to human well-being, the realized ecosystem services are of particular importance to people, and of key interest to the policy-makers. However, one of the key challenges faced by the economic valuation of ecosystem services is how to make a distinction between the values of realized and potential ecosystem services? This project addresses the challenge by valuing a bundle of ecosystem services in southern Ontario, Canada, for their potential and realized values. We develop a methodology using a phenomenological model which provides a distribution of potential and realized ecosystem services in the form of indices between 0 (minimum) and 1 (maximum). For valuation of realized ecosystem services, the indices are used to conform unit values (dollar per hectare per year) of potential ecosystem services based on their use. Our results demonstrate that the value of realized ecosystem services is ~50% of the value of potential ecosystem services in the selected region of southern Ontario. The distribution map of realized ecosystem services that results from this project is of significance for land use planners to locate hotspots that should be targeted for investments in natural infrastructure.

## **CLIMATE CHANGE, FORESTS, AND RECREATION IN MINNESOTA**

***Baishali Bakshi***

Natural Resources Science and Management, University of Minnesota, Maplewood, MN, USA

Climate change is driving a shift in the composition of the boreal forests of northern Minnesota with mixed coniferous forests predicted to lose substantial habitat to more temperate and grassland species by end of the century. About 69% of Minnesotans participate in forest-based recreation (national average: 54%) with annual expenditures on hunting, fishing and wildlife watching over \$3 billion. Yet the link between forest composition and recreation has not received due attention in research. In this paper we use a combination of econometric and spatial-ecological modeling using region-specific data to link seven categories of forest composition to seven categories of forest-based recreation and a variety of related predictors to quantify the impact of climate-induced forest composition change in the Laurentian Mixed Forest Province (LMF) of Minnesota. Preliminary results indicate potential decline in key recreation categories such as skiing and deer hunting and a negative impact on future recreation. The data for this research is sourced from a variety of sources including the Forest Inventory Analysis (FIA) program of the US Forest Service, the Minnesota DNR, and the Census Bureau. We present results in terms of a range of current and future climate scenarios. Our results improve understanding of the links between forest composition and forest based recreation, and help inform effective adaptation strategies for Minnesota's forests while contributing to the valuation literature on cultural ecosystem services.

## **AN INTERSECTION AND OPPORTUNITY: ENHANCING COMMUNITY CLIMATE ADAPTATION AND ECOSYSTEM SERVICES**

**Richard J. Baldwin**<sup>1</sup> and **Pieter Booth**<sup>2</sup>

<sup>1</sup>Ramboll, New York City, NY US

<sup>2</sup>Ramboll, Seattle, WA US

One of the gravest and most significant challenges currently facing our planet is how to deal with changing climates and associated significant meteorological events. Climate change adaptation is a response to global warming, sea level rise and similar extreme weather conditions, that seeks to reduce the vulnerability of social and biological ecosystems to sudden changes. During the past decade, and most notably the 2017 hurricane season in North America, the frequency and severity of hurricanes, tornadoes and large violent thunderstorms has increased (e.g., Hurricane Katrina, Harvey, Maria and Superstorm Sandy). According to the *2017 US National Climate Assessment*, the frequency and intensity of these extreme precipitation events will very likely to continue to increase throughout most of the world. Two storm-related consequences pose highly-significant risks of property damage and loss of life in coastal communities - storm-surge flooding and high precipitation cloudbursts.

Defending human development in cities and coastal communities in the context of climate change adaptation has become an important societal consideration. Ecological engineering has emerged as a discipline dedicated to protecting coastal and waterfront communities, supporting development goals and mitigating the consequences of extreme precipitation and other climate-related events. This is accomplished by merging conventional “hard” engineering approaches with “soft” engineering approaches that protect the built environment and simultaneously preserve or enhance the natural environment.

Hard engineering measures such as large-scale barrier walls, flood-gates and pumping systems represent significant financial investments and maintenance and operations (O&M) requirements to ensure their functionality during extreme weather events. These systems have experienced recent failures that have resulted in significant impacts to large population areas. In the post-Superstorm Sandy era, soft engineering practices have emerged, focusing on so-called “Working with Nature” and “Nature by Design” concepts of resiliency. Soft engineering measures include living reefs, smart streets, smart barriers, blue-green parks, placement of dunes, engineered wetlands and constructed marsh islands.

Economic practicality, engineering safety, sustainability and social value remain key considerations for climate change adaptation planning and design. Soft engineering resiliency measures are increasingly sought by municipalities as the solution for redevelopment of waterfronts and shorelines to make their communities both resilient to extreme weather events and “liveable” by incorporating walking trails, bike paths and green space into project designs. The merger of hard and soft engineering solutions leads to healthier and more vibrant coastal and waterfront communities through improvements to environmental quality and natural habitats and providing opportunities for recreation and enhancing public open spaces.

## **VALUING LANDSCAPE FUTURES: ECOSYSTEM SERVICES AND BENEFICIARIES TRADE-OFFS**

*Rosalind H. Bark<sup>1</sup> and Michael Acreman<sup>2</sup>*

<sup>1</sup>School of Environmental Sciences, University of East Anglia, Norwich, England

<sup>2</sup>Centre for Ecology and Hydrology, Wallingford, England

Natural hazards, such as floods, can focus attention on current landuses and discussions about future landscape. In the United Kingdom new policy interest in the catchment-based approach and natural capital have raised interest in mixed grey-green approaches to flood risk management. Green approaches, sometimes called, working with natural processes, e.g. through reconnection of rivers to the floodplain or riparian and upland tree planting, have the potential to reconfigure landuses and landscape aesthetics. Using a lowland case study from Somerset, England we determine different combinations of provisioning, regulating and cultural ecosystem services (ES) under three landscape futures – status quo, investment in grey, investment in grey and green. The alternative grey-green future is based on stakeholder visioning exercises.

Estimates of the value of ES under three different landscape futures using benefit transfer were shared with a stakeholder group. Issues arose around the monetary valuation, trade-offs in ES and beneficiaries, suggesting a more deliberative approach would be valuable. Follow-up stakeholder workshops revealed a large overlap around a shared vision, expressions of strong cultural attachment to place and an appreciation of trade-offs. Yet, despite evidence of a willingness to experiment with a mixed grey-green flood risk management approach, in many catchments there remains a mismatch around preferences to experiment and available funding. We conclude that there are trade-offs between ES and their beneficiaries under different landscape futures and that monetary valuation is not a silver bullet for choosing between them. Stakeholder deliberation reveals many shared values but also different priorities between, and within, different groups.

## MAINSTREAMING ECOSYSTEM SERVICES IN POLICY AND PRACTICE

***Ann Bartuska<sup>1</sup> and Erica Goldman<sup>2</sup>***

<sup>1</sup>Resources for the Future, Washington DC, USA

<sup>2</sup>National Council for Science and the Environment, Washington DC, USA

In recent years, the federal government, working in partnership with the private sector, has made great progress in integrating ecosystem services considerations into policies and programs. Government agencies are bringing the principles and practices of ecosystem services into the mainstream as they work to efficiently meet the nation's environmental, public health, and economic goals. The foundation underlying these principles and practices was built through a collective effort on the part of individuals in the nation's universities, non-governmental organizations, businesses, and government agencies—federal, state, tribal, and local. Policies and programs at the federal level have evolved considerably over the last 30 years as a result of bipartisan actions on the part of multiple Administrations and Congresses. In this interactive, Town Hall, panelists will offer different perspectives – from science to markets to policy -- on the various conditions that have enabled ecosystem services considerations to become more mainstream and they will share thoughts about the opportunities and challenges for the future.

## HOW MITIGATION CREDIT AGREEMENTS CREATE INCENTIVES TO PROTECT ECOSYSTEM SERVICES

**Chris Beale**

Resources Law Group, LLP, Sacramento, CA, USA

Under a 2017 California law, the California Department of Fish and Wildlife (“CDFW”) may enter into mitigation credit agreements (“MCAs”) that establish terms and conditions under which *conservation actions* and *habitat enhancements* that measurably advance the conservation objectives of an approved regional conservation investment strategy (“RCIS”) can be used to create mitigation credits that fulfill compensatory mitigation requirements under California law for projects that impact species and habitat, as well as other natural resources. (See, California Fish and Game Code, section 1850, et seq.) MCAs do not replace mitigation banks. Rather, MCA’s are intended to apply the high standards required of mitigation banks to advance mitigation strategies and programs that are guided by an RCIS and can encompass several mitigation actions at a range of sites over the course of several years. MCAs can also be combined with local, state, or federal “in-lieu fee programs,” such as in-lieu fee programs established pursuant the United States Corps of Engineers’ and United States Environmental Protection Agency’s regulations. (See, 33 CFR Parts 325 and 332; 40 CFR Part 230.)

MCAs can provide infrastructure agencies an efficient and effective way to develop the capacity to address mitigation requirements for impacts to biological resources in advance of project permitting or project impacts. By implementing conservation actions or habitat enhancements at several sites within the region covered by an approved RCIS, an MCA can enable such agencies to create a range of mitigation credit types (i.e., for a range of species or habitats). This can in turn encourage larger, longer-term, and more strategic investments in advance mitigation.

MCAs can also provide public and private conservation entities (e.g., conservancies, open space districts, and land trusts) a valuable way to finance conservation actions and habitat enhancements. Conservation entities planning to implement a range of conservation actions and habitat enhancements over the course of several years might determine that some or all of the actions or enhancements could be used to create mitigation credits. An MCA could then allow these entities to create and sell mitigation credits, recoup their costs, and invest in new conservation actions and habitat enhancements.

Whether used to establish advance mitigation programs, or used as a means to finance ongoing conservation programs, MCAs can, through the creation and sale of mitigation credits, provide direct economic incentives to protect and enhance natural ecosystems and the services they provide.

## **LANDSCAPES, AT YOUR SERVICE: OPTIMIZING ECOSYSTEM SERVICES DECISION-MAKING IN RESTORATION USING THE RESTORATION OPPORTUNITIES OPTIMIZATION TOOL (ROOT)**

**Craig R. Beatty<sup>1</sup>, Leander Raes<sup>2</sup>, Peter Hawthorne<sup>3</sup>, Adrian Vogl<sup>4</sup>, Kelly Meza Prado<sup>3</sup>**

<sup>1</sup>International Union for Conservation of Nature, Washington, DC, USA

<sup>2</sup>International Union for Conservation of Nature, San Jose, Costa Rica

<sup>3</sup>University of Minnesota, Institute on the Environment/Natural Capital Project, MN, USA

<sup>4</sup>Stanford University, Woods Institute for the Environment/Natural Capital Project, CA, USA

Governments have so far committed over 160 million hectares to forest landscape restoration under the Bonn Challenge. These commitments seek to bring degraded and deforested land into restoration by 2020 and 2030 and are a massive global commitment to increasing ecological productivity and human well-being. At the core of these commitments are restoration activities that work to increase the ecosystem services provided by landscapes to the people who depend on them. Until recently, the trade-offs inherent in restoration decision-making for the procurement of ecosystem services confounded the decision-making process – forcing decision-makers to prioritize one ecosystem service over another. In practice, stakeholders are interested in supporting the restoration of multiple ecosystem services for multiple beneficiary groups.

To address these trade-offs, IUCN and The Natural Capital Project developed the Restoration Opportunities Optimization Tool (ROOT <https://www.naturalcapitalproject.org/root/>). ROOT is a tool to perform optimization and tradeoff analysis. It uses information about potential impact of restoration or management change activities together with spatial prioritization or serviceshed maps to identify key areas for ecosystem service provision. Multi-objective analysis allows users to consider how to best manage tradeoffs between different project goals. Technically, ROOT applies an integrated linear programming algorithm which optimizes and displays the location of the expected ecosystem services generated through restoration. Most notably, it does so for multiple ecosystem services at the same time and can weigh these optimizations based on the location of people who rely on such services. This includes optimizing landscape restoration interventions in areas that would generate clean water, or avoiding areas where disadvantaged people might be negatively affected by changes or modifications in land use. The result is knowledge that is not purely biophysical, but instead blends the social priorities of those with the rights to manage land with the ecosystem service benefits that are expected from restoration.

This session will explore recent case studies in the application of ROOT and demonstrate that optimizing investments in landscape restoration to achieve multiple ecosystem service benefits is not only good for nature, but can provide elegant and cost effective nature-based solutions to conservation and development challenges.

## **IMPACTS OF LAKE WATER QUALITY ON RECREATIONAL VISITATION IN ALBERTA, CANADA**

**Marcus Becker<sup>1</sup>, Patrick Lloyd-Smith<sup>2</sup>**

<sup>1</sup>Alberta Biodiversity Monitoring Institute, University of Alberta, Edmonton, AB, Canada

<sup>2</sup>Department of Agricultural and Resource Economics, University of Saskatchewan, Saskatoon, SK, Canada

Alberta's network of provincial parks feature a broad diversity of landscapes, ecological communities, and recreational experiences. Visitors to these parks engage in a wide variety of outdoor activities, including camping, picnicking, hiking, and water-related recreation, making these areas an important public resource and source of ecosystem service benefits.

Lakes feature prominently as a natural attribute across this network of parks, and these sites are popular destinations for recreationists seeking water-related experiences. However, in recent years, harmful algal blooms (HABs) have become more prevalent in lakes across the province, including a subset of those located in provincial parks. Depending on the severity of the bloom event, public advisory warnings may be posted by provincial health authorities warning recreationists to refrain from making contact with the water. The purpose of this research is to test how impaired lake water quality impacts trip decision-making among recreational users of the park system, and assess the welfare losses associated with the decrease in the quality of recreational services.

Data on overnight trips made to 52 provincial parks spread across south and central Alberta in the years 2014-2016 was obtained for this analysis from a reservation database managed by Alberta Environment and Parks. Each of these parks featured a lake, and nearly half (23) experienced at least one water quality advisory during that three year span. In addition to advisories, raw data on cyanobacteria levels at each lake was obtained and remote sensing techniques were used to map the temporal and spatial extent of algal blooms at the effected lakes. These three indicators (advisories, cyanobacteria levels, bloom extent) were used within a travel cost model framework to assess how recreationists modify their behavior in response to changes in water quality. Preliminary results indicate that public advisories have a negative impact on visitation and user welfare, but that this effect is dependent on the proximity of the algal bloom to recreational facilities (e.g., beaches, campground).

These results suggest that decreases in water quality, leading in particular to the presence of algal blooms, has a negative effect on the ability of parks to provide public benefits in the form of recreational ecosystem services. When considering policies to improve nutrient management in surrounding watersheds, these results can potentially be used in future calculations within a cost-benefit analysis (CBA) framework.

## TROPICAL VEGETATION AND RESIDENTIAL PROPERTY VALUE: A HEDONIC PRICING ANALYSIS IN SINGAPORE

*Richard N. Belcher<sup>1,2</sup>, Ryan A. Chisholm<sup>1</sup>*

<sup>1</sup>Department of Biological Sciences, National University of Singapore, 117543, Republic of Singapore

<sup>2</sup>ETH Zurich, Future Cities Laboratory, Singapore-ETH Centre, Republic of Singapore

Effective urban planning depends on knowing homebuyers' preferences for neighbourhood features that provide different amenities, such as managed parks and trees. As the expansion of tropical urban areas into biodiversity hotspots is predicted to more than double by 2030, knowing homebuyers utility from different vegetation types can contribute to global biodiversity conservation strategies. We used the hedonic pricing method to estimate the economic value of managed, spontaneous and high conservation value vegetation to Singapore public housing using a mixed effects model. On average vegetation had positive effects on property selling price, accounting for 3% of the average property's value, or a total of S\$179 million for all public housing apartments sold over 13 months. These effects were almost entirely driven by managed vegetation, which had positive marginal effects on price for 98.1% of properties. The estimated marginal effects of high conservation value vegetation were mostly negative (90.5% properties), but positive for properties without much managed vegetation nearby. The estimated marginal effects of spontaneous vegetation were mixed and mostly small. To reconcile the goals of protecting high conservation value vegetation and maximising homeowner utility, new public housing developments should contain more managed vegetation but be away from high conservation value vegetation.

## **PREDICTING THE EXISTENCE AND PERFORMANCE OF U.S. WATER QUALITY TRADING PROGRAMS**

*Todd K. BenDor and D. Timmerman, and S. Wraight*

Department of City and Regional Planning, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Recent years have seen a ground-swell of bi-partisan support for market-based environmental policies, such as water quality trading (WQT). WQT programs include a number of arrangements for redistributing pollution that can increase the efficiency with which polluters can reduce effluent. However, the performance of WQT programs is uneven; while several WQT programs have found frequent use, many experience operational barriers and exhibit low trading activity.

Evaluations of WQT programs have tended to focus solely on a few successful programs, producing little evidence about what sort of program trading structures exist, or even *if* trades regularly occur. Few studies have sought to understand the abundance of WQT programs (including small-scale programs), where they tend to be established, and where trading actually occurs (as opposed to pilot studies or programs that exist only on paper). Currently, there is little research that attempts to look across geographies and market designs to comparatively study different types of trading programs. Comprehensive analysis is needed to better understand the factors promoting, or detracting from, the viability of WQT as a resource protection strategy and to synthesize policy lessons for improving program design, implementation, and performance.

What are the common inhibitors to implementation WQT programs? Where and why have these programs overcome barriers to become functional and productive and when do these programs frequently become stalled in their implementation?

In this presentation, we present the most complete database to date on WQT programs in the United States. We have compiled program information from numerous data sources over the last two years, creating a geo-database of trading programs. Each program includes separately mapped markets that are specific to separately traded pollutants, distinctive geographic service areas, market designs, and distinct trading mechanisms. Drawing on demographic, political, urban, and environmental co-variates, we use logistic regression modeling to better understand factors associated with the existence and relative operating state of WQT programs. We use this analysis to generate lessons that can inform program design and implementation, as well as improve our understanding of why WQT programs often have limited implementation and performance.

## **ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC IMPACTS OF CONSERVATION EASEMENTS IN THE UPPER CHATTAHOOCHEE WATERSHED**

*Fabio Jose Benez-Secanho, Puneet Dwivedi*

Warnell School of Forestry and Natural Resources, University of Georgia, Athens GA, USA

Ecosystem Services (ESs) are defined as the direct and indirect benefits people obtain from ecological systems, and they play a critical role in ensuring overall human wellbeing. However, due to urban sprawl in the Upper Chattahoochee watershed, ESs are in the state of decline in this area. Quantifying and evaluating ESs provided by this watershed is especially important because it supplies the majority of drinking water to the Atlanta metropolitan area. There are many private and public tools that can be used in conserving natural lands to maintain ESs. A conservation easement (CE) is one such legal tool which places a permanent restriction on the development of a private land parcel and in turn provides tax benefits to the landowner. Although there are 48 CEs within this catchment, there is no clear information on the provision of ESs by these CEs. This study uses the modular toolset InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) to quantify provision of four ESs (nutrient retention, sediment retention, water production, and carbon storage) provided by the Upper Chattahoochee watershed, and the value transfer technique to assign monetary values to them. This study determines the efficacy of CEs in maintaining selected ESs compared to other areas within this catchment. The output of this study could be used by decision makers as a guide for sustainable landscape planning for ensuring maintenance and enhancement of ESs across the Southern United States where most of the watersheds are facing urbanization pressures.

## **SENSITIVITY OF THE INVEST NUTRIENT DELIVERY RATIO MODEL RELATIVE TO THE INPUT SPATIAL DATA**

*Fabio Jose Benez-Secanho and Puneet Dwivedi*

Warnell School of Forestry and Natural Resources, University of Georgia, Athens GA, USA

Modeling ecosystem services (ESs) inherently involves combining tabular and spatial data. The most popular tool to quantify ESs is the InVEST, within which the Nutrient Delivery Ratio (NDR) model is widely used to model nutrient runoff. The output of NDR model is sensitive to the spatial resolution of input data. It is critical to assess variability in the model outputs relative to the spatial resolution of input data for better forecasting of ecosystem services. We analyzed the sensitivity of the NDR model outputs to three digital elevation models (DEMs), two land cover datasets (NLCD and GlobCover), and three precipitation grids (one retrieved from PRISM and two created using weather stations data) for 57 watersheds located within Georgia, United States. Selected input data had different spatial resolutions. We used multivariate regression models to test the significance of input spatial data. Results suggested that changes in spatial resolutions of DEM and land cover caused highest impact on nutrient runoff. Precipitation grids did not significantly influence the results at the 95% confidence level for all watersheds combined, but was significant when modeling nutrient runoff in some smaller physiographical regions of Georgia. We hope that our results will inform the decision makers about the uncertainty related to the quantification of ecosystem services and help in developing modeling guidelines for the future.

## **RELEVANCE OF ECOSYSTEM SERVICES AND ECOLOGICAL RESILIENCE IN MANAGING CORPORATE LANDS**

***Gregory R. Biddinger***

Natural Land Management, LLC, Belfast, Maine, USA

In managing corporate lands to achieve sustainable performance, compatibly integrating business objectives with the natural capital associated with real property is key. Designing operational uses for landscapes which have acceptable environmental footprints and which achieves minimal disturbance or even increase the functional value of working lands, generally requires attention to the functional ecological services that flow from the landscape. To achieve and maintain that balance between operational use and sustained ecological quality requires understanding how the ecosystem services are connected to the landscape and what controls the ecological resilience of the landcover.

The challenge to integrating ecosystem services and ecological resilience into corporate planning, design and performance assessment is that these ecological attributes are generally described in universally conceptual terms and provide difficulty at the level of specific individual parcels of land to identify structural or functional elements of the landscape that can be the focus of adaptive environmental resource management.

This presentation will review an operational framework for actively integrating these ecological principles and considerations into corporate planning and land management processes through out a properties operating lifecycle. Examples of how these ecological considerations can be included in corporate planning will be discussed in light of specific habitat types. Information resources and tools that can be utilized to achieve greater incorporation of nature into corporate land management will be identified.

## **DETECTING INFLUENTIAL ACTORS FOR ECOLOGICAL KNOWLEDGE UTILISATION IN URBAN GOVERNANCE NETWORKS**

***Antonija Bogadi***

Department of Spatial Planning, Vienna University of Technology, Vienna, Austria

Actor's influence has a significant impact on the knowledge diffusion and consequent decision making processes in governance networks. The influential actors in an urban areas can be found in elected officials, corporations, commercial establishments, developers, neighbourhood associations, NGOs, universities. New knowledge acquired in one of them flows into adjoining groups through network contacts. The hypothesis advanced here is that the way groups or individuals deal with knowledge utilisation does not reflect identifiable institutional processes. The speed and success of putting knowledge to use largely depends on whether and how the idea is moving through the "bonds of influence".

The core questions are: Whose understanding of Urban Ecosystem Services matters so the new knowledge about UES makes it into project? What is a correlation between personal characteristics of the knowledge influencers and their perceived influence?

A way for dealing with these concerns is to correlate actors' particular characteristics — exposure to information, position in informal network, formal authority, likability, ability, competence, availability, motivation — disclosed as a structural positions in social network diagrams, with their perceived level of influence on knowledge utilisation. The case study of green infrastructure project implementation in Vienna, Austria and analysis of the adjacent governance network are taken in account. The results show that combined effect of above mentioned characteristics coincide with perceived level of actual influence on knowledge utilisation in the governance networks, and that individuals that not have the right set of the characteristics will be ranked lower in terms of influence. The use of the described method can reveal the traits of "hidden leaders" or most influential actors in a process of using the new knowledge for implementing it into urban green infrastructure project.

The work presented here has implications for future studies for identifying actors who can contribute in preferable way to the management of ecosystem services and help design appropriate governance network. Knowledge utilisation can be managed, that is, influencers can be targeted and directed by network management strategies once there is reliable method in use to identify them via their relevant characteristics. Proposed method can be used to maximise the diffusion of desirable knowledge with respect to urban green infrastructure implementation.

## CONSERVATION AND ECOSYSTEM SERVICES OF SACRED NATURAL SITES IN NIGERIA THROUGH TRADITIONAL KNOWLEDGE AND LAWS

**T. Israel Borokini**

Department of Biology, University of Nevada, Reno, Reno, NV, USA  
National Center for Genetic Resources and Biotechnology, Ibadan, Nigeria

Dendrolatry and veneration of sacred trees, groves and other natural sites is central to traditional religion and culture of Yoruba people of southwestern Nigeria. This is exemplified by designation of sacred natural sites, while historical records show that most cities were established with reference to, and protected by forests, mountains and surface waters. This study seeks to unravel the how these traditional norms and cultural beliefs have helped protect and manage local biodiversity and its ecosystem services. Data were collected from folklore, and open-ended interviews with elderly people (n=15) in South-western Nigeria. Sacred natural sites in southwestern Nigeria were highlighted from this study, comprising (1) sacred trees such as *Milicia excelsa*, *Okoubaka aubrevillei*, and *Newbouldia laevis*, among others; (2) sacred groves, such as Osun shrine and grove, evil forests, king's forests, and hunter's forests, among others; (3) sacred mountains, including Olumo rock, *Oke-badan*, and over 500 christian prayer mountains; (4) sacred waters which include almost all rivers in the region. Sacred trees, for example, offer important conservation values and cultural ecosystem services which include the use of their leaves for festivals and sacrifices and their wood for carving totems used in rituals, festivals and promotion of cultural beliefs. Furthermore, many cities and streets across southwestern Nigeria were named after sacred trees. These natural sites were protected by taboos and traditional laws. These include laws that forbid harvesting parts of a sacred tree by people of specific age, status or gender, and laws that only allows for seasonal harvesting, collecting or hunting of wild natural resources. For example, strong traditional laws helped regulate the harvesting of *O. aubrevillei* and *Irvingia gabonensis* resources. Sacred groves were also protected by traditional laws that prohibit incursion and trespassing. These taboos were enforced by traditional volunteers, king's guards, and workers of traditional religious bodies. Violations of taboos were noted to attract heavy fines, libations and sacrifices to avert punishments for offenders. The current threats to the persistence of sacred sites were also identified, including embracing western culture, which has eroded respect for traditional culture and the sacred sites, religious and political changes, high rate of urbanization causing land use change, Nigeria's unfavorable land ownership policy, and proliferation of scientific knowledge used as tools to demystify traditional basis of sacred trees veneration. The author recommends policy changes and management strategies to allow for land ownership by traditional institutions, and community-based management of these sacred sites; while collaborations among religious leaders, traditional institution and researchers should be encouraged.

## **NON-USE VALUES: THE IMPORTANCE AND CHALLENGE OF COMMODITY DEFINITION**

***James Boyd***

Resources for the Future, Washington DC, USA

Economic valuation of ecosystem services requires identification of the “ecosystem commodity” (the biophysical features, qualities, or quantities) to which value is attached. Until recently, relatively little attention has been given to the definition of these commodities by economists. The talk will describe the theory and practice of commodity definition, with an emphasis on the particularly thorny question of the commodities to be used when estimating non-use values.

One way to think of these commodities is that they are the quantifiable biophysical features that best facilitate social and economic interpretation of ecological conditions and change. The talk will explain how that definition relates to the concept of final ecosystem goods and services (FECS). It will also argue that a FECS-based definition is crucial if subsequent valuations are to be transferable (via benefit transfer methods) and appropriately interpreted by policymakers.

Nonuse values, by definition, cannot be related to observable behaviors in the way we can relate (for example) recreational, real estate, or harvest behaviors to use values. Put another way, revealed preference (behavioral) evidence does not exist to help us identify or validate nonuse commodity measures. That creates a challenge for stated preference method practitioners who must themselves define the commodities in play in a choice experiment. The fact that nonuse values can in theory be held for almost any type of ecological change, combined with the wide variety of – and inconsistency in – commodities used in past research, contributes to criticism of nonuse valuations and can thwart their uptake by policymakers.

Despite those challenges, the measurement of nonuse values should continue because both evidence and intuition suggest that those values may be large and important to policy. The talk will argue that the FECS perspective on commodity definition suggests a research agenda that could help evaluate alternative nonuse commodity definitions and thereby improve the validity and relevance of nonuse valuations for policymaking.

## **APPLYING BIODIVERSITY METRICS WITHIN AN ECOSYSTEM SERVICES FRAMEWORK TO A HABITAT CONSERVATION PLAN: A CASE STUDY IN PARTNER ENGAGEMENT**

***Kenneth G. Boykin<sup>1</sup>, William G. Kepner<sup>2</sup>, Alexa J. McKerrow<sup>3</sup>, and Anne C. Neale<sup>4</sup>***

<sup>1</sup>Department of Fish, Wildlife, and Conservation Ecology, New Mexico State University, Las Cruces, NM, USA

<sup>2</sup>U.S. Environmental Protection Agency, Office of Research and Development, Las Vegas, NV, USA

<sup>3</sup>United State Geological Survey, Core Science Analytics, Synthesis, & Libraries, Raleigh, NC, USA

<sup>4</sup>U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC, USA

The ability to assess, report, map, and forecast the life support functions of ecosystems is absolutely critical to our capacity to make informed decisions that help maintain the sustainable nature of our environment now and into the future. Because of the variability among living organisms and levels of organization (e.g. genetic, species, ecosystem), biodiversity has always been difficult to measure accurately, especially in a systematic manner and over multiple scales. In answer to this challenge, we have developed an approach that uses deductive habitat models for all the terrestrial vertebrates of the conterminous United States and clusters them into biodiversity metrics that relate to ecosystem service-relevant categories reflecting A) Biodiversity Conservation; B) Food, Fiber, and Materials; and C) Recreation, Culture, and Aesthetics at 30m (Landsat) resolution. Collectively, these metrics provide a consistent scalable process from which to make geographic comparisons, to provide thematic assessments, and to monitor status and trends in biodiversity. Currently, we include 1590 terrestrial vertebrate species (621 bird spp., 365 mammal spp., 322 reptile spp., and 282 amphibian spp.) for the conterminous U.S. In the present effort, we worked with the participants of the Apple Valley Multispecies Habitat Conservation Plan (MSHCP) in California to identify and quantify biodiversity metrics for the MSHCP and the Mojave Ecoregion as a whole. We focus on species richness metrics including all species richness; taxa groupings, e.g. amphibians, birds, mammals, and reptiles; and special status species. Metrics were mapped based on potential species occurrence within the Apple Valley MSHCP and the Mojave Desert to demonstrate the multi-scale utility of the approach. Analysis of desert tortoise habitat identified multiple other species benefitting from tortoise habitat conservation. In these examples, geographic patterns differed among metrics and across the study area. Our approach incorporates built-in extensibility so that as other metrics become identified, they can be explored and added to the system. This process allows for similar analysis and application anywhere within the conterminous United States at varying scales.

## **PRIORITIZING SITE REMEDIATION AND RESTORATION TO ACHIEVE ECONOMIC AND CONSERVATION GOALS**

***Steven S. Brown***

Environmental Remediation and Restoration, The Dow Chemical Company, Traverse City, MI, USA

Corporate environmental remediation managers are charged with investigating and addressing contaminant risks in order to achieve effective site remediation and liability closure quickly and cost effectively. Corporate and regulatory managers might emphasize differing priorities, but all would do well to focus early on options and opportunities for future uses for these properties. Sites in urban areas frequently provide opportunity for economic redevelopment, subject to any necessary restrictions. Redevelopment options are often prioritized in urban settings, but these sites also afford the chance to restore and protect riparian buffers and floodplains (green infrastructure) and to reconnect neighborhoods with natural resources. Redevelopment and environmental stewardship are not mutually exclusive! In cases where large corporate land holdings are located in more remote and ecologically sensitive areas, which may or may not be subject to remediation, these lands sometimes have the potential to support high-priority, regionally significant conservation objectives. Within the Environmental Remediation and Restoration Group at Dow, we have prioritized planning for future land use that provides a mix of redevelopment and green infrastructure at urban sites, and maximizes conservation value and ecological services at more remote sites. In this presentation, ongoing projects will illustrate a collaborative approach that utilizes scientific research with academic partners to address site-specific risks, and interactions with land planners and conservation partners to create future use options that maximize economic and ecological value, as appropriate for each site. Trust derived from these partnerships and mutually beneficial future use scenarios help create a project climate that can serve to expedite site remediation/restoration, closure, and subsequent transaction for redevelopment and/or conservation.

## THINKING ABOUT RESILIENCE IN THE URBAN ENVIRONMENT

***William Browning***

Terrapin Bright Green, New York, NY, USA

Thinking about resilience in an urban setting leads to the realization that communities that have the best potential for recovery have both special social and ecological characteristics. Involvement in the reconstruction of The Lower Ninth Ward, LA, Pattonsburg, MO and Greensburg KS, has taught us that communities with strong social fabric, that involve multi-generational stakeholders achieve better results. Urban design strategies like the Japanese koban, Solar 1's education shack, and the Greening of Harlem's crack-lot community gardens help build the necessary social fabric. The use of ecosystem services performance metrics can inform the long-term retrofitting of a neighborhood to support these resilience strategies. Restoration of local ecosystem services using community gardens, street tree planting and landscape storm water management can help address heat island, flooding and other disasters while building social fabric and recovery.

## **HUMAN WELL-BEING IMPLICATIONS OF PAYMENTS FOR ECOSYSTEM SERVICES**

***Katherine Brownson***

Odum School of Ecology, University of Georgia, Athens, GA, USA

The River Basin Center, University of Georgia, Athens, GA, USA

The Center for Integrative Conservation Research, University of Georgia, Athens, GA, USA

While the poverty alleviation outcomes of Payments for Ecosystem Services (PES) have received significant attention in the literature, there has been much less focus on other pathways by which PES can impact Human Well-Being (HWB). Beyond the economic benefits of payments, research suggests that landowners can benefit from the increased provisioning of ecosystem services, as many farmers participate in PES when payments are not sufficient to cover opportunity costs. However, the benefits of PES participation are mediated by eligibility requirements if formal land titles are required, which can exclude poor farmers in developing countries. In contrast, grassroots PES efforts may be able to better target incentives to poor and disadvantaged groups, including farmers without formal land titles. In this study, I compare the national PES program in Costa Rica with grassroots PES reforestation initiatives to evaluate how program governance affects HWB impacts. I first used focus groups to identify locally-relevant HWB indicators. I then used a survey and semi-structured interviews among participants in both program types and a non-participant control group to evaluate participation obstacles and HWB impacts.

I found that on average, participants in the national PES program types had a larger monthly income, property size and educational level than other respondents. In terms of obstacles to participating in the national PES program, the majority of respondents indicated that they either did not have enough land or enough information to enroll. Although some members of the control group were not aware of the grassroots PES reforestation programs, most were reforesting anyways. The primary perceived benefit of the national PES program was the monetary payment. Although the grassroots PES programs only offered in-kind incentives, some participants nonetheless attributed an increased income to improved agricultural productivity resulting from reforestation. Other perceived benefits of grassroots PES included improved emotional health, water supplies and increased biodiversity. However, it is difficult to attribute these changes to specific programs given widespread reforestation and conservation practices found in the control group. Interviews revealed that community engagement in earlier grassroots PES reforestation efforts triggered broader cultural shifts. Improved awareness regarding the importance and benefits of environmental stewardship catalyzed increased conservation and reforestation regionally, which in turn improved overall HWB.

This study reveals that grassroots PES are more effectively engaging with poorer, less-educated and smaller landowners than top-down PES programs. It also demonstrates the potential for PES to improve HWB without cash payments. Future PES efforts can maximize long-term HWB impacts by directly engaging with communities and investing in educational activities that raise consciousness regarding the diverse benefits of environmental stewardship.

## **COLLABORATIVE FOREST LANDSCAPE RESTORATION (CFLR) PROGRAM CHALLENGES AND OPPORTUNITIES: A TEMPLATE FOR LANDSCAPE SCALE RESTORATION**

*Jessica Robertson<sup>1</sup>, Lindsay Buchanan<sup>2</sup>, Nikola Smith<sup>3</sup>, Chris Miller<sup>4</sup>*

<sup>1</sup>USDA Forest Service, Washington Office, Forest and Range Management and Vegetation Ecology, Integrated Restoration Coordinator, Washington, DC, USA

<sup>2</sup>USDA Forest Service, Washington Office, Forest and Range Management and Vegetation Ecology, Collaborative Forest Landscape Restoration Program Coordinator, Portland, OR, USA

<sup>3</sup>USDA Forest Service, Pacific Northwest Regional Office, Natural Resources, Ecologist and Ecosystem Services Specialist, Portland, OR, USA

<sup>4</sup>USDA Forest Service, Washington Office, Ecosystem Management Coordination, Economist, Ogden, UT, USA

Across the country, tens of millions of acres of forests and grasslands are in need of restoration in order to sustain the range of benefits and services that communities depend on, from water purification to recreational opportunities, to wildlife and plant diversity, to a sustainable supply of wood products. Restored landscapes are not only better able to sustain these benefits – they are also more resilient to escalating threats from catastrophic wildfire, invasive species infestation, drought, and other stressors. Furthermore, community members and stakeholders rely on and value the benefits and services these landscapes provide in diverse ways.

Recognizing the need to accelerate restoration at the landscape scale for multiple benefits, Congress created the Collaborative Forest Landscape Restoration (CFLR) Program in 2009 to support healthy forests and watersheds, reduce the risk of catastrophic wildfires, and promote economic well-being in rural communities. Since then, the CFLR Program has invested in collaborative approaches to forest restoration in 23 landscapes across the country, ranging from 130,000 to 2,400,000 acres. More than 200 local businesses, counties, state governments, tribes, federal agencies, utilities, nongovernmental organizations, and associations are working to restore landscapes using a collaborative, place-based approach.

With nine years of implementation across 23 projects, each with a unique socioeconomic and ecological context, the CFLR Program provides valuable lessons about working collaboratively at the landscape-scale for a range of benefits and values. By highlighting examples from CFLR projects across the country and identifying common themes, this talk will highlight opportunities, challenges, and lessons learned about identifying and articulating these benefits in a complex, landscape-scale context with diverse stakeholders. We will discuss the evolution of performance metrics and approaches at these scales and their evolution over time. These lessons offer potential implications for the policy and practice of restoration at the landscape-scale for multiple benefits.

## **BENEFIT-COST ANALYSIS OF WATER QUALITY INVESTMENTS FOR COASTAL CALIFORNIA INVOLVING HUMAN HEALTH AND RECREATION**

**Mark Buckley**

ECONorthwest, Portland, OR, USA

High quality water resources can provide extremely important and economically fundamental values to communities. Maintaining and improving upon already high levels of water quality services can be extremely costly to communities. While the total value of water quality is undeniably fundamental to society, the magnitude of costs can eventually run into budget constraints that require prioritization and tradeoffs. For southern California, coastal waters and beaches serve as natural capital with direct use and amenity benefit contributions to the region essential to its social and economic character. Consequently regulatory agencies continue to pursue the highest levels of protection. At some level of investment though, either affordability and budget constraints present a barrier, or impose opportunity costs in terms of limiting other, potentially more valuable investments of public and private resources.

In that context, co-permittees of the city of San Diego, San Diego County and Orange County along with the San Diego Regional Water Quality Control Board and in coordination with USEPA commissioned a series of studies to evaluate the benefits and costs as well as cross-strategy cost-effectiveness of options to prevent stormwater, wastewater and other sources of pathogens from causing water quality conditions unsafe to public health during storms and days after. The project involved a multi-year epidemiological evaluation of pathogen exposure and illness effects among surfers, numerous studies and models of the effects of green infrastructure, stream restoration, and gray infrastructure strategies on pathogen loading to waterbodies, and long-term modeling of water quality conditions and associated illness rates for each of 20 separate watersheds with a total of 150 million annual beach visits but only 1 million annual wet weather surfing and swimming trips. Economic analysis focused on daily recreation demand and water exposure modeling based on beach-specific lifeguard counts combined with estimates of trip and avoided illness willingness-to-pay. Economic analyses also included measurement and valuation of a wide range of additional co-benefits including other ecosystem services.

Results demonstrated very high costs per avoided illness and additional beach trip based on pollution control strategy options, and motivated questions regarding the most socially-efficient investments to maintain and improve water quality in the region. The most cost-effective strategy targeting human sources of pathogens (leaking wastewater systems, homeless camps, etc.) would achieve avoided infectious illnesses at a cost of \$1000 per avoided illness and additional beach trips at a cost of \$154 per trip. Benefit-cost analyses found no strategies with benefits outweighing costs, although uncertainty and sensitivity analyses identified feasible conditions under which benefits could outweigh costs.

## **MAPPING ECOSYSTEM SERVICES FOR DECISION MAKING IN MARYLAND**

*Elliott T. Campbell, Rachel M. Marks, Christine Conn*

Maryland Department of Natural Resources, Annapolis, MD, USA

Mapping ecosystem services is increasingly a focal area in ecosystem service research; doing so allows spatial variability in the benefits being received to be observed and incorporated in decision making. Services vary in the biophysical supply, or the benefit relevant indicator, as well as the economic value due to demand for the service. We map and present both vectors of change for seven ecosystem services for the state of Maryland in this work. Economic value is estimated by observing previous instances of payment for increasing or avoiding loss to ecosystem services in Maryland or adjacent states. Using this approach, the economic value of ecosystem services from natural lands in Maryland is significant, totaling \$8 billion every year for the seven non-market services we value here. Stormwater mitigation is the largest service from natural systems, totaling \$3.1 billion, followed by wildlife habitat at \$2.6 billion. Groundwater recharge, nitrogen removal, surface water protection, carbon sequestration, and air pollutant removal total \$1.3 billion, \$417 million, \$247 million, \$235 million, and \$141 million of benefits per year, respectively. These values are in addition to the economic contributions from outdoor recreation and resource extraction. This work is somewhat unique in that it was conducted by a state government and has several active or planned applications for the state- prioritization of land acquisitions and ecological restoration funding, and setting compensatory value for impacts on state land. Results from this work are currently viewable on the Maryland GreenPrint web map, <http://geodata.md.gov/greenprint/>

## SPATIAL AND TEMPORAL DYNAMICS OF ECOSYSTEM SERVICES IN THE THREE-RIVER-SOURCE NATIONAL PARK, CHINA

**Wei Cao<sup>1</sup>, Lu-lu Liu<sup>2</sup>, Dan Wu<sup>3</sup>**

<sup>1</sup> Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China

<sup>2</sup> School of Architecture and Civil Engineering, Chengdu University, Chengdu, China

<sup>3</sup> Nanjing Institute of Environmental Sciences, Ministry of Environmental Protection, Nanjing, China

The Three-River-Source National Park is located in the hinterland of the Qinghai-Tibet Plateau, which covers an area of 123,100 km<sup>2</sup>. The establishment of the Three-River-Source National Park is beneficial to the strictest ecological protection in the Three-River-Source region, strengthening sustainable protection on the "Chinese water tower", and enhancing the national ecological security barrier. Understanding the ecological background and change trend is crucially important for the ecological restoration and scientific management of national park. We comprehensively investigated the spatial distribution of ecosystem which was interpreted from medium and high-resolution remote sensing images (Landsat TM/ETM+/OLI and HJ-1A/1B). Then we simulated the ecosystem services of water regulation, erosion control and sediment retention in 2000-2015 by water balance model, RUSLE (Revised Universal Soil Loss Equation) and RWEQ (Revised Wind Erosion Equation) respectively. Finally we identified the extremely important area in the Three-River-Source national park by the quality of ecosystem services and analyzed the spatial and temporal dynamics of ecosystem services. The results showed that (1) Grassland, desert, and wetland were the dominant ecosystems in the Three-River-Source National Park, accounting for 56.2%, 35.2%, and 8.4% of the total area, respectively. (2) In 2000-2015, the average annual water regulation volume was 6.54 billion m<sup>3</sup>/yr, the average annual soil retention against water erosion and wind erosion was 152 million t/yr and 480 million t/yr respectively. Over this period, the water regulation service and the erosion control service of water erosion prevention had improved in large part of the national park, whereas the erosion control service of wind erosion prevention showed decline trend. (3) 47.1% of the total area in the Three-River-Source National Park was the extremely important area which can provide valuable ecosystem services. (4) Warm and wet climate and implementation of the ecological protection project were the main reasons for improvement of the ecosystem services in the Three-River-Source National Park. However, grassland degradation was not fundamentally reversed, and vegetation coverage was still declined regionally, especially in the western region with critical climate condition. Thus, the restoration of degraded grassland must be further strengthened. For strict protection and sustainable use of the natural resources in the Three-River-Source National Park, overall planning and scientific layout should be paid more attention.

## **DEVELOPING A SOCIAL VALUES TYPOLOGY FOR LAND-USE CHANGE AND ECOSYSTEM SERVICES IN THE UPPER MISSOURI RIVER BASIN**

***M. Carnes, M. Jarchow***

Department of Sustainability and Environment, University of South Dakota, Vermillion, South Dakota, USA

There are many drivers of land-use change, many of which are economic. Social values are an under-considered impetus for land-use change which can be difficult to measure. Social values mapping is one method of measuring social values as they relate to land-use change and ecosystem services. In order to map these values, a typology is needed. The purpose of this research was to develop a values typology for use in the Upper Missouri River Basin (UMRB). Interviews were conducted in four locations in the UMRB: Bozeman, MT; Gillette, WY; Mitchell, SD; and Williston, ND. Each of these areas are considered micropolitan, or cities with populations of 10,000-50,000 that serve as regional hubs for surrounding rural communities. Micropolitan communities in these areas are experiencing land-use changes related to agricultural transitions, energy extraction industry fluctuations, and urban development. These communities also represent social cultures similar to both metropolitan and rural areas. The interviews conducted in these areas focused on social values related to land use and land-use change. Analysis of these interviews identified value themes which formed the foundation for an ecosystem services values typology. Eleven total values were identified, some of which include community building, conservation and stewardship, agricultural, and energy values. While similarities were found between this and other typologies, this research identified unique values which specifically relate to the dominant land uses in the UMRB.

## **WATER, ECOSYSTEMS, AND HEALTH: CAPTURING THE MULTIPLE BENEFITS OF NATURAL INFRASTRUCTURE**

*Jan Cassin*

Forest Trends, Seattle, WA, USA

**Background/Introduction:** Natural, or green, infrastructure solutions for source water protection and flood hazard mitigation are gaining traction, as communities, businesses and water resource professionals recognize these can be cost-effective, no-regrets approaches in a complete tool box for sustainable water management. Drinking water utilities have been pioneers in adopting natural infrastructure approaches – most frequently for source water protection and based on the avoided costs or return on investment from incorporating natural infrastructure into their overall infrastructure portfolios. Even though natural infrastructure for water delivers a wide range of health, food security, disaster risk reduction, and climate benefits, potential partners for water utilities from these sectors have rarely been engaged in these water-focused natural infrastructure decisions. There is an immense opportunity to realize synergies across multiple benefits and economic efficiencies by more strategically designing natural infrastructure for water.

**Approach and methods:** We use a case study approach to evaluate how water utilities and municipalities around the world have explicitly designed natural infrastructure for water to achieve multiple benefits, how and when cross-sectoral partnerships were important in securing political support and/or financing, and lessons these cases provide to communities in the Pacific Northwest. Fifteen case studies were examined from the Pacific Northwest, British Columbia, California, Peru, Ecuador, and the European Union. We examined how water utilities or municipalities made the case for investing in multiple benefit natural infrastructure to their customer (payer) base, to other sectors that would benefit from investment in natural infrastructure, whether co-financing (or other cost-sharing) was secured from other beneficiaries, and/or whether political support from other sectors was instrumental in securing investments for natural infrastructure.

**Results:** Very few water utilities are reaching out to potential partners in other sectors who will benefit from source water protection investments in natural infrastructure; explicit natural infrastructure or natural asset management plans by water utilities can be a first step in engaging other sectors in design and co-financing natural infrastructure; municipalities (e.g., for stormwater management, disaster risk reduction) have been more successful at engaging multiple sectors in planning and designing natural infrastructure, but few are developing co-financing structures based on multiple benefits; and successful examples involve explicitly accounting for multiple benefits.

**Conclusions and recommendations:** The water, conservation, health, disaster risk reduction, and climate communities have a largely unrealized opportunity to align projects and investments in new types of water infrastructure to achieve multiple health-related goals. Explicit accounting for multiple benefits is necessary to engage cross-sectoral partnerships in financing and developing natural infrastructure; municipal and utility natural asset management plans can facilitate cross-sectoral partnerships; and the potential number of partners is much larger than the set of partners that developers of natural infrastructure typically engage.

## **IDENTIFYING SOURCES AND MECHANISMS OF PARTICULATE MATTER POLLUTION IN URBAN AREAS**

*Su-Ting Cheng and Chuang-Yuan Kuo*

School of Forestry & Resource Conservation, National Taiwan University, Taipei, Taiwan

The particulate matter has been receiving considerable attention for its adverse impacts on human health. In particular, studies showed that the fine particulate matter (PM) pollution with aerodynamic diameter  $\leq 2.5 \mu\text{m}$  (aka PM<sub>2.5</sub>) produced higher risks of mortality associated with respiration-related disease, especially via pulmonary deposition. However, the sources of PM<sub>2.5</sub> and mechanisms controlling the concentration of PM<sub>2.5</sub> are highly variable in time and space. Agriculture, mining, construction, road traffic, and biological origin are possible sources generating PM<sub>2.5</sub>; yet human activities, weather and environmental conditions could interact simultaneously to change the magnitude of it, making reduction of PM<sub>2.5</sub> a highly challenging task for urban areas. In this study, we intend to identify the sources and mechanisms of PM<sub>2.5</sub> in Taipei, a highly urbanized city, so that guidance of PM<sub>2.5</sub> pollution mitigation strategies could be made to build resilient, healthy, and livable space. We first examine the contribution of multiple variables to the changes of PM<sub>2.5</sub> under complex interactions among air temperature, precipitation, wind speed, traffic flow in major roads, green land areas and trees. Since transferred abroad pollution occurred mostly from October to April next year, we analyze data from May to September to focus on the domestic PM<sub>2.5</sub> pollution. Then we construct a system dynamic model to evaluate the potential reduction mechanisms of PM pollution considering complex effects from crucial driving forces. Results reveal that major sources of PM<sub>2.5</sub> pollution in Taipei are resulted from vehicles and blown-up particles. Results indicate that the dispersion mechanisms are enhanced with lower temperature, higher wind speed, and precipitation, in which they are all negatively but non-linearly, correlated to lower PM<sub>2.5</sub> concentration. Meanwhile, ratio of green land areas and tree densities are contributed to the deposition mechanisms for eliminating PM<sub>2.5</sub> pollution, and have the potential to assist air quality improvement for urban residents through landscape plantation design. Lastly, we recommend conducting further investigation or assessments on plant species, age, size, and tree health conditions to help quantify detailed functions of urban trees and green lands on reducing PM pollution.

## **DATABASE OF QUANTIFICATION TOOLS USED IN BIODIVERSITY AND HABITAT MARKETS**

*Scott J. Chiavacci and Emily J. Pindilli*

Science and Decisions Center, U.S. Geological Survey, Reston, VA, USA

Biodiversity and habitat markets use economic incentives to more efficiently conserve, restore, and offset impacts to species and habitats. Quantification tools play a vital role in these markets, as they measure the positive and negative impacts from alternative conservation, restoration, enhancement, and development activities (e.g., energy or transportation infrastructure, residential development). However, these tools are not yet widely available, nor is information about them easily accessible. To better understand the availability and types of quantification tools used for biodiversity and habitat markets in the United States, the U.S. Geological Survey (USGS) Science and Decisions Center (SDC), in partnership with the U.S. Department of Agriculture (USDA) Office of Environmental Markets (OEM), developed a database of quantification tools including detailed information on critical tool attributes. This database provides tool developers, users, regulatory agencies, landowners, and the general public with a central location from which to search for tools that apply to species, habitats, or locations of interest and to get summary information about each tool. To date, we have identified over 69 tools covering at least 34 species and 39 habitat types. Database attributes to be discussed include details on geographic, habitat, and taxonomic coverage of tools, ecological features assessed by tools (e.g., spatial scales, types of risk/viability factors), level of tool transferability, user skill level requirements, and tool complexity. We'll also address potential gaps in tool availability and how the database can facilitate greater standardization among future tool development efforts.

## **MAXIMIZING BENEFITS IN CHESAPEAKE BAY RESTORATION**

***Sally Claggett***

Chesapeake Bay Program, Annapolis, MD, USA

Abundant scientific and technical information is available to environmental managers and planners in the Chesapeake watershed to inform restoration efforts. High resolution imagery and the prospective ability to monitor land use change--such as are forests increasing or decreasing across a jurisdiction-- is one example. Partners wanted to be able to map where water quality practices for the Bay TMDL will also have positive ecosystem services benefits. Bay Program staff developed an online interactive data dashboard that consolidates and provides one-stop access to monitoring, modeling, co-benefits, and other scientific data. This presentation will show how the new data dashboard can be used to guide decisions about restoration and conservation in the Bay watershed. The ecosystem service benefits of forest restoration and forest conservation as part of the TMDL will be featured.

## **SOUTH CAROLINA FORESTS POTENTIAL TO CONTRIBUTE TO THE CALIFORNIA CARBON MARKET**

*Lucas Clay, Bo Song, Marzieh Motallebi*

Clemson University, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC, USA

South Carolina (SC) has a variety of different forest types, and they all have potential to sequester a certain amount of carbon. Private forest landowners control a significant portion of the overall forestland in SC, and their management efforts can maintain or improve forest carbon stocks. This ability to sequester carbon in forests can be directly translated to the concept of ecosystem services. Carbon sequestration helps mitigate climate change. Currently, the second largest carbon market in the world is the California Carbon Market, which gives a monetary value to the sequestered carbon. One carbon credit is equal to one metric ton of carbon, and is currently worth around \$14.00. Certain requirements are necessary, though, for landowners to be approved to sell carbon credits. It is required that the forestland be put under a 100 year easement, with an improved forest management plan. These management plans are geared toward increasing carbon sequestration over time. Implementation of the carbon market and the monetary value given to sequestered carbon can encourage conservation of private forest lands across the country.

The purpose of this project is to communicate the benefits of joining to the carbon market to SC landowners. In this study, we aim to educate forest landowners about various forest management practices that contribute to increasing carbon stocks, how to calculate carbon credits, and how to participate in the carbon market. This ultimately will help forest landowners diversify their income sources while retaining their forests.

The study investigates various types of forests in the state of SC and their current carbon stocks. We utilize the US Forest Services database, known as the Forest Inventory Analysis (FIA) to obtain forest area, forest type, sequestered carbon, stand age, and productivity class. Also, the Forest Service Carbon Online Estimator (COLE) was used to determine current carbon stocks for each SC county and the types of forest that are sequestering the most amount of carbon.

Preliminary results show that there are significant areas of privately owned forest lands in SC that could potentially contribute to this market. Loblolly/slash pine forests have by far the highest acreage of forest lands in SC (make up 2,272,068 hectares). In the piedmont area of the state, the Oak/Hickory forests are the dominant forest type, with 1,154,267 hectares of forested area. Interestingly, Oak/Sweet Gum/Cypress forests are among the highest carbon stocks, with an average of 3,433 metric tons/hectare across all of SC. By county, Cherokee county in northern SC has the largest carbon stocks in the Oak/Gum/Cypress forest with 175 metric tons/hectare.

## USING SOCIAL PERCEPTIONS TO FOSTER ECOSYSTEM SERVICES OPERATIONALIZATION

*Rui Santos<sup>1</sup>; Paula Antunes<sup>1</sup>; Pedro Clemente<sup>1</sup>; Marta Calvache<sup>1</sup>; Jorge Orestes Cerdeira<sup>2,3</sup> and Maria João Martins<sup>3</sup>*

<sup>1</sup>Center for Environmental and Sustainability Research, Universidade Nova de Lisboa, Caparica, Portugal

<sup>2</sup>Departamento de Matemática and Centro de Matemática e Aplicações, de Matemática e Aplicações, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, Caparica, Portugal

<sup>3</sup>Centro de Estudos Florestais (CEF), Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal

There is a growing interest from scientists and policy makers on ecosystem services (ES) as they may potentially support a balance between conservation and development objectives. The concept of ES can be a powerful communication tool, which may approach conflicting interests and facilitate conservation support by a broader set of stakeholders.

The goal of this research is to explore, together with local stakeholders and policy makers, ways to operationalize the concept of ES into policy and decision-making in the Sudoeste Alentejano and Costa Vicentina Natural Park, Portugal. This research is part of the OpenNESS project – Operationalization of Natural Capital and Ecosystem Services: From Concepts to Real World Applications.

We evaluate the potential of different participatory mapping methods to assess ES and provide reliable data to inform public and private stakeholders. We conducted individual interviews, collaborative workshops, participative modelling and social media data to map key ES. Building on that knowledge a more thorough work to operationalize ES was developed with a private company managing hiking trails, a farmer's association and with a governmental body.

The Rota Vicentina Association used cultural ES to inform the design of new hiking routes and to create measures to reduce environmental impact. The farmer's association focused on pollination services to provide guidelines and technical support for farmers to reduce production costs. The Park managers are to incorporate recreation and aesthetic ecosystem services into the design of the new Park's Nature Sports Chart. Other ES are also going to be used to optimize the monitoring activities by the park's authority.

The approaches explored in this research contributed to bring the ES concept to local and regional stakeholders and promoted the exchange of perspectives and discussion, enabling awareness raising and social learning but also led to the integration of ES into decision-making processes of some stakeholders. These methods not only provided an assessment of a large territory and a vast diversity of ES, as they facilitated the evaluation of intangible ES, often less visible to stakeholders. Still, none of these methodologies based on social perceptions should be used alone. Instead, these are to be complemented with more objective measurable data, such as biophysical or socioeconomic indicators.

## AN ECO-HEALTH INDEX FROM ENVIROATLAS COMMUNITY METRICS

*Ferdouz Cochran<sup>1</sup>, Laura Jackson<sup>2</sup>, Annie Neale<sup>2</sup>, Raquel Silva<sup>1</sup>, Betsy Smith<sup>2</sup>, Liem Tran<sup>3</sup>*

<sup>1</sup>Oak Ridge Institute for Science and Education (ORISE) participant at the Office of Research and Development, U.S. Environmental Protection Agency, Durham, NC, USA

<sup>2</sup>Office of Research and Development, U.S. Environmental Protection Agency, Durham, NC, USA

<sup>3</sup>Department of Geography, The University of Tennessee Knoxville, Knoxville, TN, USA

To support human health and well-being, ecosystem services (ES) need to be fully understood and incorporated into local decision-making. Geospatial tools, such as the EnviroAtlas developed by the U.S. Environmental Protection Agency and partners, allow decision-makers, public health professionals, urban planners, and other stakeholders to view and assess information from multiple ES metrics. To facilitate and possibly expedite decision-making related to urban ecosystem services and human health, ES indices can be created at the community or neighborhood level. This presentation introduces a framework and method for aggregating geospatial ES metrics to map a Community Eco-Health Index (CEHI). The eco-health framework and index include health promotion and hazard buffering ES metrics, such as walking distance to parks and tree buffer along busy roadways. An urbanization factor is included so as not to penalize densely-populated units. Aggregation of the selected metrics involves a weighted Euclidean distance measure, and objective, data-driven weights were generated for each community. The CEHI was calculated by Census Block Group (CBG) for over 20 EnviroAtlas featured communities. CEHI rated CBGs as between one to five stars, where one star indicates lower and five stars indicates higher ES for public health benefits. Of the featured communities, Minneapolis/St. Paul, Minnesota exhibited the highest proportion of four- and five-star CBGs or neighborhoods. Ultimately, socio-economic data could be overlaid or combined with CEHI in EnviroAtlas to better understand discrepancies among neighborhood ES and improve decision-making for human health and well-being.

This abstract has been reviewed and approved by the U.S. Environmental Protection Agency. Its contents do not necessarily reflect the views and policies of the Agency.

## **ECOSYSTEM SERVICES IN FOREST SERVICE LAND MANAGEMENT PLANNING**

***William Connelly***

USDA Forest Service, Washington, DC, USA

In 2012, the US Forest Service promulgated a new rule for the planning of the National Forests of the United States. This rule contained certain requirements for the consideration and provision of ecosystem services in land management plans. In 2014, the Forest Service also published policy directives outlining how land management planning can fulfill these requirements. The presentation will review the ecosystem services requirements in the planning rule, the approach in the directives and the implementation of that approach in some of the plans in revision under the new rule.

## **INTRODUCTION OF ECOSYSTEM SERVICES INCORPORATION INTO LAND MANAGEMENT AND RESTORATION ON THE MONONGAHELA NATIONAL FOREST.**

***Stephanie J. Connolly***

Monongahela National Forest, Elkins, WV USA

The Central Appalachians are comprised of intermediate- to high-elevations, which include the headwaters for millions in the eastern US. The highest mountain ranges are topped with red spruce forests and coves filled with hardwoods that provide the foundations for this region's biological diversity. Despite the water values and rich ecology, legacy impacts, especially from resource extraction during the 20<sup>th</sup> century, remain evident across both public and private lands throughout the region.

Cross-boundary restoration in this regional landscape can enhance the quality of life of local communities by sustaining the ecosystem services that support clean air and water, quality recreation opportunities, and wildlife habitat, while also protecting important forest types, such as red spruce and oak-hickory forests. Healthy forests and watersheds can help buffer the adverse effects of air, soil, and water pollutants. Afforestation projects, sustainable forest management, and watershed restoration practices also can reduce pollutants and sequester carbon above- and below-ground. Red spruce forests have an exceptional capacity to store carbon and regulate the release of water to streams from precipitation and snowmelt events, while also providing critical habitat for a variety of threatened, endangered, and sensitive species.

Every national forest has a responsibility to sustainably manage natural resources and a fundamental responsibility to ensure that support of local communities, businesses, and individuals is a central consideration during forest and watershed management and restoration activities. Within West Virginia, the Monongahela National Forest understands that land management actions taken to ensure healthy forests and streams can be a direct means for supporting local economies. Environmental protection and improvement are quite compatible with protecting and improving local economic health; indeed, environmental improvements can serve as a nexus for the provision of local economic health and ecosystem services.

## OVERVIEW OF GREEN INFRASTRUCTURE ROI STUDIES IN LATIN AMERICA AND THEIR IMPACT ON WATER MANAGEMENT DECISIONS

**Hugo Contreras**

Water Security Unit, Latin America, The Nature Conservancy, Mexico City, Mexico

The purpose of this presentation is to offer insights as to how Return on Investment Studies (ROI) could drive private and public sector investments in green infrastructure to mitigate some of the water security risks they face in the Region. The background studies reviewed address some of the most relevant challenges investors have laid out such as: lack of solid scientific reference to correlate environmental gains with economic benefits; lower economic returns than traditional grey solutions; and higher transaction costs. The studies shed light into how projects should be designed to maximize returns and make them more attractive for investors.

The scope of the studies reviewed is Latin America, in particular, but not limited to the cities of Quito in Ecuador, Sao Paolo in Brazil and Monterrey in Mexico. Results from some other projects focusing on natural infrastructure for water management will be used as references.

The referenced studies have used direct information whenever available, complemented it with scenarios produced from modelling exercises. Quito for example, has been systematically investing in conservation activities in high Andean paramos where they source their water from. This information is combined with estimates of the avoided treatment costs for City's water utility EPMAPS. Similar methodology is used for the case of Sao Paolo. In Monterrey, the economic case is made for the mitigation of costs due to flooding caused by extreme weather events.

Although studies are still to be completed, initial results show that investing in green infrastructure to address water security challenges makes economic sense. ROI's range in the order of 10 percent. These results are consistent with other studies (Abell, R., et al. (2017). *Beyond the Source: The Environmental, Economic and Community Benefits of Source Water Protection*. The Nature Conservancy, Arlington, VA, USA.).

Among the most important insights derived from the studies are that water sector stakeholders should look at their investment portfolios in a more holistic way, incorporating green infrastructure alternatives as complement to traditional built in solutions. Perhaps the most appropriate time to do it is at the early planning stage, right when solutions are being conceptualized. Additionally, some experiences show that governments need to play a more active role incentivizing utilities and other water users to include green infrastructure and reduce initial adoption risks. Finally, vehicles such as water funds may also play a role in reducing transaction costs to facilitate project design and implementation

It is worth mentioning that there exist at least 24 cities that have created water funds under the Latin American Water Funds Partnership ([www.fondosdeagua.org](http://www.fondosdeagua.org)), which are governance and financial mechanisms that aim to fill some of the regulatory and market failures that prevent societies from dedicating more resources to natural infrastructure.

## NATURAL CAPITAL OF LAND BASED ECOSYSTEMS – MODELLING AND SCENARIOS

**Robert Costanza**

Australian National University, Canberra

The Economics of Land Degradation (ELD) initiative aims to estimate the full range of costs and benefits of various land management practices at multiple scales from local to global, and to establish a global approach for analysing the ecology and economics of land degradation, restoration, and sustainable management. This includes the analysis and valuation of natural, built, human, and social capital assets and the ecosystem and other services that these assets provide. While the *concepts* of natural capital and ecosystem services have been broadly accepted and their contribution to better environmental management widely appreciated, there are still several challenges to their practical application. We are developing a unique integration of scalable, dynamic landscape modelling, advanced gaming user interfaces, and novel valuation techniques to take the assessment of land values and management options to the next level of both sophistication and utility. The system is based on an integrated, dynamic, spatially explicit, scalable, computer simulation model that is being developed in a participatory way and calibrated at a number of sites around the world. It will also allow land use policy scenarios to be quickly run and compared. An advanced gaming interface will allow the model to be 'played' by a large number of people and their trade-off decisions (and the valuations they imply) to be accumulated and compared. This will allow the full value of land under multiple scenarios to be assessed in a consistent and relatively inexpensive way.

## **A SYNTHESIS OF RECENT LINKS BETWEEN CLIMATE CHANGE IMPACTS AND ASSESSING AND MANAGING ECOSYSTEM SERVICES SUPPLY AND DEMAND**

*Marcy Delos<sup>1</sup> and Janet A. Cushing<sup>2</sup>*

<sup>1</sup>Department of Environmental Science & Policy, George Mason University, Fairfax, VA, USA

<sup>2</sup>National Climate Adaptation Science Center, U.S. Geological Survey, Reston, VA, USA

With escalating effects of climate change on the supply and demand of ecosystem goods and services, it becomes more necessary to monitor trends and identify gaps in how climate change informs the ways that ecosystem goods and services are assessed and managed. To distill these insights, systematic literature reviews play an important role. A crucial example is Incorporating climate change into ecosystem service assessments and decisions: a review, in which Runting et al. (2016) fulfilled the need for a quantitative synthesis of how scientific journal literature has assessed ecosystem services with regard to climate change impacts. However, no similar synthesis effort has examined more recent scientific journal literature and/or grey literature.

For these reasons, this synthesis follows much of the conceptual framework and methodology of Runting et al., while also expanding upon them. Mirroring key characteristics of Runting et al.'s investigation enables comparisons between their reviewed 1990-2014 scientific journal literature and the most recent literature. These comparisons may reveal emerging shifts or stability in aspects such as how studies address uncertainties in the effects of climate change and/or decision-making on ecosystem services, which ecosystem services are more commonly assessed, and how the frequency of ecosystem service assessments in the context of climate change is distributed geographically. This synthesis also seeks further insight by considering recent scientific journal articles of types that were beyond Runting et al.'s criteria, such as assessments framed at global (rather than sub-global) scales and literature reviews.

By further extending the scope to include grey literature since 2010, this synthesis captures patterns in how entities like federal agencies and non-governmental organizations have integrated climate change impacts with ecosystem services paradigms in assessments, interventions (e.g., particular management approaches), and conceptual models. Across both recent scientific journal literature and grey literature, broadly examining the supply and demand of ecosystem goods and services in the context of intensifying climate change impacts may suggest how to pursue directions, prioritize resources, and inspire collaboration for relevant research and decision-making.

## EMPOWERING TOMORROW'S DECISION-MAKERS: ENVIROATLAS AND ECOSYSTEM SERVICES IN THE CLASSROOM

Jenna M. Hartley<sup>1</sup>, and Jessica Daniel<sup>2</sup>

<sup>1</sup>Research Participant, Office of Research and Development, US Environmental Protection Agency, Research Triangle Park, North Carolina

<sup>2</sup>Office of Research and Development, US Environmental Protection Agency, Research Triangle Park, NC, USA

Interactive web tools provide rich learning experiences for students of all levels. U.S. EPA's EnviroAtlas contains two primary tools for exploring ecosystem goods and services: An *Interactive Map*, which provides access to 300+ maps at multiple extents for the U.S., and an *Eco-Health Relationship Browser*, which displays evidence from hundreds of scientific publications on the linkages between ecosystems, the services they provide, and human health. This talk introduces a suite of educational activities that have been designed for use with the tools in EnviroAtlas for students K-undergraduate.

Over the course of two years, the EnviroAtlas educational activities were developed alongside 20 classroom teachers, ranging from K-5 teachers, AIG and ESL teachers, middle school teachers, high school teachers, and STEM coaches and science outreach representatives. Classroom visits took place in over 30 schools, complete with lesson plan pilots, feedback, and edits from teachers.

These educational activities encourage critical thinking and engage students and community users in a variety of ways, from connecting with the outdoors to exploring high-tech tools online. In the "*Building a Greenway Case Study*" lesson students use available information to guide collaborative decision-making using maps and available data. "*Connecting Ecosystems and Human Health*" shows eco-health linkages that are particularly important for vulnerable communities using an engaging, hands-on activity.

To date, the educational activities have been conducted with over 2,340 participants, of which 1,500 were students, and 73% of those students were from low-resource schools and programs. Centered on ecosystem services, these EnviroAtlas educational materials encourage a systems approach to thinking about the world. By learning through this approach, students can gain a more holistic view of study topics and see real world applications of specific science disciplines while also learning how to use freely available online tools.

This talk will cover the suite of EnviroAtlas lesson plan packages, including the three that are currently available for varying grade levels and others that are in development. All lesson plans are freely available for download at <https://www.epa.gov/enviroatlas/enviroatlas-educational-materials>. This abstract has been reviewed and approved by the U.S. Environmental Protection Agency. Its contents do not necessarily reflect the views and policies of the Agency.

## **TRADEOFFS IN TIMBER, CARBON, AND CASH FLOW UNDER ALTERNATIVE MANAGEMENT SYSTEMS FOR DOUGLAS-FIR IN THE PACIFIC NORTHWEST**

*David D. Diaz<sup>1,2</sup>, Sara Lorenzo<sup>2</sup>, Greg Ettl<sup>1</sup>, and Brent Davies<sup>2</sup>*

<sup>1</sup>University of Washington, School of Environmental and Forest Sciences, Seattle, WA, USA

<sup>2</sup>Ecotrust, Portland, OR, USA

Forest management choices offer significant potential to mitigate global climate change and biodiversity loss. To illuminate tradeoffs relevant to policymakers, forest sector stakeholders, and consumers of forest products, we utilize three Key Performance Indicators—average carbon storage in the forest and wood products; cumulative timber output; and discounted cash flow—to compare four alternative management scenarios for Douglas-fir forests on 64 parcels across western Oregon and Washington. These scenarios are designed to meet one of two alternative management objectives: (i) maximize Net Present Value; or (ii) maximize sustained timber yield; according to one of two alternative sets of forest practice constraints: (i) compliance with minimum Oregon/Washington Forest Practices Act (FPA) rules; or (ii) two key requirements (increased green tree retention and wider riparian buffers) of Forest Stewardship Council (FSC) certification. Improved performance in terms of carbon storage for these alternatives generally also corresponded with reduced Net Present Value and timber yields. The gap between FSC and FPA performance indicators was wider in Oregon than Washington, which is primarily attributed to the higher level of stream protection required under Washington versus Oregon FPA rules. We observed consistently higher average carbon storage per cumulative timber output among FSC scenarios relative to business-as-usual, indicating FSC-certified wood carries an embedded carbon benefit. Our findings highlight options for targeted policies to incentivize management that increases carbon storage and minimizes disruptions in timber output, as well as for narrowing the financial gap (or opportunity cost) that would be involved in a transition away from contemporary common practice on industrial timberlands in the coastal Douglas-fir forests of the Pacific Northwest.

## **ECOSYSTEM SERVICES AND INTERNATIONAL FINANCE CORPORATION PERFORMANCE STANDARDS: EXAMPLE FROM LATIN AMERICA**

***Alicia De la Cruz-Novey<sup>1</sup>, Greg Reub<sup>2</sup>, Roberto Roca<sup>3</sup>, and Collin Ray<sup>4</sup>***

<sup>1</sup>EcoAnalysts Inc, Washington D.C., USA

<sup>2</sup>EcoAnalysts Inc, Olympia, WA, USA

<sup>3</sup>BEP Advisors, Panama

<sup>4</sup>EcoAnalysts Inc, Port Gamble, WA, USA

In 2012, the International Finance Corporation (IFC) updated its 2006 Environmental and Social Performance Standards (PS) to expand and elaborate on requirements for management of ecosystem services as well as to introduce stronger specifications for biodiversity offsets. This update has been a key activator for a growing international emphasis and interest regarding the consideration of ecosystem services (ES) in the framework of biodiversity offsetting (BO).

While the majority of BO have been commonly used to mitigate the negative impacts of development on biodiversity, there is a growing approach from financial institutions (multilateral banks and private lenders) and international consultants to considering ES goals within the development of BO. With this approach, project developers identify management actions focused on ES that not only mitigate adverse impacts on biodiversity, but also promote local support towards the implementation of offsets. In some cases, the implementation of offsets includes the identification of community projects that could help the project maintain the social license of the project.

This presentation will provide a summary of information about International Finance Corporation (IFC), PS 6 (Biodiversity Conservation and Sustainable Management of Living Resources) focused on ES and BO, as well as information about IFC, PS 1 (Assessment and Management of Environmental Social Risks and Impacts) focused on Stakeholder Engagement. It will also explore the results and lessons learned from a hydropower project in Latin America that considered ES goals to develop BOs.

## **ON THE FRONTLINES: INTEGRATING ECOSYSTEM SERVICES INTO USFS POLICIES AND PROGRAMS FROM NATIONAL TO LOCAL SCALES**

***Robert Deal<sup>1</sup>, Nikola Smith<sup>2</sup>, and Jonas Epstein<sup>3</sup>***

<sup>1</sup>USDA Forest Service, Pacific Northwest Research Station, Portland, OR, USA

<sup>2</sup>USDA Forest Service, Region 6 Regional Office, Portland, OR, USA

<sup>3</sup>Office of Watershed, Fish, Wildlife, Air & Rare Plants, USDA Forest Service, Washington, DC, USA

Ecosystem services are increasingly recognized as a way of framing and describing the broad suite of benefits that people receive from forests. The USDA Forest Service has been exploring use of an ecosystem services framework to describe forest values provided by federal lands and to attract and build partnerships with stakeholders to implement projects. Recently, the agency has sought place-based applications of the ecosystem services framework to national forest management to better illustrate the concept for policymakers, managers and forest stakeholders. In response to growing interest in ecosystem services, the USFS is identifying needs and opportunities to incorporate an ecosystem services approach into its programs and activities. This includes describing the ecosystem services provided by forest landscapes, examining the potential trade-offs among services associated with proposed management activities, and attracting and building partnerships with stakeholders who benefit from particular services forests provide.

Projects that describe objectives and outcomes using an ecosystem services framework are quickly gaining respect and could provide an optimal method of managing forests to better serve the needs of people. We describe how project-scale guidelines can be designed to address commonly recognized products such as timber and clean water, as well as critical regulating, supporting and cultural services. We build on past successes and lessons learned to propose an agency wide shift to design, integrate, and implement ecosystem services science, tools, and communications into Forest Service policy and operations. This approach focuses on three key opportunities: (1) consider a broad suite of services in decision-making and priority setting, (2) quantify and communicate in terms of benefits to people in measurement and reporting, and (3) connect providers and beneficiaries of ecosystem services through partnership and investments. We present results from national programs to forest plan assessments to project-scale applications that enhance the provision of ecosystem services and sustainable forest management at broad to local scales.

## **USFS PERSPECTIVES ON USING ECOSYSTEM SERVICES TO IMPROVE AGENCY EFFICIENCY AND COMMUNICATION**

***Robert Deal<sup>1</sup>, Sherry Reckler<sup>2</sup>, John Allen<sup>3</sup>, and Greg Arthaud<sup>4</sup>***

<sup>1</sup>USDA Forest Service, Pacific Northwest Research Station, Portland, OR, USA

<sup>2</sup>USDA Forest Service, Region 5 Regional Office, Vallejo, CA, USA

<sup>3</sup>USDA Forest Service, Deschutes National Forest, Bend, OR, USA

<sup>4</sup>USDA Forest Service, Washington Office, Washington, DC, USA

The USDA Forest Service has been recognized as one of the most innovative federal agencies for incorporating ecosystem services into programs and operations as evidenced by the 2012 Forest Service Planning Rule and management efforts across mission areas. This final panel session will highlight how ecosystem services concepts and metrics are addressing agency priorities related to increasing efficiency, modernizing operations and delivering benefits to the American public. This panel will feature examples of efforts at national, regional and local scales to communicate the relevance of public lands to diverse audiences, build meaningful and consistent performance metrics, and work across ownerships to achieve management goals and the successes and challenges of these efforts.

The new USDA administration has placed an increased emphasis on expediency and efficiency in decision-making processes, programs, and projects, while continuing to provide benefits that serve all Americans. In the meantime, the Forest Service is faced with a backlog of forests that need to be restored and maintained, with less resources to do so. Forest Service efforts include key project, regional and programmatic examples of how Forest Service staff are applying ecosystem services concepts to 1) communicate social relevance; 2) quantify success; and 3) increase scale across landscapes. Invited speakers will discuss initial challenges and successes, and includes a facilitated panel of practitioners who are implementing these practices at multiple scales.

This last presentation will be a panel session with panel members providing perspectives from different Regions and Stations in the US Forest Service. Panelists will provide key examples of how the Forest Service as a natural resource management agency is incorporating the ecosystem services and natures benefit concept in Agency work. They will discuss and present how researchers are seeking to develop methods for use in addressing ecosystem services in applied natural resource policy and management settings, as well as practitioners seeking to apply ecosystem services methods in landscape management, stakeholder engagement, and communication strategies.

## CLIMATE CHANGE VULNERABILITY ASSESSMENT OF THREE LARGE LANDSCAPES IN KENYA, WITH IMPLICATIONS FOR ECOSYSTEM SERVICES

*K. Mwangi*<sup>1</sup>, *T.DeMeo*<sup>2</sup>, and *N.M. Smith*<sup>2</sup>

<sup>1</sup>Earth Observation and Geo-Information Specialist at Intergovernmental Authority on Development, Climate Prediction and Applications Centre, Kenya

<sup>2</sup>Ecologist, USDA Forest Service, Portland, OR, USA

Kenya's forested landscapes are the key source of water and other ecosystem services for the country. These resources are expected to come under increasing stresses due to population growth, agricultural needs, and climate change. We focused on three large landscapes—Mau Forest Complex, Cherangany Hills, and Mt. Elgon—because they provide much of the country's water supply, both locally and for downstream cities, as well as their support for agriculture and other livelihoods. We assessed climate change exposure factors of temperature change and trend, a drought index, and temperature/precipitation projections for 2030, 2050, and 2070 to generate sensitivity effects on land use degradation, vegetation condition, and socioeconomic factors of poverty levels, population growth rate, and malaria incidence. We mapped these vulnerabilities and were able to identify the adaptive capacities of these landscapes.

Results show an increasing temperature trend. Precipitation is expected to decrease during the long rains (March through August) and increase during the short rains (October to December). The overall trend is one of decreased precipitation, consistent with other predictive work for East Africa. Of the three landscapes, the Mau Forest Complex is expected to show the most decrease in rainfall. Overall vulnerability varied considerably within and among the landscapes. Water availability from the landscapes overall is expected to decrease, with only mild effects on hydropower potential but significant impacts on agriculture and water availability for cities. Climate change will exacerbate land use pressures from a growing population. Agricultural production will be under increasing stress, and conflicts with livestock grazing during droughts, already in evidence, will likely increase. Both human and livestock diseases also show a potential for increase. These findings imply Kenya should implement aggressive land use conservation practices to conserve resources, notably water, particularly since the country recently set increasing irrigation as a development goal.

## HOW MODERN DAY TECHNOLOGY IS INSTRUMENTAL IN ENSURING CONSERVATION PROGRAM SUCCESS

### ***Matt Deniston***

Sitka Technology Group, Portland OR, USA

Conservation program operations and performance reporting for ecosystem services are typically complicated and expensive. These issues often result in slower adoption, disheartened funders, and delayed attainment of ecological goals. But, as Montana's Sage-Grouse Habitat Conservation Program and Nevada's Conservation Credit System have demonstrated, *it doesn't have to be that way*.

This presentation will outline recommended key steps every ecosystem program should take prior to deciding on a technology solution. These steps include:

- Conducting a technical review of all existing applications, databases, systems, etc.;
- Compiling the initial set of performance metrics;
- Defining key high-level program requirements;
- Performing a lightweight discovery process to build an agile development plan; and
- Publishing a development roadmap.

Matt will share how this process was instrumental in the development of both the Montana Sage-Grouse Habitat Conservation Program web application and the Nevada Conservation Credit System. He will also provide an overview of the technical backbone of both systems, and how they were built to scale to continue to serve the states, their staff, and their citizens for years to come.

## ASSESSING THE TRANSFERABILITY OF ECOLOGICAL MODELS TO NEW SETTINGS

*Theodore H. DeWitt<sup>1</sup>, Jessica B. Moon<sup>2</sup>, Melissa Errend<sup>3</sup>, and Lauri Green<sup>4</sup>*

<sup>1</sup>US EPA, Office of Research & Development, Western Ecology Division, Newport, OR, USA

<sup>2</sup>Biological Sciences Department, University of Arkansas, Fayetteville, AR, USA

<sup>3</sup>Integrated Statistics, NOAA Fisheries, Northeast Fisheries Science Center, Falmouth, MA, USA

<sup>4</sup>Department of Biological and Allied Health Sciences, Bloomsburg University, Bloomsburg, PA, USA

Analysts and scientists seeking to rapidly or comprehensively estimate ecosystem service flows frequently apply existing models to settings where the models have not been used previously, and where data to parameterize and validate the models might be sparse. Prior to transferring an existing model to a new setting, analysts should consider whether the model is likely to perform as intended. Failing to do so increases the likelihood of generating unsupportable results. We present a framework to assess the transferability of ecological models that compares and identifies settings similar to those where the model was previously applied based on analyses of model-relevant ecological contexts. Model suitability for a new site is evaluated based on the performance of the model at the most-similar sites relative to predetermined performance requirements. If the model fails to meet the performance criteria, analysts are provided with several alternative actions. We demonstrate this methodology using a wetland condition model that we were interested in transferring to a southern Oregon site. The power of our methodology lies in providing a logical framework for making consistent and transparent decisions to ensure the accurate application of models. Our goal is to improve the likelihood of successful model transfers, prior to investment in additional data for the parameterization and validation of a model.

## THE ECOSYSTEM SERVICES GRADIENT AND THE BIOLOGICAL CONDITION GRADIENT LINK CHANGES IN BENEFITS AND BIOLOGY TO INCREASING STRESS IN AQUATIC SYSTEMS

*Giancarlo Cicchetti<sup>1</sup>, Theodore H. DeWitt<sup>2</sup>, Matthew C. Harwell<sup>3</sup>, Susan K. Jackson<sup>4</sup>, Margherita Pryor<sup>5</sup>, Kenneth Rocha<sup>1</sup>, Deborah L. Santavy<sup>3</sup>, Leah Sharpe<sup>3</sup>, Emily Shumchenia<sup>6</sup>, and Susan Yee<sup>3</sup>.*

<sup>1</sup> Atlantic Ecology Division, Office of Research and Development, United States Environmental Protection Agency, Narragansett, RI, USA

<sup>2</sup> Western Ecology Division, Office of Research and Development, United States Environmental Protection Agency, Newport, OR, USA

<sup>3</sup> Gulf Ecology Division, Office of Research and Development, United States Environmental Protection Agency, Gulf Breeze, FL, USA

<sup>4</sup> Health and Ecological Criteria Division, Office of Water, United States Environmental Protection Agency, Washington, DC, USA

<sup>5</sup> Office of Ecosystem Protection, Region 1 – New England, United States Environmental Protection Agency, Boston, MA, USA

<sup>6</sup> E&C Enviroscape, LLC, Ashaway, RI, USA

Characterization of ecosystem services can be a valuable element of Ecosystem Based Management in identifying meaningful measures of ecosystem change, understanding the natural resource gains or losses associated with changing ecosystem conditions, and communicating those benefits and tradeoffs to stakeholders in an intuitive way. Here, we introduce a descriptive model of the Ecosystem Services Gradient (ESG), an analog to the Biological Condition Gradient (BCG). Originally designed to support Clean Water Act programs such as water quality standards, monitoring and assessment, non point source and point source programs, the BCG is a conceptual framework that allows scientists and managers to characterize the status of an aquatic ecosystem along an anthropogenic disturbance gradient by describing and quantifying changes in biological or ecological condition with increasing levels of stressors. The ESG descriptive model builds upon the BCG approach by more clearly defining concepts of final ecosystem goods and services (FEGS) - those ecosystem goods and services that are actually used by and have direct effects on human beneficiaries.

We present an overview of the ESG concept which covers the basic steps in developing the model together with several potential applications. The core ESG approach improves environmental decision making by linking changes in ecosystem condition to direct effects on human health and well-being. This involves identifying and prioritizing ecosystem services (including both FEGS and beneficiaries), defining specific FEGS indicators, and applying ecological production functions to translate levels of ecological condition to FEGS metrics. Overlaying a BCG assessment with relevant ESG elements can help communicate changing levels of ecological condition together with potential changes in natural resource use (e.g., fishing, recreation). A focus on ESG elements helps decision makers understand how different actions may affect ecosystem components of primary interest to people, and thus evaluate potential tradeoffs or co-benefits of those actions. Incorporating ESG elements can significantly enhance how scientists and decision makers communicate these direct benefits to people, and thereby improve stakeholder engagement and communication in Ecosystem Based Management.

## **ECOSYSTEM GOODS AND SERVICES: A FRAMEWORK FOR INTEGRATING DESIGNATED USE PROTECTION AND RESTORATION STRATEGIES UNDER THE CLEAN WATER ACT**

*Jerry Diamond<sup>1</sup>, B. Topping<sup>2</sup>, K. Parry<sup>1</sup>, and C. Boschen<sup>3</sup>*

<sup>1</sup>Tetra Tech, Inc., Owings Mills, MD, USA

<sup>2</sup>Tetra Tech, Inc., Fairfax, VA, USA

<sup>3</sup>Tetra Tech, Inc., San Diego, CA USA

The US EPA water quality standards program is based on the concept of designated uses (DUs), which specify maximum pollutant levels and, in some States, aquatic biological community characteristics that are thresholds for waterbody compliance with the Clean Water Act (CWA). Most of the DUs adopted by states and tribes are similar to certain provisioning ecosystem goods and services (EGS) such as drinking water supply and recreation (e.g., swimming and boating). Absent in the DU concept is supporting or regulating services, which results in disjointed and often ineffective aquatic ecosystem protection and restoration strategies. Furthermore, the focus on water quality in the DU approach, often to the exclusion of physical habitat and hydrology concerns, result in conflicting DUs and non-attainment of at least some DUs.

The Los Peñasquitos watershed in San Diego, CA, USA was used to demonstrate ways in which an EGS framework can help address current limitations of the DU approach and provide beneficial results for both regulated parties and the larger community. This watershed empties into a coastal lagoon, which is one of the few remaining native salt marsh lagoons in southern California and home to several endangered species, bird, fish, and wildlife habitats, and a refuge for coastal marine species. The Los Peñasquitos watershed has a TMDL for excess sediment, which thus far, is being evaluated in a piecemeal manner that ignores much of the ecological information available in the watershed.

We demonstrate how an EGS framework can provide more meaningful restoration within the TMDL while also incorporating stakeholder interests and goals for the watershed. A combination of Invest and EnviroAtlas were used to identify final EGS in the watershed spatially and to determine optimal placement of best management procedures that mitigate sediment transport while providing many co-benefits of interest to stakeholders. EGS that will be provided include enhanced recreational opportunities, fish and wildlife enhancements, and higher quality water for the coastal lagoon system, which is recognized as a very valuable ecosystem by stakeholders and the State of California. A process is presented that could help regulatory agencies and stakeholders make better use of the EGS framework in DU decisions, including watershed protection and restoration. The EGS framework presented, coupled with a watershed stakeholder process, could help achieve multiple beneficial uses in an aquatic system.

## IDENTIFYING THE INTERSECTION BETWEEN RESTORATION AND CULTURAL ECOSYSTEM SERVICES

*Maude Dinan<sup>1</sup> and Bethany Cutts<sup>1,2</sup>*

<sup>1</sup>Department of Parks, Recreation, and Tourism Management, North Carolina State University, Raleigh, NC, USA

<sup>2</sup>Center for Geospatial Analytics, North Carolina State University, Raleigh, NC, USA

**Purpose:** This study seeks to understand how the language of cultural ecosystem services (CES) can capture the impacts of restoration in Southwest New Mexico. Commonly, land management focuses more exclusively on economic or functional aspects of ecosystems, recognized via regulating or provisioning services. Including CES in management can contribute to a comprehensive understanding of the human-nature relationship and assist in achieving ecosystem health. For example, CES have been found widely to contribute to human well-being and motivate human actions that sustain ecosystems. Restoring ecosystem health and maintaining social structures that cultivate CES can create a viable option for sustainable use of the land. Restoration that seeks to mitigate encroachment of invasive brush species can alter the New Mexican landscape, potentially changing the delivery of CES. This idea presents a need for new research that evaluates how changing environments facilitate or hinder the delivery of CES.

**Scope:** This research aims to understand how restoration changes the way stakeholders in Southwest New Mexico perceive CES, or the nonmaterial benefits such as spiritual enrichment, intellectual development, recreational opportunity, and aesthetic values provided by ecosystem functions.

**Methods:** 30 participants that adequately represent the breadth and diversity of public land values will be recruited for interviews. Interviews will identify the range of CES perceived in Southwest New Mexico and determine stakeholders' opinions of restoration. Subsequently, a Q-method survey will determine how stakeholder opinions of restoration relate to their perception of CES.

**Results:** Preliminary results indicate that stakeholders perceive six out of nine CES categories outlined by the Millenium Ecosystem Assessment, while similar groups of stakeholders held different opinions on restoration.

**Conclusions:** Creating a pathway to understanding the complexity of the human-environment relationship on changing landscapes, this study will enhance discussion on land management in Southwest New Mexico. Identifying CES and their relationship with restoration will help improve alignment between land management and socio-cultural priorities of stakeholders. Likewise, findings will add to the literature on CES language and identification, setting the stage for new opportunities to link CES to ecosystem function.

## **ECOSYSTEM SERVICES AND RESTORATION OF ANCIENT IRRIGATION SYSTEMS: CASCADE TANK SYSTEMS IN SRI LANKA**

*Shamen Vidanage<sup>1</sup> and Sahan T. M. Dissanayake<sup>2</sup>*

<sup>1</sup>IUCN Sri Lanka

<sup>2</sup>Department of Economics, Portland State University and IUCN Sri Lanka

Cascading Tank Systems are an ancient irrigation system in South Asia developed to support agriculture and population expansion to dry/arid areas by collecting rainwater during the wet season for use in the dry season. The system, which has parallels to the Japanese land use system of Satoyama, was established and fostered by ancient ruling kings.

Research from the last few decades have re-discovered that these tanks are not occurring randomly, but are spatially organized based on the natural landscape and are hydrologically and socio-economically interlinked. The individual tanks are components of large systems or units called 'cascades' and the cascade ecosystem follows the principles of Integrated Water Resources Management (IWRM). The traditional socio-hydrologic system incorporates conservation buffers, wind barriers, phyto-remedial plants, de-silting structures, and community practices and multiple other water and soil conservation aspects into planning and governance.

The cascading tank system in Sri Lanka, which has a history of over 2,000 years, captures Northeast monsoon rains and allows for agriculture in the dry season, prevents floods, and increases ground water recharge. There are approximately 14,200 small tanks feeding an extent of about 200,000 hectares (25% of the total irrigable area of the country) in Sri Lanka. Over the last few centuries the structure of the cascade tanks and the hydrologic system connecting the tanks have slowly deteriorated due to lack of maintenance and the disappearance of the traditional community institutions that were responsible for the cascade tank system.

There is growing interest in studying and restoring these ancient irrigations systems. The FAO declared cascade tanks systems in Sri Lanka as a Globally Important Agricultural Heritage Systems (GIAHS) in 2016. The HSBC-Global Water Program provided a \$500,000 grant for the ecological restoration of one cascade system in 2013. Most recently UNDP and GCF co-funded a \$52 million effort to restore 300 tanks.

We present a comprehensive discussion of (1) the biodiversity and ecosystem services of the cascade system, (2) a detailed mapping of ecosystem benefits, (3) the traditional landscape level ecosystem structure and management practices, (4) results from a choice experiment survey to understand ecosystem values and WTP for cascade restoration, (5) how cascade restoration contributes to achieving 14 of the 17 SDGs.

We end our presentation with a discussion of the broad ecological and socio-hydrological research agenda to better understand these ancient irrigation systems and an invitation for collaboration.

## **USING PERFORMANCE TO ALIGN THE NEEDS OF ECOSYSTEMS AND PEOPLE**

***Eoin Doherty***

Environmental Incentives, LLC, South Lake Tahoe, CA, USA

The environmental challenges of today operate in a complex climate of regulatory, economic, and community needs. How can we make the most of often limited investments in the environment? How can we design ecosystem management to meet the needs of both people and nature?

Communities across the U.S. are maximizing their effectiveness by incorporating performance information into conservation programs. Effective metrics track how individual actions contribute to overarching ecosystem goals, inspiring effective conservation in the regions where it is needed most. Social, regulatory, and financial incentives influence individual decision-making and serve as the foundation for lasting behavior change; while web-based tools and reporting systems make performance information accessible to those who can use it, and increase communication and understanding among both program participants and external stakeholders.

This presentation will provide an example of how the state of Nevada employed a performance-driven approach when designing a market-based mitigation program to preserve and enhance the sage-steppe ecosystem. The program aligns diverse stakeholder needs and motivations, creating an opportunity for ranchers, state agencies, and industry to be part of the solution. Working together, the Conservation Credit System is creating net benefit for sage-grouse and the Nevada way of life. The performance-driven practices and lessons learned in this context can be tailored to suit a variety of ecosystem challenges and community needs.

## **POTENTIAL EFFECTS OF DEVELOPING OIL AND GAS RESOURCES ON ECOSYSTEMS IN THE WILLISTON BASIN**

*Monica A. Dorning<sup>1</sup>, Seth S. Haines<sup>2</sup>, Darius J. Semmens<sup>1</sup>, Jay E. Diffendorfer<sup>1</sup>, Karen E. Jenni<sup>3</sup>, Kenneth J. Bagstad<sup>1</sup>, and Todd M. Preston<sup>4</sup>*

Development of energy resources is a major driver of landscape change, affecting wildland landscapes as well as those where people live and work. Extracting oil and gas resources across the U.S. has the potential to dramatically alter landscapes and the ecosystem services they provide. We are applying an energy simulation model, energySim, to estimate the potential landscape-scale effects of future oil and gas development on ecosystems. EnergySim combines USGS assessments of technically recoverable petroleum resources with a spatially explicit, stochastic energy footprint model. The model provides probabilistic output regarding the full range of potential landscape changes that may occur due to resource extraction, including uncertainty associated with the quantity of undiscovered petroleum resources and the land area required to accommodate well pads and roads. We applied the model across six continuous (also known as unconventional) resource accumulations in the Williston Basin, representing the majority of remaining and technically recoverable petroleum resources in the region. We tested alternative assumptions regarding the surface area required to accommodate future well pads and roads. Variation in these assumptions strongly influenced estimates of the amount of probable land-surface change and related ecosystem impacts that may be associated with resource extraction. We also linked model outcomes to potential changes in soil erosion, water availability, and other ecosystem services to estimate potential broad-scale ecosystem effects associated with extracting assessed quantities of oil and gas resources. Implemented nationwide, this approach could provide generalized, probabilistic estimates of potential changes in land use and service provision that may result from fully developing the country's petroleum resources.

## **DEVELOPING AND VERIFYING GRASSLAND CARBON PROJECTS ON RANGELAND**

### ***Max DuBuisson***

Climate Action Reserve, Los Angeles, CA, USA

This presentation will be based on a project funded through a 2015 Conservation Innovation Grant (CIG) from the USDA Natural Resources Conservation Service. Led by the Climate Action Reserve, the project goal was to reduce transaction costs and lower barriers to entry to greenhouse gas markets for grassland conservation projects, ultimately developing credits on two pilot grassland conservation projects using the Reserve's grassland protocol. This project has included extensive efforts to conduct outreach and educate landowners and ranchers in order to encourage participation in greenhouse gas markets.

This session will explore the process of targeted landowner outreach and engagement when introducing landowners to the steps involved in developing grassland carbon credits and participating in greenhouse gas emissions markets. The speaker will discuss the process of developing offsets on rangeland, challenges encountered in outreach, development, and verification, as well as lessons learned throughout the project. The session will also address the important roles played by various regional stakeholders—including land trusts and non-Federal agencies—as liaisons to landowners, drawing upon existing tools and relationships to assist in the credit development process.

Conversion of grassland to cropland causes significant emissions of greenhouse gases (GHGs) in the form of soil carbon loss and emissions from crop cultivation (related to fertilizer and fossil fuel use). Because of these GHG impacts, financing from the carbon market can be used to leverage other conservation dollars in order to permanently protect grassland and grazing land. In 2015 the Climate Action Reserve (Reserve) completed the public development of a streamlined protocol which balances methodological rigor with a user-friendly approach, with the goal of alleviating some of the high costs of market access. Details can be found here:  
<http://www.climateactionreserve.org/how/protocols/grassland/>

As of October 2018, there are nine voluntary grassland projects listed with the Reserve, representing 44,660 acres of protected grassland. Three projects have completed their initial verification, earning a total of 18,200 credits, and four more issuances are expected during 2018. These projects are located on grazing lands in CO, MT, and OR. The monitoring and reporting activities for a carbon project can dovetail well with existing easement monitoring activities of land trusts. There has also been immense interest from voluntary carbon buyers who appreciate the opportunity to address climate change mitigation and grassland conservation through a single project.

Founded in 2001, the Reserve is a 501(c)3 nonprofit carbon offset project registry and climate policy organization. The Reserve has issued more than 116 million offset credits (tonnes of CO<sub>2</sub>e) to hundreds of projects across the U.S. and Mexico, and has adopted 18 different offset project protocols.

## **ENLISTING CONSERVATION DISTRICTS TO ACCELERATE PARTICIPATION IN ENVIRONMENTAL MARKETS**

### ***Rich Duesterhaus***

National Association of Conservation Districts, Washington, DC, USA

This presentation will focus on lessons learned and advice gleaned from a national review of conservation district activities in water-quality trading and other ecosystem services markets. Conservation districts have played important roles in the establishment and implementation of environmental markets. Activities have included organizing stakeholder groups to build programs, providing technical assistance to landowner participants, aggregating credits, monitoring implementation, and conducting third-party verification and certification.

## QUANTIFYING CONSERVATION: NEW FINANCIAL AND TECHNOLOGY SOLUTIONS TO MEASURE AND SCALE CONSERVATION INVESTMENT

*Carolyn duPont<sup>1</sup>, Jeff Allenby<sup>2</sup>, David Primozych<sup>3</sup>, Marshall Moutenot<sup>4</sup> and Margaret Bowman<sup>5</sup>*

<sup>1</sup> Director, Quantified Ventures, Washington, DC, USA

<sup>2</sup> Director of Conservation Technology, Chesapeake Conservancy, Annapolis, MD, USA

<sup>3</sup> Conservation Director, The Freshwater Trust, Portland, OR, USA

<sup>4</sup> Co-Founder, Upstream, Somerville, MA, USA

<sup>5</sup> Program Director, Spring Point Partners, Philadelphia, PA, USA

The United States faces a growing need for natural infrastructure and ecosystem services investments across the country and the world – to help cope with urgent issues such as water shortages, coastal flooding and land subsidence, and pollution of fresh and drinking water due to agricultural run-off. At the same time, public and philanthropic funding for these initiatives is flat or declining. There is a need to both stretch public dollars, as well as to attract significant amounts of private capital into these projects.

A critical approach to addressing both of these needs is better quantifying ecosystem services and benefits provided by the investments themselves - in order to convince governments to take on new investments that are viewed as “risky” by allowing them to pay for outcomes, as well as to enable private ecosystem services markets and convince investors that environmental returns on investments are real.

Innovative technology solutions for quantifying ecosystem services can play a key role in addressing these investment needs. This panel highlights a number of financial and technology solutions from Quantified Ventures, The Freshwater Trust, Chesapeake Conservancy, and Upstream that are being developed that help maximize the effectiveness of conservation projects by bringing rigor to evaluating and learning from these projects regarding performance and impact —and doing so faster and less expensively than before. The panel will also include an investor viewpoint on the importance of this quantification from Spring Point Partners, a family office that invests in environmental organizations and projects.

## **DEVELOPING NATURAL CAPITAL ACCOUNTS FOR THE COASTAL AND MARINE CONTEXT: LESSONS LEARNED FROM PILOT APPLICATIONS**

***Anthony Dvarskas***

School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, USA

Recent international efforts have focused on the development of metrics to supplement or adjust Gross Domestic Product (GDP) to better account for the broader environmental and social impacts of economic development. In this regard, the United Nations System of Environmental-Economic Accounting, through its Experimental Ecosystem Accounting (EEA) work, is developing a standardized approach to accounting for the value of ecosystem services generated by ecosystems and documenting the relationships between ecosystem services and economic activity. Limited examples exist of the application of the EEA approach to coastal and marine habitats. The purpose of the current research is therefore to develop a pilot process for applying the EEA within a coastal area, using South Shore Long Island Bays and Long Island Sound as a case study. The research focuses on two priority ecosystem service benefits for the region—recreational use of coastal areas and commercial shellfishing. Indicators of ecosystem condition and ecosystem services are proposed, drawing from previous academic literature and ongoing monitoring plans for the region, data are compiled for the study site, and population of EEA tables as proposed by the United Nations is undertaken. Results indicate significant data gaps for marine and coastal areas that may limit the immediate ability to compile these ecosystem accounts. However, based on identified data gaps and implementation challenges, the process undertaken at the pilot site provides guidance for potential future research activities. Recommendations are also provided for connecting the ecosystem services to industrial and product classifications.

## **SCALING SOIL HEALTH THROUGH ECOSYSTEM SERVICE MARKETS: A WATER PERSPECTIVE**

***Alex Echols***

Principle, Terra Altus, LLC, Alexandria VA, USA

Improving soil health has a cascade of additional environmental and economic benefits. Notably, both practices and improved soil health improve water quality and can improve efficiency in water use. Quantifying these benefits will leverage investment in conservation and should be used to drive capital to agricultural producers adopting enhanced management. Broadening sources of funding for agricultural conservation is critical to overcoming one of the major impediments to delivering enhanced water quality and other environmental improvements. The Noble Research Institute (NRI) Ecosystem Service Market (ESM) Program will quantify and monetize ecosystem service enhancements – water in particular. The Program will seek to deliver low cost quantification protocols that can be used to foster commerce in conservation and hold down overhead costs. The Program seeks to increase financial support to agricultural producers from delivery of ecosystem service benefits as well as quantify on farm benefits from improved management. This strategy will be used to better align incentives to provide enhanced water quality production and other environmental benefits.

## **SOIL CARBON – MORE THAN JUST THE O-HORIZON**

***Pamela J. Edwards***

USDA Forest Service, Northern Research Station, Parsons, WV, USA

The USDA Forest Service is mandated to consider carbon management through several laws and rules. However, aside from direct effects of timber removal on carbon reserves and associated losses of organic matter at the soil surface, carbon management and carbon sequestration are not well understood by many National Forest resource specialists and carbon is not specifically addressed during most NEPA analyses. Fortunately several of the more traditional concerns addressed during planning inherently include soil carbon. For example, road analyses typically are focused on accelerated runoff and erosion and sedimentation from road construction, use, and maintenance, and off-road activities typically focus on soil disturbance and compaction. These activities negatively affect soil carbon reserves and soil carbon storage due to elevated soil losses from the watershed, accelerated decomposition of exposed below-ground carbon, increasing mobilization loss of dissolved organic carbon, and reductions in soil voids that limit organic matter leaching and biotic colonization deep in the soil, so any efforts to reduce soil disturbance, soil loss, and soil compaction will contribute to retaining soil carbon.

However, soil carbon also can be influenced by less conventional, manipulative approaches. The USDA Forest Service's Monongahela National Forest and Northern Research Station are working together to develop a framework that can be applied to both federal and non-federal lands to increase carbon sequestration on forested lands. This work involves a number of steps, including gathering information about existing carbon reserves, synthesizing state-of-the-science techniques that can increase carbon stores, and initiating research in hardwood ecosystems to fine-tune manipulative techniques for maximum effectiveness in Eastern region conditions. Our ultimate focus is on understanding the effects and magnitude of carbon management techniques on enhancing other ecosystem services, such as water retention, biomass growth rates, and wood quality, that are typically of more interest to land owners and the public than is carbon. These ecosystem services can serve as the "hook" to help land managers and land owners understand the importance of carbon management.

## **INTEGRATING ECOSYSTEM SERVICES INTO NATIONAL STRATEGIC PLANNING: THE CASE OF THE NATIONAL OCEANIC ADMINISTRATION (NOAA) CORAL REEF CONSERVATION PROGRAM**

***Peter E.T. Edwards***

The Baldwin Group Inc., Manassas, VA

National Oceanic and Atmospheric Administration, Coral Reef Conservation Program, National Ocean Service, Silver Spring MD, USA

The National Oceanic and Atmospheric Administration's Coral Reef Conservation Program (CRCP) is currently undergoing a strategic planning process. In this new strategic plan, CRCP recognizes the explicit connections between healthy, fully functioning, coral reef ecosystems and the vital economic and societal benefits they provide. The Coral Program's overall vision is to work with partners towards thriving diverse, resilient coral reefs that sustain valuable ecosystem services for current and future generations. The program's mission and activities are organized around the sustainable use of coral reef ecosystems that benefit local communities and the nation. Ecosystems and the ecosystem services framework are therefore key components of the overall strategic planning process. The strategic plan is focused on the conservation of U.S. coral reef ecosystems in conjunction with sister federal agencies, state, territorial and local partners.

NOAA CRCP activities are organized into four key focus areas or pillars that address; Climate Change, Fisheries Sustainability, Reducing Land Based Sources of Pollution and Restoring Viable Coral Populations. Ecosystem services are the connection between conservation for enhanced coral reef ecosystem function and human wellbeing outcomes.

The major drivers of coastal ecosystem change are linked to a range of anthropogenic influences. Greater connections and inferences between observed changes in coastal ecosystem quality, and human and social parameters can be achieved if biophysical and social science disciplines work together for effective coastal resource management. Strategic planning for a national coral reef management program requires integrated approaches that are built on ecosystem services frameworks. Successful implementation should result in improved integration of biophysical, social and economic scientific approaches that leads to more efficient coastal resource management. Ecosystem services can be a useful bridge between biophysical and social science approaches.

In this poster, we highlight NOAA Coral Reef Conservation Program planning process, some challenges to implementation and how ecosystem services are playing a key role in integrated coral reef management.

## PROCUREMENT OF ECOSYSTEM SERVICES FOR MUNICIPAL REGULATORY REQUIREMENTS: “HIDDEN” INVESTOR GEMS?

*Jennifer Egan<sup>1</sup> and Naomi Young<sup>2</sup>*

<sup>1</sup>Skelly and Loy, Inc. Hunt Valley, Maryland USA, University of Delaware Department of Applied Economics and Statistics, Newark DE, USA

<sup>2</sup>Center for Regional Analysis at the Economic Development Company of Lancaster County, Lancaster, PA, USA

Over the last two decades, urban development has spread out from large metropolitan centers, transforming once rural and small-town landscapes into suburban settings. With expanded urban development comes expanded and new urbanized areas (UA) that trigger environmental and land use obligations – namely, for clean water and stormwater – with which small municipal governments have little experience and/or familiarity. Depending upon the intensity of development pressure and comprehensiveness of land use planning, these newly designated UA’s manage to retain and preserve pockets of agricultural land and open space. These “softscapes” serve a highly valuable role in terms of ecological and watershed health. They also present new opportunities for piloting initiatives that draw impact capital, private-public partnerships, and other approaches harnessing market-based dynamics for water quality improvements.

Moderate to substantial information gaps exist in the current state of efficient ecosystem service delivery for this expanded investment frontier of water quality improvement. The close and often interwoven nature of land uses patterns (agriculture, residential, commercial, open space) expand and diversify the suite of best management practices available to municipalities facing municipal separate storm sewer systems (“MS4”) and other environmental obligations. For example, studies have touted agricultural best management practices as “cost effective.” Therefore, in mixed urban settings, public and private landowners working together offer potential efficiency gains and cost savings through siting best management practices guided by real highest and best use principles. Capitalizing on this cost differential requires a willingness to depart from business as usual when little infrastructure is established to make the necessary chain of connections – that is, connecting farmers, local government with MS4’s water quality needs and investors that are interested in environmental return coupled with modest monetary return.

In the last 3 to 5 years, several contracting mechanisms new to environmental services are being implemented in US cities which provide opportunities for impact capital and other financing tools to secure water quality improvement. These contracting approaches are, in general, successfully used in other sectors including the pay for performance or success in social and health settings and public private partnerships (P3) in the transportation sector. The early success of contracting mechanisms new to environmental services piloted in highly urbanized, county, and large-cities have raised interest in their application to smaller markets and local governments. Some examples of recent application to environmental service contracting are in Maryland to achieve the Chesapeake Bay Total Maximum Daily Load, the pay for success model of DC Water, and recently funded US Department of Agriculture Conservation Innovation Grant pay for success projects. This study will give the background of the contracting mechanisms, explain how they apply to environmental service settings, highlight a comparative study of recent projects in the Mid-Atlantic, US, and provide early insights from the transfer of these contracting mechanisms to settings challenged by scale and limited municipal budgets. This study will demonstrate that knowledge gaps need to be filled through understanding: the important role basic economics of transaction costs, supply, and demand play in the framework of these contracting mechanisms, definition of the shared information set for parties, and the importance of indexed performance to account for progress where you have heterogeneity in measurement of outcomes.

## **A RESILIENCE MODEL FOR THE RESTORATION OF THE RIO DOCE BASIN**

*Presenting Author: Cary Ehrman*

Ramboll Environment and Health, Dublin, Ohio, USA

A Resilience Model was prepared to support the restoration of the Rio Doce Basin after the Fundão Dam failure. The Resilience Model focuses not only on providing much-needed assistance and support to communities affected by disaster, but also aims to optimize, implement, and monitor the progress of the proposed socio-economic and socio-environmental program strategies and actions. In practice, the Resilience Model embodies two critical aspects – (a) the intrinsic sustainability dimensions that are internationally-recognized as necessary for building resilience capacity in Society; and, (b) holistic considerations for the integration of the environmental socioeconomic and factors associated with proposed restoration strategies and actions and their potential effects on impacted communities. The principal objectives were to construct and apply a practicable, metric framework for:

- Assessing the Pre-Disaster, Post-Disaster (current performance of response actions / programs), and Regulatory Level (Desired State) status and/or condition across the whole of the Rio Doce Basin (as divided into the 4 separate areas based on type and severity of impacts).
- Support the concept that as Ramboll's recommended programs are implemented over time, community resilience will grow.
- Establish the starting point for monitoring the performance of the collective programs organized under each resilience dimension over time.

The paper will focus on the development and application of the Resilience Model, which was constructed by populating each dimension with indicators, calculating the individual scores of the indicators representing each dimension, attributing that score to the appropriate Dimension of the model, and graphically illustrating their interrelated performance.

## **IMPROVING SOIL HEALTH ON RENTED FARMLAND**

***Pipa Elias***

The Nature Conservancy, Arlington, VA, USA

Maintaining or improving soil health can improve producer profitability, reduce soil loss, improve water quality and quantity, and provide climate mitigation and adaptation. A number of market forces can incent or create a barrier to increased adoption of soil health practices.

In the U.S., over half of farmland is rented, and farmers are half as likely to apply conservation practices on land they rent compared to land they own due to up-front costs that may take years to create an ROI. On the other hand, companies at the 'downstream' end of the agricultural supply chain, such as consumer-facing brands, are interested in how soil health can help them achieve sustainability pledges, and can create incentives for practice adoption.

The Nature Conservancy will share the work we are doing with our partners to understand the demographics and motivations of non-operating landowners, provide these landowners with financial and legal tools to work with producers to implement soil health practices, and help companies meet sustainability targets related to conservation agriculture.

## LONG-TERM EVOLUTION OF WILDERNESS RECREATION VALUES

*Jeffrey Englin<sup>1</sup>, Thomas Holmes<sup>2</sup>, Octavio Valdez Lafarga<sup>3</sup>*

<sup>1</sup>Arizona State University, Mesa, AZ, USA

<sup>2</sup>US Forest Service, Raleigh, NC, USA

<sup>3</sup>Autonomous University of Occident, Mexico

Effective social planning for the use of public lands is an ongoing, inter-generational effort requiring a clear understanding of past and evolving trends in the use and value of natural areas. A fundamental definition of wilderness provided by the Wilderness Act of 1964 was an area “that has outstanding opportunities for solitude or a primitive and unconfined type of recreation”. Since the signing of the Act, many characteristics of American society have changed, and little is known about how demographic and social transformations have influenced the value of wilderness recreation. In this study, we utilize a unique dataset of wilderness permits, spanning roughly 40 years and 40 wilderness areas, allowing us to investigate the evolution of wilderness values over time and across ecological regions. By compiling and merging data on individual wilderness trips with census-based demographic information and ecological designations, we are able to consistently estimate pooled time-series and cross-sectional travel cost models of wilderness demand. The results of this study identify social and economic factors that are driving long-term trends in the value of wilderness recreation, allowing us to forecast needs for resource protection and management activities. This information will help policy-makers and land managers plan for measures needed to sustain the provision of cultural ecosystem services from this unique land base.

## **TRAVEL COST MODELS USING CONTINUOUS NON-NEGATIVE DISTRIBUTIONS AND OUT OF SAMPLE PERFORMANCE: AN APPLICATION TO ADMINISTRATIVE USE PERMITS**

**Jeffrey Englin<sup>1</sup>, Thomas Holmes<sup>2</sup>**

<sup>1</sup>Arizona State University, Mesa, AZ, USA

<sup>2</sup>US Forest Service, Raleigh, NC, USA

Big data is becoming more prevalent in the valuation of non-market goods. This is partly due to large environmental events with widespread impacts such as Deepwater Horizon, partly due to the ability to merge large detailed ecological data sets onto behavioral datasets but also due to the realization that administrative data can be used to infer environmental values. This analysis uses both large ecological and administrative data sets. The econometric analysis introduces the excess zero exponential and excess zero log normal distributions to travel cost modeling. Traditional excess zero count models are also employed for comparative purposes. The new distributions allow large national data sets to be applied to specific areas, in this case wilderness areas, and derive nationally valid welfare estimates. In particular, they allow for extremely high usage counts (popular sites) while dealing effectively with a excess number of zeros as well. The analysis proceeds by using stratified sampling without replacement from a 100 million observation data set to repeated samples of 2 million observations. Half of the samples are used to estimate maximum likelihood and Bayesian travel cost models while the other half are retained to validate the estimated models. The performance of each model and method is analyzed and compared.

## **APPLYING AN ECOSYSTEM SERVICES FRAMEWORK TO FOREST PLAN ASSESSMENTS**

*Jonas K. Epstein, Lori Swiderski*

Wayne National Forest Supervisor's Office, USDA Forest Service, Nelsonville, OH

As a multiple-use public agency, the National Forests of the United States must manage federal land based on the values and benefits desired by their surrounding communities. Managing healthy and resilient forests for ecosystem services is essential for sustaining economic and social well-being. In order to strategically optimize investments across each Forest to achieve those desired conditions and associated benefits, Forest Plans are established and revised every fifteen to twenty years to guide the implementation of projects based on an overarching vision.

The 2012 Forest Service Land Management Planning Rule requires direct public engagement and collaboration to ensure that the Forest Plan meets the needs of the public. It explicitly requires that land management plans “provide for ecological sustainability and contribute to social and economic sustainability...protecting and enhancing water resources, restoring land and water ecosystems, and providing ecological conditions to support the diversity of plant and animal communities while providing for ecosystem services and multiple uses.” It also establishes the three phases of Forest Plan Revision: Assessment, Plan Development, and Monitoring.

The Wayne National Forest - spanning 246,000 acres in southeast Ohio - is the first National Forest in the Northeastern Region to undergo plan revision under the 2012 Rule. An interdisciplinary team was assembled in early 2018 and the team is currently focusing on completing a Forest Assessment by early spring 2019. The Assessment is intended to be “a rapid evaluation of existing information about relevant ecological, social and economic trends and their relationship to the plan within the context of the broader landscape”. The purpose of the Assessment is to use verifiable information and analysis to determine whether the current Wayne National Forest Plan from 2006 is sufficient in meeting the desired public benefits.

Given the inherent linkages to social and economic contributions of land management and the integrated nature of natural resource issues, the Forest Plan Revision Team opted to take a streamlined, ecosystem services based approach to forest planning, to be captured and quantified at the onset of Assessment and carried forward through Plan Development and Monitoring phases. This framework integrates the 15 natural resource topics areas required for consideration in Assessment, while providing avenues for direct public engagement with issues that are most relevant to their interests in forest management.

The Wayne National Forest will present its preliminary Assessment findings and synthesize Lessons Learned from the early stages of the process. There is interest from the Regional Office in using the Wayne National Forest approach as template for other Forests in the future.

## **PRINCIPLES TO GUIDE COMPREHENSIVE ECOSYSTEM SERVICE VALUATION – INSIGHTS FROM ASSESSMENTS OF THE GREAT DISMAL SWAMP AND HURRICANE SANDY RESTORATION**

***David E. Ervin***

Portland State University

Lacking well-functioning markets and credible values, critical services of ecological systems can be neglected in public and private management decisions. Buoyed by recent scientific advances, federal agencies have begun incorporating ecosystem service values into program decisions. Implementation of such valuation in the policy arena lags the advances in science. The distillation of a set of guiding principles for ecosystem service valuation can help realize the potential benefits of conserving natural capital and limit attendant risks. Building on the findings of an expert workshop, the following guiding principles are proposed:

1. Identify salient ecosystem services (and disservices) in a transparent and inclusive stakeholder process.
2. Use interdisciplinary teams to develop benefit-relevant 1) monetary and 2) non-monetary (as appropriate) indicators to capture the full spectrum of human welfare effects.
3. Specify the conceptual model (causal chain) of ecological structure, function and process that determines the salient service benefit flows.
4. Conduct assessments at a geographic scale that has ecological integrity (supply side) and for which demand-side preferences are understood.
5. Estimate 1) monetary and 2) non-monetary (as appropriate) value metrics for all salient services using the best available science.
6. Characterize confidence intervals for the values due to uncertain changes in determining factors over time and the effects on natural system resilience.
7. Identify key missing theory, methods and data that limit the accuracy and relevance of the value estimates to inform federal policy.

Analysis of two major federal natural resource valuation exercises with the principles suggests seven recommendations to advance credible assessments of ecosystem service values.

## **DC'S STORMWATER RETENTION CREDIT TRADING PROGRAM: FACTORS CONTRIBUTING TO A SUCCESSFUL ECOSYSTEM SERVICES MARKET**

*Brian Van Wye, Matthew Espie, Nat Lichten*

Regulatory Review Division, Department of Energy and Environment, Washington, DC, USA

Impervious surfaces in the District of Columbia generate millions of gallons of stormwater runoff, flooding neighborhoods and polluting local waterways. Green stormwater infrastructure (GI) provides important ecosystem services by retaining runoff, improving water quality and reducing erosion. It also can reduce urban heat island effects, improve landscaping aesthetics, and provide other social and ecological co-benefits.

Under the District's 2013 Stormwater Rule, DOEE created a first-of-its-kind marketplace for stormwater retention through the Stormwater Retention Credit (SRC) trading program, leveraging private investment to more effectively and quickly provide this ecosystem service. This program allows properties to voluntarily install GI, generate SRCs, and sell those SRCs to developers to meet regulatory requirements. The resulting SRC market creates an incentive for private investment to build GI in areas where these practices have the greatest environmental benefit, where there are fewer competing uses for space, and where it may be less costly. To date, over 200,000 SRCs have been purchased, and market activity has tended to grow cumulatively.

This session will describe the strategies the District of Columbia Department of Energy and Environment (DOEE) has used in establishing the SRC program and in facilitating the growth of the SRC market, including:

- How the 2013 Stormwater Rule creates a regulatory framework that drives demand for SRCs.
- How DOEE structured the SRC market based on local context to maximize environmental outcomes in the District's most impaired watersheds.
- The steps DOEE has taken to reduce trading barriers and provide program transparency, such as the implementation of an online interface for submitting applications, public reporting of market data, and the creation of trading tools and template contracts.
- The steps DOEE has taken to support early actors in the market through government purchases of SRCs and grants to support SRC aggregators.
- Finally, the session will introduce plans to cultivate new sources of demand in the form of "stormwater footprint offsets" from events and organizations with sustainability goals.

The District's SRC program provides a unique example of the application of market-based mechanisms to stormwater management. Participants will leave the session with an understanding of the factors that have contributed to this success, and strategies that can be applied to environmental markets elsewhere.

## **USING BIG DATA TO SUPPORT DECISION-MAKING AROUND ECOSYSTEM SERVICES IN WASHINGTON, DC**

***Matthew Espie***

Regulatory Review Division, Department of Energy and Environment, Washington, DC, USA

The District of Columbia Department of Energy and Environment (DOEE) has several programs in place to protect and restore ecosystem services through the implementation green infrastructure (GI) practices. These GI practices capture harmful stormwater runoff, preventing pollution of waterways while providing co-benefits such as increasing green space and reducing the urban heat island effect. It is challenging to analyze GI policy and make decisions that maximize environmental benefit, so DOEE has developed a custom database for this purpose. The Stormwater Database, which track GI practices installed through regulatory and voluntary programs, also manages program workflows and supports evaluation of GI implementation to assist the District government in the decision-making process with respect to stormwater management.

The Stormwater Database contains detailed information about individual GI practices within the District. To understand how these GI practices are working to restore the District's rivers, this information is synchronized with the District's Total Maximum Daily Load (TMDL) Implementation Plan Modeling Tool. Additionally, charts and reports within the database display real-time program information to let DOEE track the status of its unique Stormwater Retention Credit (SRC) trading program. This allows DOEE to analyze how the SRC program is motivating GI implementation in priority areas. The database also contains detailed information about individual permit applications that trigger the District's stormwater management regulations, including calculations of runoff volumes. Using the database and related tools, DOEE is able to quickly analyze program status, evaluate how policy changes could affect environmental outcomes, and use this information to make decisions that maximize environmental benefit.

This session will discuss the overall context of the Stormwater Database for the District's stormwater management programs. The session will also provide examples of how the Stormwater Database has been used to evaluate program implementation and to make decisions to maximize GI implementation in priority areas. The session will provide success stories and lessons learned for other municipalities.

## EXPANDING THE FIELD OF ES PRACTITIONERS—18 BENEFITS FROM USING CLASSIFICATION SYSTEMS

*John Finisdore<sup>1</sup>, Charles Rhodes<sup>2</sup>, Roy Haines-Young, Simone Maynard, Jeffrey Wielgus, Anthony Dvarskas, Joel Houdet, Fabien Quétier, Helen Ding*

<sup>1</sup>John Finisdore, Founding Partner, Sustainable Flows, Washington, DC, USA

<sup>2</sup>Dr. Charles Rhodes, Sustainable Flows, Washington, DC, USA

Ecosystem services (ES) practitioners have been working to better define and measure how nature contributes to society. The Millennium Ecosystem Assessment's (MA) four types (supporting, provisioning, regulating, cultural) is the most widely used definitional grouping of ES, despite ecosystem services classification systems (ES-CS) being proposed by the European Environment Agency and the US Environmental Protection Agency. These ES-CS employ final ecosystem services (FES) principles that are being used by leaders including the Chinese Academy of Sciences.

Benefits of adopting formal ES-CS naturally proliferate when common definitions are applied among practitioners. Eighteen specific benefits are defined in five functional categories:

1. *Unifying language* among ecologists, economists, accountants and policy makers
2. *Understanding how all the elements of the CS interrelate* throughout the entire hierarchy
3. *Improved identification of elements, metrics and analytical techniques* from the specificity, completeness, and mutual exclusivity within a classification systems' hierarchy
4. *Improved knowledge transfer* for analytic techniques from benefits transfer to cost benefit analysis and development of biophysical production functions
5. *Improved knowledge management within organizations* that follows from a broader understanding of ES, their definitions, and interrelationships

Analysis shows tremendous advantages from ES-CS versus the current "ad hoc/MA-based" approach to defining ES. Use of ES-CS reduces costs of defining and discovering data, while avoiding the costs of recreating CS. The enabling conditions for wide adoption of ES-CS exist and the likely benefits far exceed expected costs of transitioning to ES-CS. The following steps are encouraged to advance this transition:

- a. Integrate stakeholder's understanding of the "benefits of nature" with ES-CS, ensuring analysis and policy recommendations are technically strong and readily understood by stakeholders
- b. When not using an ES-CS, clearly define the ecosystem, ecological end-product, uses, and users
- c. Where practical, use an ES-CS
- d. Promote the adoption of ES-CS among colleagues and institutions

A movement toward a common understanding of FES, the principle that facilitates ES-CS, is underway. Advancing this trend through expanded use of ES-CS will reduce the cost of and barriers to ES research. This can expand the set of ES practitioners, helping ES become a common part of decision making.

Sustainable Flows working paper will be posted on [www.ResearchGate.net](http://www.ResearchGate.net)

## DISCIPLINARY BIAS IN ECOSYSTEM SERVICE ASSESSMENTS THREATENS ENVIRONMENTAL OUTCOMES

**Dillon T. Fogarty<sup>1</sup>, Dirac Twidwell<sup>1</sup>, and Craig R. Allen<sup>2</sup>**

<sup>1</sup>Agronomy & Horticulture, University of Nebraska, Lincoln, NE, USA

<sup>2</sup>U.S. Geological Survey – Nebraska Cooperative Fish & Wildlife Research Unit, University of Nebraska, Lincoln, NE, USA

The ecosystem service (hereafter ES) concept was operationalized to incorporate the benefits of nature into decision making processes and improve environmental outcomes. ES assessments are increasingly used to evaluate how policy, environmental change, or infrastructure will alter ES suites. However, ES assessments can be used to promote disciplinary norms when assessments reflect a single discipline and fail to recognize the interconnectedness of social ecological systems, introducing ES biases. To examine this issue and provide recommendations, we assess ES change associated with juniper tree (*Juniperus* spp.) afforestation of the Great Plains grasslands. Juniper trees were historically rare in the Great Plains, but have since been widely planted in windbreaks for associated ES benefits. Juniper invasion of rangelands has accompanied the distribution of juniper seed sources and fire suppression. While juniper planting and invasion are intrinsically related, they are studied within disciplinary “silos” of agroforestry (planting) and applied ecology (invasion). Our objectives are to (1) conduct disciplinary ES assessments from agroforestry and applied ecology perspectives and (2) combine disciplinary assessments and compare the messaging that results from disciplinary and interdisciplinary assessments. To inform each disciplinary assessment, we conducted systematic literature reviews using search phrases relevant to agroforestry (e.g., windbreak, etc.) and applied ecology (invasion, etc.) perspectives of afforestation. Alteration of ES (or lack thereof) was recorded from all studies that empirically investigated ES change as a function of planting juniper trees (agroforestry) or juniper invasion (applied ecology) in the Great Plains.

We reviewed a total of 322 titles for agroforestry and 314 for applied ecology, resulting in 19 and 16 ES for agroforestry and applied ecology, respectively. For agroforestry 14 ES increased as the result of planting trees in working landscapes while three did not change and two decreased; notable ES gains were regulation of soil erosion, crop production, wind regulation, and regulation of home energy use. For applied ecology 12 ES decreased, two did not change and 2 increased; notable ES losses consisted of biodiversity, streamflow, aquifer recharge, wildfire regulation, and herbaceous forage production—a ES that supports the ranching industry in the Great Plains. Each disciplinary based ES assessment resulted in clear messaging (i.e., minimal ES tradeoffs) that can be summarized as (1) planting juniper trees increases ES provisioning near homesteads and crop field margins (agroforestry) and (2) juniper invasion reduces ES provisioning on rangelands. However, messaging from our interdisciplinary (agroforestry and applied ecology) ES assessment indicated that major ES tradeoffs exist between localized ES benefits near plantings and ES losses across rangelands. Disciplinary assessments failed to capture the interconnected dynamics of social ecological systems and resulted in misleading messaging. Indeed, current policies align with disciplinary assessments, in that both juniper planting and removal from rangelands are incentivized (e.g., NRCS incentive programs and others). Disciplinary bias and failure to incorporate foundations of ecosystem science in ES assessments may compromise ES provisioning at large scales. To advance the ES concept and improve environmental outcomes, interdisciplinary approaches that capture social ecological system dynamics are needed.

## HOW A DEDICATION TO FIRST FOODS BY TRIBAL NATIONS SUPPORTS HEALTH AND CULTURAL CONNECTION

***Monique Fordham***

USGS-DOI

Traditional Native American diets comprised of “First foods” – plant and animal food sources that sustained Native Peoples for millennia – provide essential connections to cultural identity, cultural traditions and good health. But centuries of forced assimilation efforts, agricultural commercialization, chemical contaminants and changing environmental conditions saw a shift away from these “First Foods.” The resulting effects included impacts on the ability to carry out cultural practices and severe health problems in tribal communities. But tribal resilience in the face of these pressures has resulted in strong efforts to reestablish these traditional dietary practices.

This session will present the views of two indigenous presenters deeply involved in the work to protect these food sources and support their sacred role within their respective communities... and beyond.

Yakama Nation fisheries biologist Elaine Harvey holds multiple degrees in fisheries science and resource management and approaches her duties from the perspective instilled by growing up with her grandmother, who lived a traditional Plateau lifestyle. She is dedicated to sharing these traditional teachings from her tribal elders with Native youth. Ms. Harvey is dedicated to underscoring the significance of First foods to the health of her people. She also communicates the urgency surrounding the need to ensure the survival of these traditional food sources. Working on the Rock Creek Fish and Habitat Assessment Project, Ms. Harvey has concern for the Rock Creek subbasin, which is located in eastern Washington and is already seeing low precipitation levels. “I am concerned for the fish, deer, roots, berries and other medicinal plants that we utilize not only in the Rock Creek subbasin but all the usual and accustomed gathering places we travel to for subsistence.”

As a boy, Steven Bond-Hikatubbi regularly visited his great-grandparent’s subsistence farm in Wister, OK, where he was first introduced to traditional Chickasaw and Choctaw foods. These early experiences manifested into a drive to better understand nature and ancestral farming practices. Undergraduate work at Southwestern Oklahoma State University (SWOSU) led to Steven’s double major in Biology and Environmental Chemistry, which led to research in the fields of Biochemistry and Entomology. Steven’s graduate studies at Oklahoma State University began in the Botany Department; he subsequently shifted towards Biosystems Agricultural Engineering, earning him his M.S. in the field of Environmental Science with a specialty in Watershed Resource Management. In the years 2008 thru 2012 Steven became involved in the development of the Ecological Resources and Sustainability Program with the Chickasaw Nation, serving as their ethnobotanist. He then began his work with the Intertribal Agriculture Council, spending the years 2012 to 2014 working with Western Region Tribes; from 2014 to the present Steven has been working with Eastern Oklahoma Region and Southern Plains Tribes in the development of sustainable agricultural operations, both commercial and traditional. Steven continues to serve as the tribal ethnobotanist for the Chickasaw Nation.

## IMPLEMENTATION STRATEGIES: BUILDING SCIENTIFIC KNOWLEDGE INTO POLICY AND MANAGEMENT DECISIONS

*Leska S. Fore<sup>1</sup> and Katharine Wellman<sup>2</sup>*

<sup>1</sup>Puget Sound Partnership, Tacoma, WA, USA

<sup>2</sup>Northern Economics, Inc.

The Puget Sound Partnership is a Washington State agency charged with accelerating the region's collective efforts to recover Puget Sound. The Partnership supports the use of science to inform decisions and evidence to select the best actions to manage, protect, and restore the Puget Sound and its watershed. While consideration of ecosystem services is often implicit in decision making, a more explicit use of ecosystem valuation is needed.

Thousands of individuals and hundreds of organizations share a similar mission to restore Puget Sound. The Partnership aligns this collective effort by tracking and reporting a shared set of Vital Sign indicators that measure the condition of key species and habitats, water quality and quantity, and human wellbeing. While some Vital Sign indicators have shown improvement over time, most indicate little progress toward their recovery targets.

In order to improve Vital Sign indicators, the Partnership brings together diverse, cross-sector teams to agree on a set of strategies to accelerate progress toward recovery targets. Implementation strategies are created collaboratively by technical, professional, and policy experts in a facilitated setting. The cross-sector groups develop logic models to support their selection of the best strategies for ecosystem recovery.

In 2018, the Vital Sign indicator for summer stream flows will be the focus of an implementation strategy. Urban development and climate change threaten water availability, which impacts salmon and other wildlife. Recent legislation in Washington requires watershed planners to balance water use by new development with instream flows for salmon. The legislature authorized \$300 million over 15 years to restore stream flows and criteria are being defined now to measure the "net environmental benefit" of proposed restoration projects.

Ecosystem valuation could be a good fit to address these issues of cost vs. benefit of restoration actions and ecosystem services. Nonetheless, challenges to adopting this framework include concerns about applying data derived from other regions to Puget Sound, model complexity, and difficulties reviewing and vetting the models. The Puget Sound provides an excellent case study to resolve these technical challenges.

## **ADVANCING SUSTAINABLE FARMS THROUGH ENVIRONMENTAL MARKETS: OHIO RIVER BASIN WATER QUALITY TRADING PROGRAM**

*Jessica Fox<sup>1</sup> and Brian Brandt<sup>2</sup>*

<sup>1</sup>Electric Power Research Institute, Palo Alto, CA USA

<sup>2</sup>American Farmland Trust, Columbus, OH USA

In 2007, the Electric Power Research Institute (EPRI) joined with a large group of collaborators, including both EPA and USDA to develop a large-scale WQT program in the Ohio River Basin (ORB). We understood that we would have to systematically overcome a multitude of challenges to establish a self-sustaining market where farmers could sell nutrient credits. Trading across jurisdictional boundaries meant we would face differing social and political concerns in developing a common trading platform. From the start, we maintained a high level of stakeholder engagement necessary to ensure successful pilot trades through multiple farmer listening sessions, active advisory committees and numerous meetings. On August 9, 2012, the state agencies in Ohio, Indiana and Kentucky signed the nation's first interstate WQT trading plan. The resulting plan achieved the strict level of due diligence and certainty required by both the state agencies and the large power companies, while also recognizing the privacy concerns and flexibility needed by farmers. Six years later, we have issued multiple funding opportunities for landowners throughout Ohio, Indiana, and Kentucky and have contracts in place with approximately 40 farmers that range from 5 and 40 years long. We have funded cover crops, heavy use areas, fencing, milkhouse waste management, forest planting, among others. Adding forest planting in 2016 as a particular BMP of focus has been challenging and engages a different landowner demographic compared to traditional agricultural practices. We have learned many lessons regarding how best to engage farmers, issue contracts, on-farm verifications protocols, and the eventual issuance of associated water quality credits. This presentation will share some of these unique insights and lessons.

## **SELECT ECONOMIC BENEFITS OF INCREASING SOIL ORGANIC MATTER ON CALIFORNIA RANGELANDS AND CROPLANDS**

*Frank Casey and Fabiano Franco*

US Geological Survey, Science and Decisions Center, Energy and Minerals Mission Area, Reston, VA, USA

We investigate the ecosystem services of carbon sequestration, forage production and groundwater recharge associated with increasing the organic matter content of soils across California's working lands. Results indicate that a one-time ¼" application of compost to rangelands can lead to carbon sequestration rates in soils that are maximized after approximately 15 years, and more than offset greenhouse gases emitted by the compost addition for at least five decades longer. Modeled increases in total soil organic matter of 3% enhanced hydrologic benefits across 97% of working lands. Economic valuation indicated all benefits increasing over time, also demonstrating a large potential for the California carbon market to support incentives in regionalizing the impacts in the coming decades. Results can be effectively used with land use change scenarios to identify where on California's working lands hydrologic and biogeochemical benefits of soil organic matter enhancement coincide with development risk, highlighting counties in California that may be good targets for strategic soil management and land conservation.

## **ASSESSMENT OF ECOSYSTEM SERVICES IMPACTS FROM LANDSCAPE URBANIZATION IN THE MOBILE BAY WATERSHED**

*R.S. Fulford, M. Russell, J. Bousquin, and M. Jackson*

US EPA Office of Research and Development, Gulf Ecology Division, Gulf Breeze, FL, USA

Coastal watersheds have become increasingly urbanized resulting in declines in ecosystem goods and services (EGS) to community beneficiaries. Urbanization includes increases in impervious surface, decreases in access to greenspace, and declines in both air and water quality. The result is a negative impact on human well-being. Restoration efforts in such watersheds need to account for the impacts of urbanization both in prioritizing restoration targets and in the development of restoration assessment metrics. Here we take a quantitative EGS approach to examine the impacts of both urbanization and watershed restoration on the production and delivery of key ecosystem services to people. The EPA H2O tool was used to evaluate change through time in land use/landcover and to examine the interaction of this change with small-scale restoration projects implemented as a part of the Mobile Bay National Estuary Program comprehensive management plan. Model analysis with the H2O tool indicated that EGS services are impacted by both landcover change and watershed restoration focused on reducing stream damage from large rain events and increasing user access. However, there are important differences in both beneficiaries and spatial scale of restoration impacts that need to be considered in prioritizing restoration targets. The intent of this analysis is to inform restoration planning and decision making from an EGS perspective and to place restoration in the spatial context of longer-term issues such as watershed urbanization.

## LESSONS LEARNED ON DEMAND DYNAMICS OF ECOSYSTEM MARKETS IN THE UNITED STATES

*Genevieve Bennett,<sup>1</sup> Melissa Gallant,<sup>1</sup> Kristiana Witherill<sup>2</sup>*

<sup>1</sup>Forest Trends' Ecosystem Marketplace, Washington, DC, USA

<sup>2</sup>National Network on Water Quality Trading, Portland, OR, USA

Certain environmental markets, such for carbon offsets, have taken off in the United States, while other environmental markets, including water quality trading, has been slow to develop in comparison. In order to investigate why this is the case, Ecosystem Marketplace recently partnered with the National Network on Water Quality Trading to conduct a rapid review of the historical performance of ecosystem markets in the United States, extract lessons learned about the key drivers shaping demand in those markets, and identify potential implications for developing markets for water quality trading.

In this review, we examined the following ecosystem markets in the United States: voluntary markets for carbon offsets; compliance carbon markets accepting forest and/or land-use offsets; compliance markets for wetland/stream credits developed by mitigation banks or in-lieu fee (ILF) programs; and compliance and voluntary markets for species/habitat credits developed by conservation banks, ILF programs, or other conservation crediting systems. We drew on a range of sources, including academic literature, journalistic coverage, "grey" literature, and Ecosystem Marketplace's published markets analysis and internal data. Based on this research, we assessed how policy/regulatory context, institutional factors, economic factors, market actors, market infrastructure and design, events/developments, and other forces played a role in stimulating or inhibiting demand.

This presentation will focus on the factors that have influenced demand across markets, take-home lessons, and potential implications for water quality trading. A rapid review of historical experience in ecosystem markets in the United States suggests that across markets, the fundamentals are the same:

- The core ingredients of compliance demand are environmental impact, bad alternatives, and clear regulatory signals.
- In compliance markets, regulators are the gatekeepers to demand, in terms of both market design and implementation/interpretation of market rules.
- Early on, virtually all markets struggle with buyer perceptions that the mechanism is risky—sometimes reinforced by initial mistakes by market administrators. If buyers see changes as course-correction rather than a crisis, confidence in the market can be maintained.
- In compliance markets, the public sector may have the advantage in predicting demand.
- Regulatory uncertainty can be tenacious.
- Voluntary and pre-compliance demand has a mixed track record.
- An industry association can be a very effective force in lobbying for regulatory or market rules that create new demand.

These lessons learned have implications for any ecosystem market, especially water quality trading: demand requires a co-occurrence of environmental impact, high costs or complexity of alternative compliance options, and a predictable regulatory process. Trading program administrators should develop a clear understanding of threats to buyer confidence (particularly regarding liability risk and perceptions of market mismanagement) and consider the ways in which regulators are ultimately the gatekeepers of demand in compliance markets. Finally, offering the lowest-cost compliance option is not everything: predictability and simplicity matter too, and for some buyers, the benefits of restoration and conservation to their local environment and community are ultimately more important than credit price.

## **GEOGRAPHY OF DEMAND: ASSESSING POTENTIAL DEMAND FOR WATER QUALITY TRADING/NONPOINT SOURCE WATER QUALITY IMPROVEMENTS IN THE UNITED STATES**

*Genevieve Bennett<sup>1</sup>, Melissa Gallant<sup>1</sup>, and Kristiana Teige Witherill<sup>2</sup>*

<sup>1</sup>Forest Trends' Ecosystem Marketplace, Washington DC, USA

<sup>2</sup>The Willamette Partnership, Portland OR, USA

Water quality trading is a promising tool that offers a flexible, more cost-effective approach to reducing pollution in our waterways than more traditional engineered solutions. Yet a lack of sufficient demand for credits has been a consistent barrier to scaling up water quality trading in the United States. The National Network on Water Quality Trading (NNWQT) partnered with Forest Trends' Ecosystem Marketplace and the US Environmental Protection Agency's EnviroAtlas project team to map watersheds where potential demand for water quality trading may exist.

Here, we present detailed results of a geospatial analysis mapping potential demand for both agriculture-generated water quality credits and stormwater credits. These maps are intended to inform the NNWQT in its work crafting a new national strategy for scaling up demand. Development of a suitability analysis has helped the NNWQT to test its assumptions about what drives demand for trading, identify where opportunities to influence demand drivers may exist, and communicate visually the potential scale of trading.

We present findings from two suitability analyses mapping potential demand for agricultural water quality credit trading and stormwater trading at the level of the 12-digit HUC watershed. In each analysis, we considered a range of biophysical, economic, and policy/regulatory drivers of demand. Our results include regions where trading is already active or in development, including Chesapeake Bay Basin states, North Carolina, the Willamette Valley, the Ohio River Basin, and Boise. Our analysis also suggests other areas where potential demand for agricultural water quality credit trading exists, including Sacramento, Akron, Cleveland, Toledo, Buffalo, Lexington, Fort Collins, Kansas City, and a number of major cities in Florida and along the Gulf Coast including Houston and Lafayette. Similarly, a number of urban areas received scores suggesting potential demand for stormwater trading, including the greater New York City area, Rochester, Syracuse, Ithaca, Providence, Greater Chicago, Green Bay, Coeur d'Alene, Fort Collins, St. Louis, Lexington, Chattanooga, Greater Charlotte, Durham, Memphis, Birmingham, Mobile, New Orleans, and most of Florida's major cities.

Mapping can also help identify opportunities for enabling policy. This study also produced maps identifying watersheds where strong biophysical and economic demand drivers appear to exist, but where enabling policy, guidance, and regulation are lacking.

## THE COST OF ENSURING SALT MARSH MIGRATION UNDER SEA LEVEL RISE: USING A PROPERTY VALUE MODEL TO INFORM ECOSYSTEM SERVICE CONSERVATION

*George Gardner and Robert J. Johnston*

Clark University, Worcester, MA, USA

Planning for ecosystem service preservation that maximizes social benefits requires information on ecosystem service values and attendant preservation costs. The natural production of most ecosystem services requires particular types and configurations of natural systems – the preservation of which is rarely equivalent to the “average” cost of land preservation in a particular area. However, managers often lack systematic information on preservation costs associated with ecosystems or land types with the attributes required to provide specific ecosystem services. As a result, conservation planning is often conducted using crude proxies for future preservation cost that can lead to misguided decisions. This presentation illustrates a novel model designed to forecast the cost of preserving land to ensure the future provision of particular types of ecosystem services. We illustrate the approach using an application to ecosystem services provided by US mid-Atlantic salt marshes. The price patterns revealed by the model can be used by conservation agencies to inform cost-effective preservation of land that ensures the persistence of marsh ecosystem services under sea level rise. Specifically, we illustrate a unique hedonic pricing model constructed to forecast the cost of preserving land suitable for salt marsh migration. The model is illustrated using a case study from the southern tip of Virginia’s Eastern Shore (Accomack and Northampton Counties). Given limits in the extent to which salt marshes can build elevation naturally (and hence keep up with sea level rise), the preservation of these systems under sea level rise requires the purchase and preservation of marsh transgression zones—undeveloped and unarmored uplands onto which marshes can migrate as sea levels rise. We use a unique data set consisting of sales of vacant land on the open market to predict the future cost of fee-simple preservation of undeveloped land with specific attributes suitable for marsh migration. For example, the model estimates changes in preservation cost (implicit prices) associated with conditions such as coastal distance, elevation, land cover and other features that determine whether a parcel of undeveloped land will (if preserved) be suitable for future marsh migration. Results indicate that some features required for marsh migration such as lower elevation are associated with lower prices, while others such as coastal proximity are associated with higher prices. Results also demonstrate the errors that can occur if conservation agencies use simplified proxies to approximate preservation costs. Simulations suggest that approximations of this type—for example using the simple average cost of undeveloped land in the area—lead to errors of up to 87%. Results such as these demonstrate that approaches of this type can lead to significant improvements in the ability of managers to plan for cost-effective ecosystem service conservation, by providing more accurate information on preservation costs.

## THE IMPACT OF INTERACTIONS WITH NATURE ON WELL-BEING AMONGST REFUGEE COMMUNITIES

*Rachelle Gould<sup>1,2</sup>, Tatiana Gladkikh,<sup>1,2</sup> Kimberly Coleman<sup>1</sup>*

<sup>1</sup>Rubenstein School of Environment and Natural resources, University of Vermont, Burlington, VT, USA

<sup>2</sup>Gund Institute for Environment, University of Vermont, Burlington, VT, USA

Cultural Ecosystem Services (CES) are strongly linked with human well-being, and scholarly understanding of the nuanced ways that CES affect human well-being can help support more comprehensive assessment and management of natural resources. This study contributes to this understanding by providing a review of existing literature on the effects of nature on the well-being of refugee communities, a group that is often under-represented in ecosystem services planning and research. We systematically identified peer-reviewed journal articles that address the experience of refugees with the natural environments in their new home countries. We characterize this work in multiple ways, with particular attention to the non-material benefits resulting from interaction with an ecosystem. We explore how those reported non-material benefits contribute to the most commonly identified components of well-being, such as mental health, physical health, connectedness, certainty and sense of control, inspiration, spirituality, learning, identity, and subjective, overall well-being. We also consider whether the studies introduce novel CES and benefits that may be uniquely relevant to refugee populations.

Our analysis revealed that nature positively affected refugees' well-being across all constituents; mental health, connectedness, and cultural heritage were the most commonly cited contributions. Some of the novel benefits included sense of agency, hope, and facilitation of resettlement. The studies reviewed offered limited insight on how refugees co-produced CES with the natural world in new geographical contexts and how their diverse backgrounds influence this co-production. Further, the studies almost exclusively examined urban farms and gardens; the review thus reveals a knowledge gap in how these communities experience non-agricultural green areas, including parks and forests. The review points to a limited representation of refugees and their relationships with nature in ES assessments and environmental planning. Further research on how ethnically diverse and mobile communities construct relationships with the natural world is needed in order to ensure a comprehensive and representative inclusion of CES into the decision-making process.

## INTEGRATING “RECORDS OF ENGAGEMENT” WITH ECOSYSTEM SERVICES

*Pierre D. Glynn<sup>1</sup>, Fabiano Franco<sup>1</sup>, Alice H. Aubert<sup>2</sup>, Joseph Guillaume<sup>3</sup>, Bethany Laursen<sup>4</sup>, Nicole Herman-Mercer<sup>5</sup>, and Carl Shapiro<sup>1</sup>*

<sup>1</sup>U.S. Geological Survey, Reston, VA, USA

<sup>2</sup>Eawag, Switzerland

<sup>3</sup>Aalto University, Finland

<sup>4</sup>Michigan State University, MI, USA

<sup>5</sup>U.S. Geological Survey, Lakewood, CO, USA

Stakeholder engagements, such as those that may occur in application of the Ecosystem Services (ES) framework, would benefit from the facilitated creation of a Record of Engagement (RoE). A RoE would document the facilitated engagement(s), the knowledge lines brought in, the tools and approaches used, and the broad characteristics of the engagement. This includes: (a) the constituencies present and their types and levels of power, (b) the emotions, beliefs, and innate reactions expressed, (c) the facts, evidence and lines of argumentation provided or developed, and (d) the resulting decisions and actions.

We see four potential benefits from integrating ES and RoEs. **(1)** The RoE would complement the ES framework for advancing transparency, examining both monetary and non-monetary ecosystem benefits, and considering diverse knowledge lines (e.g. indigenous knowledge). An RoE would (a) create a reward system to spur engagement, (b) modulate behavior to encourage results and group decisions, and (c) benefit transferability and future use of the RoE. **(2)** The RoE and its facilitation could help document the role of human Biases, Beliefs, Heuristics, and Values (BBHV), and assess the appropriateness of the BBHV. BBHV affect all human thinking and reactions: especially the fast, innate, responses that psychologists call “system I thinking” (in contrast to slower, more energy-intensive, analytical, “system II thinking”.) BBHV and innate emotional responses are adaptations to past human evolution and learning. They are not necessarily always appropriate to present system conditions and issues, but do affect ES valuations and applications. **(3)** Facilitation, creation, and future use of the RoE will be dependent on in-depth understanding and application of the role of memes -- which predominantly solicit and use system I thinking -- balanced with with the enablement of deliberate critical thinking (i.e. system II) through different methodologies (e.g. BBHV elicitation, Value-Focused Thinking, Critical Systems Heuristics, philosophical dialogue in collaborative science) and associated tools. **(4)** The RoE would enhance the forward planning and follow-through needed for ES applications (and their uncertainties) by engaging communities in adaptive management for the long-term, and by helping bring in a diversity of stakeholders, knowledge lines, cultures, and perspectives.

Four key RoE features correspond to four potential benefits for ES: **(1)** *facilitated documentation for stakeholders and posterity*, **(2)** *BBHV recognition and suitability assessment*, **(3)** *balanced use of memes and critical thinking*, and **(4)** *adaptive management for uncertainties*. The importance of these features is supported by an increasing literature, and also by our experiences with stakeholder engagements, elicitation techniques, and the science and policy trade-offs commonly applied to the management of natural resources, hazards, and environments.

Are such RoEs feasible -- given the resources and engagement needed -- and the difficulties of eliciting and sharing emotions, beliefs, and perspectives, along with scientific information and deliberate critical thinking? We believe the potential payoffs are worth the efforts. At a minimum, knowledge advancement and practical improvements may result that advance the ES and RoE concepts. The efforts can also benefit from an expanding diversity of technology tools (e.g. artificial intelligence, natural language processing, machine vision, behavioural analysis, expert system design, gamification) and approaches (e.g. soft systems methodology, behavioural operations research, companion modelling).

## **PARTNERSHIPS TO DEMONSTRATE SUCCESS IN SOIL HEALTH**

### ***Nick Goeser***

The National Corn Growers Association, Chesterfield, MO, USA

The Soil Health Partnership, an initiative of the National Corn Growers Association, is identifying, testing and measuring management practices to improve soil health and benefit farmers' operations. Many farmers across the country are implementing innovative management practices that result in economic and environmental benefits. The Soil Health Partnership is building upon the work of these farmers to provide connections between on-farm practices and improving soil health.

We believe the results of this farmer-led project will provide a platform for sharing information from farmers to farmers, with the support and resources to benefit farmers' bottom lines and agricultural sustainability. We are helping provide the spark for greater understanding and more broadly implementing agricultural practices that work best.

## **NOBLE LAND STEWARDSHIP: SCIENCE BASED SOLUTIONS FOR ECOSYSTEM CHALLENGES**

***Jeff Goodwin***

Noble Research Institute, Ardmore, Oklahoma, USA

The Noble Land Stewardship Program is designed to quantify the ecologic and economic benefits of managing land with a stewardship ethic as a focus. Noble Research Institute has been working with Southern Great Plains working land producers for over 73 years. The foundation of these operations is the health and proper function of their soil resource. Healthy soils are paramount to the future of the agriculture industry, maintaining ecosystem function, and sustaining plant communities. The program provides producers with critical information to help them make timely decisions within their current enterprises as well as a mechanism to help them fully understand the value of their ecological contributions to society (ecosystem services). This presentation will outline how Noble Research Institute is collaborating with cooperating producers to analyze the ecologic and economic return on investment of Soil Health focused ranching.

## **RANCHING WITH A FOCUS ON SOIL**

***Jeff Goodwin***

CPRM and Noble Research Institute, LLC, Ardmore, OK, USA

The Noble Research Institute has been working with Southern Great Plains working land producers since its inception in 1945. The foundation of these operations is the health and proper function of their soil resource. Healthy soils are paramount to the future of the agriculture industry, maintaining ecosystem function, and sustaining plant communities.

Foundational to this effort is the establishment of the Noble Land Stewardship Program. The Noble Land Stewardship Program is designed to quantify the ecologic and economic benefits of managing land with a stewardship ethic as a focus. The program provides producers with critical information to help them make timely decisions within their current enterprises as well as a mechanism to help them fully understand the value of their ecological contributions to society (ecosystem services).

This presentation will outline how Noble Research Institute is collaborating with cooperating producers to analyze the benefits of Soil Health focused ranching.

## CULTURAL ECOSYSTEM SERVICES AND DECISION-MAKING: A REVIEW

*Rachelle K. Gould<sup>1,2</sup>, Joshua Morse<sup>1</sup>, and Alison Adams<sup>1</sup>*

<sup>1</sup>Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA

<sup>2</sup>Environmental Program, University of Vermont, Burlington, VT, USA

As the field of ecosystem services grows, its subfield of Cultural Ecosystem Services – services related to, for example, spirituality, heritage, identity, or aesthetics – has grown as well. During the past few years, research on Cultural Ecosystem Services, or the non-material benefits that people receive from nature, has expanded substantially. Yet this research does not always meet one of the core goals of the ES framework: to be policy-relevant. Though the field of ES overall showcases many examples of the use of Ecosystem Services science in decisions, the vast majority of those instances use biophysical science to describe tangible ES (that is, provisioning, regulating, and to a lesser extent, supporting services). There are few examples of deep inclusion of research on Cultural Ecosystem Services in decision-making.

We analyzed whether and how peer-reviewed research on Cultural Ecosystem Services discusses connections to decisionmaking. We conducted a comprehensive review of peer-reviewed research on Cultural Ecosystem Services. We reviewed over 230 articles that address Cultural Ecosystem Services—every article published through mid-2017. We recorded a uniform set of information about each study (e.g., location, methods, CES addressed) and characterized how each study addressed decision-making.

We found that papers addressed decision-making in one of four ways: they addressed a *specific* decision-making context; they made *general points* about decision-making; they made *briefly mention* of the study’s relevance to decision-making; or they *did not address* decision-making. We provide detailed descriptions of the papers in each category. We then analyze the few (~10) papers that actively engaged with decision-makers in the design or dissemination of their research, and describe both methods and outcomes of this engagement. In a final section, the paper offers reflections and suggestions related to how Cultural ES work might more deeply or effectively engage with decision-making.

The paper concludes that research on Cultural Ecosystem Services, at least as described in the peer reviewed literature, has remained largely separate from decision-making processes. Especially given the relative success of efforts to incorporate “material ES” into decision-making processes, the disconnect between Cultural Ecosystem Services and decision-making may have important implications for issues of equity and representation. Specifically, when issues related to Cultural ES are not explicitly and rigorously included in decision-making processes, they tend to seep into those processes in implicit ways. When this happens, those with political, economic, or other forms of power see their values implicitly included in decision-making, while the values of those with less power may be un- or under-represented. Our finding that few papers report active uptake of Cultural Ecosystem Services research into policy processes suggests that this potential chain of events may be occurring more than the ecosystem services community would like to admit and thus may warrant more attention. Cultural ES can help address some of the important critiques of ES related to ethics and equity, and this paper offers suggestions for how Cultural ES might be more widely represented in ES processes and land-use decision-making more generally.

## ASSESSING THE VALUE OF SOIL INORGANIC CARBON FOR ECOSYSTEM SERVICES IN THE CONTIGUOUS UNITED STATES BASED ON LIMING REPLACEMENT COSTS

**G.R. Groshans<sup>1</sup>, E.A. Mikhailova<sup>1</sup>, C.J. Post<sup>1</sup>, M.A. Schlautman<sup>2</sup>, H.A. Zurqani<sup>1</sup>, and L. Zhang<sup>3</sup>**

<sup>1</sup>Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC, USA

<sup>2</sup>Department of Environmental Engineering and Earth Sciences, Clemson University, Anderson, SC, USA

<sup>3</sup>Agricultural Sciences Department, Clemson University, Clemson, SC, USA

Soil databases are of great importance in assessing ecosystem services at different administrative levels (e.g., state, region etc.). Soil databases provide information about numerous soil properties, including soil inorganic carbon (SIC) which is a naturally occurring liming material that regulates soil pH and performs other key functions related to all four recognized ecosystem services (e.g., provisioning, regulating, cultural and supporting services). However, the ecosystem services value, or “true value,” of SIC is not recognized in the current land market. In this case, a negative externality arises because SIC with a positive value has zero market price, resulting in the market failure and the inefficient use of land. One potential method to assess the value of SIC is by determining its replacement cost based on the price of commercial limestone that would be required to amend soil. The objective of this study is to assess SIC replacement cost value in the contiguous United States (U.S.) by depth, state, region, and land resource region (LRR) using data from the STATSGO (State Soil Geographic) database. A replacement cost value of SIC was determined based on an average 2014 price of \$10.42 per U.S. ton of limestone. Within the contiguous U.S., the total replacement cost value of SIC in the upper two meters of soil is between \$2.16T and \$8.97 T (i.e., 8.97 trillion U.S. dollars). States with the highest midpoint total value of SIC were: 1) Texas (\$1.84T), 2) New Mexico (\$355B, i.e., 355 billion U.S. dollars), and 3) Montana (\$325B). When normalized by area, the states with the highest midpoint SIC values were: 1) Texas (\$2.78 m<sup>-2</sup>), 2) Utah (\$1.72 m<sup>-2</sup>), and 3) Minnesota (\$1.35 m<sup>-2</sup>). The highest ranked regions for total SIC value were: 1) South Central (\$1.95T), 2) West (\$1.23T), and 3) Northern Plains (\$1.01T), while the highest ranked regions based on area-normalized SIC value were: 1) South Central (\$1.80 m<sup>-2</sup>), 2) Midwest (\$0.82 m<sup>-2</sup>), and 3) West (\$0.63 m<sup>-2</sup>). For land resource regions (LRR), the rankings were : 1) D – Western Range and Irrigated Region (\$1.10T), 2) H – Central Great Plains Winter Wheat and Range Region (\$926B), and 3) M – Central Feed Grains and Livestock Region (\$635B) based on total SIC value, while the LRR rankings based on area-normalized SIC value were: 1) I – Southwest Plateaus and Plains Range and Cotton Region (\$3.33 m<sup>-2</sup>), 2) J – Southwestern Prairies Cotton and Forage Region (\$2.83 m<sup>-2</sup>), and 3) H – Central Great Plains Winter Wheat and Range Region (\$1.59 m<sup>-2</sup>). Most of the SIC is located within the 100-200 cm depth interval with a midpoint replacement cost value of \$2.49T and an area-normalized value of \$0.34 m<sup>-2</sup>. Results from this study provide a link between science-based estimates (e.g., soil order) of SIC replacement costs within the administrative boundaries (e.g., state, region etc.).

## **CULTURAL ECOSYSTEM SERVICES, CHANGING ENVIRONMENTS, AND THE COMMUNICATION OF SCIENCE**

*Diana Hackenburg and Rachelle Gould*

Rubenstein School of the Environment and Natural Resources, University of Vermont, Burlington, VT USA

Cyanobacteria blooms pose a threat to public health and well-being, the environment, and economic prosperity by degrading aquatic ecosystem services. Despite decades of research, concern, and action related to the blooms, they are still common in many places, and may worsen in the future due to climate change. Ongoing disagreements about the sources of the blooms, potential impacts, and possible solutions suggest differences in how stakeholders understand and respond to information about this issue. This research looks at how stakeholders in communities near a waterbody with persistent blooms in Vermont, USA perceive the issue of cyanobacteria blooms. The study focuses on impacts to cultural ecosystem services (CES) and examines factors that may contribute to the public's knowledge, including information sources, environmental attitudes, and social identities.

This study uses a mental models approach to identify how individuals perceive the causes and impacts of the cyanobacteria blooms in their local bay. We are conducting semi-structured interviews in summer 2018 with 36 community members chosen based on different relationships to the lake (recreation, fishing, etc.). Questions are designed to exhaust participants' knowledge of the causes and impacts of the blooms. We will use explicit prompts and a photo sorting exercise to understand CES provided by the bay and how blooms may impact those CES. Participants also will complete a short questionnaire about their perceived level of knowledge, sense of efficacy, environmental concern, behavioral intentions, and sociodemographics. Using Mental Modeler software, mental models created from each interview will be qualitatively and quantitatively analyzed for content, frequency, and patterns. One analysis, for example, will involve pair-wise comparisons of individual maps using similarity coefficients, to determine similarities and differences between mental model maps from certain individuals or groups. In order to identify misconceptions, beliefs, and knowledge gaps, the models also will be compared to a professionals' model (based on scientific literature and conversations with researchers and water quality experts).

Understanding how individuals perceive the causes and impacts of cyanobacteria blooms will hopefully offer insights on how the public might respond to and act upon new information about ecosystem services. Ultimately, this may prove helpful in designing multi-faceted education and communication initiatives and in building collaboration across stakeholders. It also will further the conversation about understanding and incorporating cultural ecosystem services into research, outreach, and communications.

## **RESTORATION SCALING OF CULTURAL SERVICE INJURIES USING STRUCTURED DECISION SUPPORT**

**David A. Hanson<sup>1</sup> and William Trousdale<sup>2</sup>**

<sup>1</sup>HansonRM, Blaine, WA, USA

<sup>2</sup>EcoPlan International, Vancouver, BC, Canada

Various environmental regulations require the protection from, mitigation of, and/or restoration of cultural services impacted by proposed development projects and releases of environmental contaminants. NRDA regulations require restoration and compensation of lost use of ecosystem services, including both direct-use and non-use of cultural services. Direct-use cultural service values are considered those that can be measured using traditional economic methods (e.g., tourism and recreation) and are often included in NRDA claims. Non-use values (sometimes referred to as non-market or passive values) include existence and bequest cultural values and can be described as cultural services associated with natural resources from which the public derives value independent of direct use (e.g., existence, spiritual, sense of place, educational, and other values). Non-market cultural services are especially important to Native American peoples and are generally considered nonmaterial, non-consumptive, and non-measurable using traditional economic methods. The inclusion of requirements to restore injured cultural services and compensate for their lost use associated with natural resource injuries under NRDA regulations for CERCLA, OPA, and CWA presents a dilemma for non-market services if we don't know how to measure them in an objective, acceptable manner. Based on methods developed assisting First Nations and Aboriginal peoples in Canada, this presentation presents a method for scaling threatened or lost passive cultural services associated with natural resource injuries from environmental contaminants, including a discussion of how the method aligns with NRDA regulatory requirements, using multi-criteria attribute, structured decision support, and negotiation theory.

## **GETTING TO WHY ECOSYSTEM SERVICES MATTER BEFORE YOUR AUDIENCE GETS TO ZZZ**

***Christopher Hartley***

Office of Environmental Markets, United States Department of Agriculture, Washington D.C., USA

For over a decade, ACES participants have struggled to explain what ecosystem services are, and why they are important to everyone in terms that their audiences can understand. In 2016, the ACES community identified the need to increase stakeholder engagement and improve communication and education about ecosystem services. This panel session will highlight some of the recent efforts to do so and to share some of the lessons learned. Panelists will discuss incorporating ecosystem services into early childhood education and at the university level; training professionals to communicate about ecosystem services; and, communicating ecosystem services to policy makers.

## **MITIGATION CREDITS AS A TOOL TO MONETIZE SPECIES VALUES ON PRIVATE LANDS; PAY-FOR-PERFORMANCE TOOLS IN THE SACRAMENTO RIVER REGION**

***Ann Hayden***

Senior Director (California Habitat Exchange & Western Water), Environmental Defense Fund

Environmental metrics provide science-based, objective, and transparent assessments of ecological function. Environmental metrics allow for regulators, water managers, and landowners to understand a problem in the same way, communicate with a shared language, and work towards a common goal, all of which are critical for effective landscape scale restoration. By quantifying the impact of management actions, restoration outcomes can be achieved with greater efficiency.

For this purpose, and to meet California's ambitious species conservation goals, EDF and partners of the Central Valley Habitat Exchange developed a multi-species Habitat Quantification Tool (**HQT**). The HQT evaluates quantity and quality of species habitat to inform management actions and sets a baseline for the development of monetizable habitat mitigation credits. Specifically, the HQT:

1. Applies a robust methodology for understanding the benefit of habitat on working lands for a suite of species;
2. Creates a means of consistently assessing habitat conditions so that high quality habitat can be managed to benefit multiple species;
3. Helps guide investment in restoration projects; and
4. Informs regional conservation planning across agencies and project implementers.

EDF is currently applying the HQT in the Sacramento River Region (in conjunction with a Regional Conservation Investment Strategy) to advance conservation actions that support regional objectives and to provide a new mechanism for infrastructure development that efficiently mitigates impacts to habitat. Based on this HQT application, EDF and partners are developing approaches to register and approve monetizable habitat credits as a means to incentivize landowners to adopt science-based conservation alternatives, and also to create a self-supporting funding stream (i.e. a 'pay-for-performance' tool).

## THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT'S FIRST GROUNDWATER MARKET

*Sarah Heard<sup>1</sup>, Siobhan King<sup>1</sup>, E.J. Remson<sup>2</sup>, Sandi Matsumoto<sup>3</sup>*

<sup>1</sup>The Nature Conservancy, San Francisco, CA, USA

<sup>2</sup>The Nature Conservancy, Ventura, CA, USA

<sup>3</sup>The Nature Conservancy, Sacramento, CA, USA

California's landmark groundwater law, the Sustainable Groundwater Management Act (SGMA), requires that 127 groundwater basins develop Groundwater Sustainability Plans to achieve aquifer balance. Groundwater markets represent a flexible tool for achieving sustainability while benefiting groundwater users. The Fox Canyon Groundwater Management Agency (FCGMA) in Ventura County, California is developing the first groundwater market under SGMA. This market may serve as a model for other groundwater management agencies seeking flexible tools for achieving sustainability goals.

Ventura County is one of United States' most productive agricultural counties (ranked 8th in California and 11th in the US), agricultural production valued at \$2.1B in 2016. In western Ventura County, where over 70 percent of groundwater use is agricultural, the California Department of Water Resources has designated two groundwater basins as being in critical overdraft under SGMA. The FCGMA must reduce groundwater use in these basins by as much as 40 percent to achieve basin sustainability. Such large reductions in pumping pose significant challenges to wisely managing reduced water allocations to keep irrigated agricultural land in production.

Growers in the region have identified water markets as an important tool for managing limited groundwater resources. Water markets are recognized as an effective strategy to provide market signals to manage limited water resources more efficiently and economically. A stakeholder group of groundwater users designed the market rules, and the FCGMA subsequently implemented two pilot water markets, the second of which recently launched, to install advanced metering infrastructure (AMI) on wells, create the necessary data management system and test the effectiveness and efficiency of the market by allowing trading within a sub-geography. FCGMA may expand the water market to its entire jurisdiction, incorporating lessons learned from the two pilots.

The Nature Conservancy (TNC) has played a key role in the design and implementation of the groundwater market in Ventura County, ensuring that it benefits groundwater users as well as the environment. In June 2017, TNC won a Conservation Innovation Grant of over \$1.8M from the Natural Resource Conservation Service, the majority of which supports the design and implementation of the groundwater market. As an agricultural landowner in the basin, TNC is participating in the current pilot, with the objective of testing the market, stimulating trading and securing water for nature beyond what FCGMA's Groundwater Sustainability Plan provides.

The first of its kind under SGMA, the Fox Canyon groundwater market will demonstrate the role of groundwater markets in achieving environmental benefits while preserving agriculture in one of the most productive regions in the country.

## **HERITAGE AS AN ECOSYSTEM SERVICE: IDENTIFYING METHODS, BENEFITS, AND CHALLENGES OF INTEGRATING CULTURAL RESOURCE MANAGEMENT INTO ECOSYSTEM SERVICES**

*Matthew Helmer<sup>1</sup> and Jennifer Lipton<sup>2</sup>*

<sup>1</sup>US Forest Service Pacific Northwest Research Station, Seattle, Washington, USA

<sup>2</sup>Central Washington University, Ellensburg, Washington, USA

Of all the recognized cultural ecosystem services, heritage is one of the most clearly defined from a resource management perspective. Cultural resource management in the United States is primarily guided by laws and criteria which prioritize historical importance of site specific features. However, conceptualizing cultural heritage as an ecosystem benefit at a landscape scale alongside multiple complementary or competing biophysical benefits is a novel way for approaching cultural resource management which has not been adequately explored. This paper provides a critical analysis of cultural heritage as an ecosystem service and how the concept can expand the effectiveness of cultural resource laws, focusing on national forests in the Pacific Northwest region of the United States. The paper identifies the human-ecosystem benefits that heritage provides, how those benefits connect to or compete with biophysical services, and presents a framework through which heritage can contribute to the ongoing development of cultural ecosystem services.

## **PAY FOR SUCCESS FOR WORKING FOREST AND AGRICULTURAL LANDS: KEY ROLES IN TRANSACTIONS AND MARKET DEVELOPMENT**

***Tommie Herbert***

USDA Forest Service, National Partnership Office, Washington, DC, USA

Pay for Success (PFS) is an innovative approach to contracting that links a meaningful portion of payment for services to measurable outcomes. It is a tool to align incentives to service providers, shift performance risk to the private sector, and integrate multiple stakeholders.<sup>1</sup> PFS approaches: 1) identify a critical issue and the interventions that can address the issue, 2) identify service providers capable of implementing interventions, 3) obtain investors to fund the up-front costs of the interventions, and 4) set a pre-determined rate of return to the investor if the intervention performs as expected or exceeds expectations.

The use of PFS approaches to solve natural resource challenges has been limited to date but has the potential to uncover innovative solutions to intractable environmental issues in working forest and agricultural landscapes. Two USDA agencies, the Forest Service and Natural Resources Conservation Service are exploring the use of PFS approaches to build ecosystem services quantification capacity, leverage public funding, shorten timelines for priority activities, and consolidate multiple stakeholders/ producers into single projects. USDA is working with partners to pilot PFS to support: sustainable recreation infrastructure, habitat credit exchanges, source water protection, nutrient reduction, urban wood markets, and storm water management.

Public, non-profit, and private sector partners must collaborate to make PFS a viable mechanism for addressing natural resource management challenges. Collaboration is most effective when engaged entities have a clear understanding of the roles they play. Beyond key roles in individual transactions (such as investor, payor, service provider, and evaluator), there are also critical roles in promoting the enabling conditions for PFS to flourish (such as clear policy frameworks, scientific research on ecological benefits, mapping to prioritize investment areas, etc.).

In this panel session, PFS experts and practitioners will explore and discuss these roles and how each is needed for PFS transactions to work. The goals of this panel are to:

Describe the current state of play for PFS in a natural resource context;

Discuss roles needed to support individual transactions and broader market development; and,

Explore how public, private, non-profit, and academic stakeholders can provide targeted capacity to help leverage the potential of PFS to address natural resource management needs on forests and agricultural lands.

ORAL SESSION PANEL

*Panelist, Kari Cohen or Lindsay White, Natural Resource Conservation Service*

*Panelist, Eric Letsinger or Carolyn Dupont, Quantified Ventures*

*Panelist, Jemery Sokulusky, Environmental Incentives*

*Panelist, Todd Gartner, World Resources Institute*

*Panelist, George Kelly, Resource Environmental Solutions*

## THE RELATIVE ROLES OF ECOSYSTEM SERVICES AND DISSERVICES IN RURAL LIVELIHOODS ALONG A BIODIVERSITY GRADIENT, SOUTH AFRICA

*Shannon Herd-Hoare and Charlie Shackleton*

Department of Environmental Science, Rhodes University, Grahamstown, South Africa

Since the publication of the Millennium Ecosystem Assessment report there has been a marked increase in research into various aspects of ecosystem services (ES). While ES are essential to human wellbeing, the literature has overlooked that some ecosystem goods and services also undermine human wellbeing. These are known as Ecosystem Disservices (EDS). This study aims to counter this imbalance in research, specifically in the context of rural livelihoods which are frequently dependent on local ES but often ill-equipped to manage EDS. The objectives of this study, conducted in three rural villages along a gradient of habitat diversity, were to identify a range of ES and EDS, determine their perceived contributions to or effects on the wellbeing of respondents, and identify modifications in livelihood strategies in response to EDS. The research made use of household surveys in conjunction with participatory learning and action techniques, such as focus group discussions in which ranking and trendline exercises, timelines, and participatory mapping were conducted.

Findings indicated that although numerous participants were involved in the harvest of multiple ES, such as Non-Timber Forest Products (NTFPs), livestock outputs, crops and marine wildlife, they simultaneously experienced losses from EDS, such as ticks, unpalatable grass species, monkeys, and *Lantana camara* invasion which undermined livelihoods to varying degrees. The role of ES and EDS in livelihoods was expressed in economic terms, representing a common framework with which to illustrate the magnitude of their contribution or loss. For example, the average value of livestock goods and services, amongst those who owned and used outputs, was highest in the least biodiverse village at R9 753 per annum, while the corresponding value of potential livestock goods and services lost due to EDS, despite active implementation of prevention measures, totalled R22 426. Further, the average value of cultivated plots in the most biodiverse village could have totalled approximately R20 958, but because of EDS, represented less than 20% of this value. Further, the findings highlighted that the most biodiverse village also had the highest number of EDS, supporting Dunn (2010) who hypothesised that the number of EDS increases with the number of ES. Based on these findings, we propose that a comprehensive framework which systematically contextualises both the positive and negative contributions of ES is needed to grasp the full picture of how local people conceive and engage with nature to facilitate an understanding of the resulting practices and processes.

## NEXT STEPS AND SCALING UP ECOSYSTEM ACCOUNTS TO THE NATION

*Mehdi Heris<sup>1</sup>, Ken Bagstad<sup>2</sup>, and Austin Troy<sup>1</sup>*

<sup>1</sup>College of Architecture and Planning, University of Colorado Denver, CO, USA

<sup>2</sup>Geosciences and Environmental Change Science Center, US Geological Survey (USGS), Denver, CO, USA

In this presentation, we report initial results and strategies for scaling up ecosystem accounts from the subnational to the national scale in the US. Our project aims to serve the US Natural Capital Accounting working group's efforts to integrate past scholarly work on ecosystem services modeling with the methodological needs of national-scale ecosystem accounting. Our objectives include identifying multiple ecosystem services and processes suitable for including in an initial national-scale ecosystem account, and developing models for measuring national-scale benefits from nature.

In our first sub-project, we extended a model developed for pollination services by collaborators in the U.S. Southeast, first applied to ten southern states, to the national scale. We modified the model for a nation-wide analysis, automating mapping and tabulation of changes in land cover and pollination-dependent crops with customized parameters. We provide initial results for the years 2001, 2006, and 2011, but intend to provide a higher temporal resolution upon release of NLCD's new land cover products, which will add the years 2004, 2008, 2013, and 2016, once these data are available in late December 2018.

In a second sub-project, we have started to develop conceptual frameworks for including other ecosystem services in ecosystem accounts. Urban trees are a critical provider of urban ecosystem services such as heat mitigation, air quality improvement, storm water mitigation, and habitat. Using our team's expertise in urban ecosystem modeling, we developed and validated heat and rainfall interception models using high-resolution tree canopy datasets. To scale up these services for national coverage, we use NLCD's tree cover dataset (available for 2001, 2011 and forthcoming for 2016). The spatial accuracy assessment of this layer shows higher errors (underestimation) in high-density urban areas and a relatively accurate assessment in low-density urban areas and open spaces. Our assessment will ultimately incorporate more than 50 cities in different climatic regions across the continental US. This provides a reliable platform for calibrating the NLCD tree coverage data. To generalize our models, we use local meteorological, built environment density, and socio-economic variables.

In a final sub-project, we developed a conceptual framework and acquired data to assess the role of healthy forest stands in providing wildfire mitigation ecosystem services within the context of ecosystem accounts. The impact of wildfire on ecosystems is complex, depending upon the intensity and frequency of fire. High-intensity wildfires can destroy properties and degrade the ability of nature to provide services related to water quality, air quality, carbon stocks and biodiversity. By contrast, low-intensity fires can lower the risk of high-intensity fires and may improve biodiversity. We aim to develop a model that allows us to account for ecosystems that mitigate high intensity, destructive fire, while allowing for low intensity fire.

These sub-projects provide test cases for integrating methods and data to develop iterable and scalable models based on for ecosystem accounting using open-source platforms. This will enable faster and more accurate updates in future iterations of ecosystem accounts for the US.

## **INCORPORATING NON-USE VALUES IN REGULATORY DECISION MAKING**

***Julie A. Hewitt***

US EPA, Office of Water, Washington, DC, USA

At the end of the line of inquiry into metrics, indicators, ecosystem commodities and valuation is their practical application in the public policy arena: if decision-makers are to take non-use benefits into account in their decisions, how do they and should they go about incorporating this information in benefit-cost analyses?

Though regulations often take many years to develop, the time frame and resources available for analysis to support regulatory decisions is often not fully known at the outset. Benefits transfer is a coping mechanism commonly employed in the face of this uncertainty. Benefits transfer is the practice of using benefit valuation results from the published literature in one or more contexts and adapting for application in another context. The reliance on secondary data is likely to save time and resources over primary data collection, though there may be a tradeoff between resources and how applicable are the study cases to the transfer case.

Even if the contexts in the study case(s) and transfer case are sufficiently similar to allow the use of the benefit transfer approach, other challenges may arise. The greater demand for valuation studies containing theoretical or methodological innovations by journal editors means that there is not an overabundance of purely applied studies, such that a recent meta-analysis of valuation studies in the United States includes studies representing fewer than half of the states, for example. Most stated preference studies value relatively large changes in water quality over a relatively confined area or watershed, while most benefit transfer applications involve relatively small water quality improvements over very large areas (with a few large changes in small areas). Additional research in the field can be expected to address some of these challenges (geographic coverage), but others are likely to remain (transfer to smaller water quality improvements over larger areas), owing to the limitations of the stated preference method.

This talk will also include perspectives associated with benefit transfer of nonuse values in countries other than the United States.

Decision makers have been expressing an increasing desire for benefit-cost information to help inform decision-making for a number of decades. Though social welfare is only one of many factors for consideration (equity, legal authority, practicality in implementation, etc.), without improved information on non-use values, decisions are likely to be biased to protecting aspects of the environment with direct human uses.

## **BUILDING A SCIENCE-GOVERNANCE PARTNERSHIP AROUND ECOSYSTEM SERVICES TO CATALYZE REVITALIZATION IN GREAT LAKES AREA OF CONCERN COMMUNITIES**

*Joel C. Hoffman<sup>1</sup>, T. Angradi<sup>1</sup>, K. Williams<sup>1</sup>, L. Burkhard<sup>1</sup>, D. Bolgrien<sup>1</sup>, M. Tuchman<sup>2</sup>, M. Mills<sup>3</sup>, A. Pelka<sup>2</sup>, and S. Cieniawski<sup>2</sup>*

<sup>1</sup>United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Duluth, Minnesota

<sup>2</sup>United States Environmental Protection Agency, Great Lakes National Program Office, Chicago, Illinois, USA

<sup>3</sup>United States Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, Ohio

Over the past four years, we have been developing a science-governance partnership among US EPA Great Lakes National Program Office, US EPA Office of Research and Development, and states to foster the concept of Remediation to Restoration to Revitalization (R2R2R) – a decision-support framework to help optimize ecological and social benefits from sediment remediation and aquatic habitat restoration efforts in Great Lakes Areas of Concern (AOCs). Great Lakes AOCs are coastal communities with aquatic resources that are highly contaminated or degraded, and whose clean-up is a priority under the US-Canada Great Lakes Water Quality Agreement. For AOCs, remediation and restoration goals are defined by the status of Beneficial Use Impairments (BUI), which conceptually are analogous to ecosystem services (e.g., loss of swimmable water). As such, the concept of ecosystem services can potentially serve to help AOC communities better realize the benefits of sediment remediation and habitat restoration. To do so, however, we need to determine which ecosystem services are affected and characterize the relationships between improving environmental quality, changing ecosystem services and benefits (e.g., increasing recreational or cultural value), and revitalizing urban waterfront neighborhoods. Through this partnership, we have worked closely with local and state agencies and stakeholders to identify ecosystem services, benefits, and associated revitalization indicators; develop trade-off analyses tools; and examine trade-offs from proposed projects in terms of both ecosystem services and human health and wellbeing (using a Health Impact Assessment). In this framework, translating ecological consequences from remediation and restoration projects to ecosystem services (e.g., swimmable water, potential for urban greenspace) and programmatic assessment needs into useful ecological and social metrics is critical to support decision-making. As such, we are designing the R2R2R framework to provide scientific information for decision-making, and do so by uniting environmental sciences, social sciences, and ecosystem management. The presentation will illustrate how R2R2R exemplifies overcoming practical challenges to incorporating ecosystem services in large, complex sediment remediation and aquatic habitat restoration projects.

## **“YOU’VE GOT KALE!” FARMING SIMULATION GAME**

**Taylor Hollady<sup>1</sup>, Lisa Wainger<sup>1</sup>, Hemalatha Bhaskaran<sup>2</sup>, and Judy O’Neil<sup>3</sup>**

<sup>1</sup>Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD, USA

<sup>2</sup>James M Bennett High School, Wicomico County Board of Education, Salisbury, MD, USA

<sup>3</sup>Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, MD, USA

**Purpose & Scope:** In an effort to integrate recent climate change research into high school student education, a farming simulation game was developed that explores how farm management decisions affect on-farm revenues and environmental outcomes. This game explores the tradeoffs between environmental stewardship and farm economics, along with the ability of best management practices (BMPs) to mitigate risks associated with climate change. This game also includes choices to voluntarily accept government cost-sharing for implementing BMPs. Players are given tools to weigh profitability and to contribute to a community goal of reducing nutrient runoff, in order to make the local stream fishable and swimmable. Our research team includes a high school teacher, who plans to use the simulation in her environmental sciences classes as a tool to address the environmental outcomes associated with climate change, in addition to meeting science educational standards. This simulation will be available to other institutions for educational use as a module on [www.teachococeanscience.net](http://www.teachococeanscience.net).

**Methods Used & Game Mechanics:** The game was built with data chosen to represent a kale farm in Maryland’s Eastern Shore of the Chesapeake Bay, US. This simulation game was programmed in Visual Basic for Excel, and used cost, BMP, and nutrient data from a model developed for Chesapeake Bay water quality decision support (Chesapeake Assessment Scenario Tool Phase 5 & 6). By choosing to implement certain BMPs, the player will earn “Soil Health Points” (based on soil condition) and “Environmental Stewardship Points” (based on reduction of nutrient runoff). By earning a certain threshold of “Environmental Stewardship Points,” the player will be labeled as an “Environmental Steward,” and will be able to sell their crops at a higher rate per bushel, as an incentive for reducing nutrient runoff. In order to add an aspect of risk, a “climate wheel” that randomly imposes droughts was added to simulate the unexpected weather events that can decrease crop yield. “Soil Health Points” offset some of the yield reductions that result from droughts. Players can opt-in to receive government payments (subsidies) for adopting BMPs in which a large portion of high-cost BMPs are covered.

**Conclusions & Expected Results:** From playing this farming simulation game, students will gain a realistic understanding of the tradeoffs between being an environmental steward, managing climate change risk, and maintaining farm profitability. This simulation teaches students that environmental stewardship comes with a cost to farmers, where on-farm revenue must be balanced with the costs of implementing BMPs. Players will also learn of the impacts that a farming management change, or the implementation of a BMP has on their climate change risk, and their overall farm yield. With these changes lowering their climate change risk, and decreasing nutrient runoff on their farm, students will work towards a goal of collectively restoring the community stream to a more fishable status.

## **WILDERNESS AND AMENITY MIGRATION**

*Evan E. Hjerpe<sup>1</sup>, Anwar Hussain<sup>1</sup>, and Tom Holmes<sup>2</sup>*

<sup>1</sup>Conservation Economics Institute, Boise, ID; Anchorage, AK, USA

<sup>2</sup>USFS, Southern Research Station, Asheville, NC, USA

Previous research has illustrated that Wilderness and protected public lands generally play a positive role in overall regional economic health, including being a factor in attracting amenity migrants. But the level of association between Wilderness, amenity migration, and regional economic variables has yet to be fully investigated. In this study, we compiled a dataset that can be used to statistically test for association between county-level variables for amounts of in-migration for three decades (1980s, 1990s, and 2000s), demand for amenity migration, Wilderness, and other types of federally protected lands. Because amenity migration has been most pronounced in rural communities of the American West, we examined the role of amenity migration in non-urban counties in the West. To understand the statistical association of Wilderness and other protected lands with amenity migration we conducted econometric analyses. Formal notation and mathematical representation of the Wilderness-amenity migration model were configured. Multiple regression analysis was conducted in STATA and a best fit was estimated. Results from a literature review, construction of a comprehensive data set of West-wide county statistics, and research findings will be presented. Implications of the research will also be discussed.

## USING HEDONIC AND LIFE SATISFCTION MODELS TO ESTIMATE SHADOW COSTS OF FOREST ECOSYSTEM DEGRADATION

*Thomas P. Holmes*

Southern Research Station, USDA Forest Service, Research Triangle Park, NC

Climate change is increasing the magnitude and severity of natural disturbances throughout forests of the United States, thereby altering the flow of ecosystem services in affected regions. Novel insect outbreaks, far exceeding historical levels, have recently occurred throughout the western U.S., causing tree mortality across tens of millions of acres. Many of the ecosystem services impacted by these outbreaks are not traded in markets, necessitating the use of non-market valuation methods to assess economic impacts. In this study, we show how economic values of ecosystem services impacted by large-scale forest mortality events can be estimated using complementary non-market valuation methods. The focus of the study is on forest mortality in mountainous regions of Colorado resulting from outbreaks of a native insect, the mountain pine beetle (MPB). To begin, we use the hedonic model (HM) to estimate economic impacts on residential homeowners living in locations with susceptible forest types. A critical assumption using HM is that housing prices fully adjust to capitalize changes in ecosystem services so that individual utility is equalized across locations. If factors such as moving costs or insufficient information constrain the attainment of equilibrium conditions, then estimates based using HM may be downwardly biased. In this paper, we use life satisfaction (LS) data collected by the Center for Disease Control to test the hypothesis that housing markets in the study area attained equilibrium conditions during the MPB outbreak. Results from the LS models indicate that housing markets in the study area had not fully adjusted to forest ecosystem disturbance during the study period. Further, we show how LS methods can be used to estimate the economic value of changes in forest ecosystem health. It is argued that these LS-based non-market values are complementary to values derived using HM and therefore are necessary for a full accounting of the shadow costs of forest ecosystem degradation.

## **AN ECONOMIC PERSPECTIVE ON WILDERNESS AREAS AND WATER RESOURCES**

*James Meldrum and **Chris Huber***

U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, USA

Proponents of wilderness often cite the provision of high-quality water as a key benefit provided by designated wilderness areas to society. We examine this claim by exploring the relationship between wilderness and water resources through an economic lens. Spatial and hydrological links from wilderness areas to downstream users demonstrate that substantial portions of the United States' total water resources originate in, or flow through, designated wilderness areas. This information is used to calculate a coarse estimate of the total economic value of water flowing from wilderness. This result demonstrates the many important connections between the water resources that society depends upon and public lands protected as wilderness. Next, we focus our attention on the limitations of this estimate, and then demonstrate theoretical and practical challenges to readily-available approaches for measuring the added value to water resources from wilderness areas. We argue that a more complete estimation of the economic benefits provided by wilderness through water resources would require development of case studies using alternative and more rigorous approaches.

BIO: Chris Huber is an economist with the U.S. Geological Survey located in Fort Collins, Colorado. He performs research in the economic valuation of nonmarketed natural resource topics.

## **CALIFORNIA'S NEW EXPERIMENT WITH REGIONAL CONSERVATION INVESTMENT STRATEGIES AND HOW REGULATORY STRUCTURES CAN CREATE INCENTIVES TO IDENTIFY AND CONSERVE ECOSYSTEM SERVICES**

*Kevin Hunting*

Former Chief Deputy Director of California Department of Fish and Wildlife

*Presented by: Laura Hollender*

Regional Conservation Investment Strategies (RCIS) are voluntary, non-regulatory conservation assessments that identify conservation priorities at a sub-ecoregional level. An RCIS is neither a development permit, nor does it designate areas for conservation. Practically speaking, it is a document which summarizes the location and needs of, and threats to, important wildlife, and strategies that would best serve the conservation of said wildlife, to guide conservation planning, and to allow infrastructure agencies to implement projects whilst minimizing harm to important wildlife *ex ante*. In this way, the RCIS is a unique policy tool compared to Natural Community Conservation Plans (NCCPs) and Habitat Conservation Plans (HCPs).

The RCIS concept is enshrined in AB2087 (Levine) passed in August 2016. It is complemented by two other policy tools (also enshrined in AB2087): the Regional Conservation Assessment (RCA) and Mitigation Credit Agreements (MCAs). The RCA is a more high level version of an RCIS. The RCA identifies natural community, biodiversity and species information, as well as other environmental stressor information, but primarily deviates from the RCIS in that it does not identify potential strategies that would enable conservation outcomes. MCAs may be entered into with the California Department of Fish and Wildlife (CDFW) following an approved RCIS, and create tradable credits in a similar way to conservation banking.

As a regulatory structure (albeit voluntary), RCIS' create incentives to identify and conserve ecosystem services in three major ways:

1. Reducing developer transaction costs: The *ex ante* identification of conservation priorities in a given sub-ecoregion acts as an incentive for infrastructure agencies to approve projects in the same sub-ecoregion which will trigger compensatory mitigation requirements under the California Environmental Quality Act (CEQA);
2. Encouraging advance mitigation: Infrastructure agencies are able to streamline the CEQA process via addressing compensatory mitigation requirements prior to development; and
3. Gateway to MCAs: MCAs may be entered into with CDFW following an approved RCIS, which serve as the tool to translate conservation initiatives into salable credits, potentially able to finance ongoing conservation programs.

## **EXPLORING THE RELATIONSHIP BETWEEN FRESHWATER WETLAND RESTORATION AND FLOOD MITIGATION**

***Kristen Hychka<sup>1</sup>, Lisa Wainger<sup>1</sup>, Elizabeth Murray<sup>2</sup>, and Taylor Hollady<sup>1</sup>***

<sup>1</sup>University of Maryland Center for Environmental Science, Solomons, MD, USA

<sup>2</sup>U.S. Army Corps of Engineers, Engineer Research and Development Center, San Francisco, CA, USA

Freshwater wetlands influence flood abatement, but the effects vary based on the type of wetland, its landscape location, hydrologic conditions, and overriding watershed characteristics. Less attention has been paid to the influence of wetland restoration on flood abatement, so we seek to enhance the understanding about when and where restored freshwater wetlands reduce flood risk and attempt to provide a measure of the flood abatement benefits from wetland restoration. Specifically, we are attempting to build regional multivariate regression models, using existing data, that relate change in wetland coverage to flood risk or impact, while controlling for land cover and other variables that drive hydrologic change. The models will relate changes in wetland areal extent to downstream hydrograph characteristics that are associated with flood risk, including: the rising time (time from base flow to peak flow) and the number of times stream flow exceeds its seasonal average. The most important predictor variable will be change in freshwater wetland extent due to restoration, and we will supplement area with attribute data including wetland type and landscape position. One of our case studies will focus on the Chesapeake Bay drainage where we have high quality data on wetland mitigation and USDA CRP data for wetland restoration projects in the Chesapeake Bay from 2007-2017 at the county or HUC-8 scale. For confounding variables that will help isolate the signal of wetland restoration to noise of other changes in the gage watersheds, we will use national datasets and more accurate data (in space and time) available for the individual case studies. The talk will cover the state of the modeling, including quality of the data sources found, model structure choices given data availability, and preliminary results. We expect the results to be relevant to assessing benefits of freshwater wetland restoration.

## ESTIMATING THE ECOSYSTEM SERVICES OF OYSTER REEF RESTORATION

**Thomas F. Ihde<sup>1</sup>, S. Knoche<sup>1</sup>, G. Samonte<sup>2</sup>, S. Steinback<sup>3</sup>, H. Townsend<sup>4</sup>, and K. Lewis<sup>5</sup>**

<sup>1</sup> Patuxent Environmental & Aquatic Research Laboratory, Morgan State University, Saint Leonard, MD, USA

<sup>2</sup> NOAA/NMFS, Office of Habitat Conservation, Silver Spring, MD, USA

<sup>3</sup> NOAA/NMFS, Office of Science and Technology, Ecosystems, Cooperative Oxford Laboratory, Oxford, MD, USA

<sup>4</sup> NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA, USA

<sup>5</sup> St. Mary's College of Maryland, Saint Mary's City, MD, USA

The State of Maryland has recently shown increased interest in applying ecosystem services information into some natural resource decision-making processes. In a similar fashion, more complex ecosystem modeling approaches (e.g., Ecopath with Ecosim, Atlantis), have been applied with increasing frequency, given recent increases in computational power and affordability. The results of such modeling approaches, however, are seldom applied directly to the management process. One thing hindering application of ecosystem modeling results is that the outputs of such models (biomass, or predicted landings) are not easily used by managers to inform decisions. Alternative, socioeconomic metrics like projected number of jobs, revenues, or regional income effects may be more useful for resource managers to quickly grasp ecosystem service tradeoffs of various management choices.

Our goal was to provide socioeconomic ecosystem service metrics of projected outcomes from a range of management choices for oyster restoration sites in Maryland in a Chesapeake Bay tributary. Restoration sites are currently protected in sanctuaries that do not allow oyster harvests (other fisheries are allowed). Meanwhile, there have been well-publicized calls by fishers to open the sanctuaries to oyster harvest, while environmentalists, and federal partners who led the restoration efforts want to see the sanctuaries preserved. State resource managers need information on the ecosystem service tradeoffs likely to result from the range of choices that they face.

We use the Ecopath with Ecosim model to simulate the young, restored reefs currently protected from oyster harvest by designated sanctuaries. We then simulate the effects of different oyster management strategies on harvests in the major fisheries of the region, for the following scenarios: 1) immature protected reef (rotational harvests), 2) fully mature protected reef, and 3) open oyster harvest on the previously protected reefs. Harvests by fishery are translated to dockside values by applying historic species per-unit prices to biomass harvested. Commercial fisher cost functions obtained from a primary data collection effort are used in conjunction with regional economic impact modeling software (IMPLAN) to estimate the regional socioeconomic metrics associated with each scenario. Final results estimating the economic impacts of each scenario will be presented and compared at both the county and state-levels.

## **INVESTIGATE THE EFFICIENCY OF BEST MANAGEMENT PRACTICES FOR CAPTURING STORMWATER USING SYSTEM ANALYSIS– CASE STUDY; DISTRICT OF COLUMBIA**

***Mohammadreza Jabehdari, LeeRoy Bronner***

Department of Industrial and System Engineering, Morgan state University, Baltimore, MD, USA

Stormwater has been considered as a fast-growing issue for the urbanized environment due to increased impervious surfaces. Stormwater runoff can also cause pollution added to water bodies. Stormwater Best Management Practices (BMPs) have attracted decision-makers attention due to the ability in runoff capturing and pollution reduction. These two features are known as main ecosystem services that stakeholders can gain from stormwater BMPs in urban water management. Although stormwater BMPs are designed to reduce the volume of runoff, there is still lack of efficiency in their performance. District of Columbia water and sewer authority reports the number of overflows in the sewer system annually. These reports represent that the number of sewer overflow is increasing in the combined sewer system. This shows either the stormwater runoff increasing or the current system for capturing runoff is not efficient enough to reduce the volume of stormwater. Thus, apparently, a complementary solution is needed. There is no doubt that urban managers are dealing with a complex system in an urban environment with different subsystems. Thus, there should be a systematic solution to deal with the current problems. The purpose of this research is to come up with a system analysis approach as a decision support system (DSS) tool to assist city managers in making more comprehensive decisions. As a result, we designed a framework that explains the linkage between the components of the urban system and the networks to be analyzed. The results of our research showed that using network analysis can assist in analyzing sewer system and how BMPs can be used to improve such networks. There are several steps associated with the system analysis framework. A comprehensive vision of the current system's issues can be achieved by practically providing the problem description, and visualize it by a conceptual model. This could contribute to determining the main source of the issue and clarify involved components of the system. Followed by demonstrating the actors and users of the system to identify responsibilities and duties. As a result, the requirements of the project can be extracted from the conceptual model. Then, use case scenarios contained steps of the process to fulfill requirements and object-oriented model supported the scenarios. Finally, Network Analysis Model demonstrates how BMPs as objects can play their role and capture stormwater efficiently as the main ecosystem services. This framework can be used in the whole city and pave the path for decision-makers to come up with appropriate solutions after analyzing the BMP systems.

## PARTICIPATORY MAPPING OF CULTURAL ECOSYSTEM SERVICES IN A FEDERAL STATE: LESSONS LEARNT FROM SWITZERLAND

*Rémi Jaligot, Stéphanie Hasler and Jérôme Chenal*

Urban and regional planning community, Ecole Polytechnique Fédérale de Lausanne, Switzerland

A system-based approach may not consider subjective values translated through cultural ecosystem services (CES) to the same extent as a place-based approach. In addition, federal states may be more likely to show strong variations in CES across regions due to local traditions as well as decentralized political power and potential discrepancies with regards to the implementation of land management strategies. The methodology to assess CES should consider this political context.

Switzerland is a federation of twenty-six sovereign states called cantons. Each canton has its own government and parliament. The population shows strong regional roots, and values decision-making at the local level. Based on literature review and the elicitation of five experts, five CES were selected: *Heritage, Landscape aesthetics and landmark, Outdoor activities, Inspiration, spiritual and religious, and simple existence of nature.*

Web-based mapping was suitable because 1) it was possible to zoom in and out to ensure accuracy, and 2) the entire study area could be targeted – including remote alpine areas. The completeness of the softGIS survey tool *Maptionnaire* was preferred because it combined survey questions, a customizable mapping interface, an interface for data analysis and an export tool. Each participant had to locate its residence as a preliminary condition to start the survey. The survey was initially designed to indicate points to locate CES, then to draw polygons around the supply areas. After testing with ten experts, drawing polygons was considered too challenging and time consuming. Then, participants graded the importance of each area on a scale from 1 to 10, and specified why in a multiple-choice question. Finally, they answered two multiple-choice questions for each CES about the factors that would lead to a decrease in its value, and the potential mitigation measures. 11,300 email addresses from academic institutions, city councils, cantonal offices and environmental / planning associations were put together.

Results showed that the methodology was suitable to target all regions, including remote areas because the answers were well distributed across the study area. While 20% of the receivers answered the survey, 5% managed to complete it due to the time required to map several provisioning areas for each CES. Interestingly, most participants who located provisioning areas for at least two CES completed the survey. A total of 4,342 points were collected (980 for *Heritage*, 1171 for *Landscape aesthetics and landmark*, 1074 for *Outdoor activities*, 354 for *Inspiration, spiritual and religious*, and 763 for *Simple existence of nature*). We recommend web-based participatory mapping to retrieve regional values in ES assessment at the national scale. However, the duration of the survey is a limitation to achieve a high response rate so other approaches may be more suitable for a detailed study of multiple CES at the local scale.

## WEB-BASED ASSESSMENT OF CULTURAL ECOSYSTEM SERVICES IN SWITZERLAND

*Rémi Jaligot and Jérôme Chenal*

Urban and regional planning community, Ecole Polytechnique Fédérale de Lausanne, Switzerland

A system-based approach may not consider subjective values translated through cultural ecosystem services (CES) to the same extent as a place-based approach. In Switzerland, a national assessment may show strong variations in CES values because of local traditions. Based on literature review and the elicitation of five experts, five CES were selected and assessed at the national scale for the first time: *Heritage, Landscape aesthetics and landmark, Outdoor activities, Inspiration, spiritual and religious, and simple existence of nature.*

Web-based mapping was suitable because 1) it was possible to zoom in and out to ensure accuracy, and 2) the entire study area could be targeted – including remote alpine areas. The tool *Maptionnaire* was used for its flexibility. The survey was initially designed to locate CES with points, then to draw polygons around the supply areas. After testing with ten experts, drawing polygons was considered too challenging and time consuming. The participants graded each area's importance on a scale from one to ten, and specified why in a multiple-choice question. Finally, they answered a multiple-choice question about the potential causes of a decrease in ES values. 11,300 email addresses from universities, administrations and environmental associations were put together. A statistical analysis of the survey output was performed. We created a 1kmx1km grid cell, and summed the point count for each ES in each cell. We used Pearson's  $r$  to calculate pairwise correlation between individual ES using a modified  $t$ -test to take into account the effect of spatial autocorrelation between a random selection of 1000 grid cells.

A total of 4,342 points were collected (980 for *Heritage*, 1171 for *Landscape aesthetics and landmark*, 1074 for *Outdoor activities*, 354 for *Inspiration, spiritual and religious*, and 763 for *Simple existence of nature*). While four ES were positively correlated, in particular *Heritage* to *Inspiration, spiritual and religious* (0.64) and to *Landscape aesthetics and landmark* (0.47), the ES *Simple existence of nature* was not correlated with others. It shows that people located it further away than other ES. While, most respondents consider that the main factors affecting the importance of ES were the distance from home and the frequency of use, different causes may lead to a decrease in CES values. Demographic pressure was the greatest threat to all CES except *Simple existence of nature* for which the lack of environmental awareness would be the main cause of a decrease.

We recommend web-based participatory mapping in ES assessment at the national scale to accurately identify provisioning areas, and retrieve individual's beliefs. While 20% of the receivers answered the survey, 5% managed to complete it. The duration of the survey was a limitation to achieve a high response rate so other approaches may be more suitable for a detailed study of multiple CES at the local scale.

## **MAPPING SOCIAL VALUES OF RESIDENTS OF THE UPPER MISSOURI RIVER BASIN FOR CURRENT AND FUTURE LAND USES**

***Meghann Jarchow<sup>1</sup>, Morgan Carnes<sup>1</sup> and Darius Semmens<sup>2</sup>***

<sup>1</sup>University of South Dakota, Vermillion, SD, USA

<sup>2</sup>US Geological Survey, Denver, CO, USA

The Upper Missouri River Basin (UMRB), which is comprised mostly of South Dakota, North Dakota, Montana, and Wyoming, is among the least populated regions in the contiguous United States, and it produces large amounts of food, feed, and energy. Therefore, the use of the landscape is foundational to the economy and identities of many of the people in the region. The purpose of this research is to assess the social values of residents of the UMRB towards the landscape and map the portions of the landscape where those values originate. In summer 2018, we will administer a two-part survey to people living in twelve rural, micropolitan, and metropolitan communities in the UMRB. In the first part of the survey, respondents will identify their demographic characteristics, their current uses of the surrounding landscape, and their attitudes and preferences towards current and future land uses. The second part of the survey uses a customized social-values typology to conduct a value-allocation exercise and then asks respondents to identify locations where residents currently experience those values on the landscape. We will use the SolVES (Social Values for Ecosystem Services) GIS application to link the mapped social values with the biophysical landscape features and to create integrated social-values maps of the UMRB. We will also use SolVES to model where and how social values are likely to change under alternative future land uses, such as increased presence of cellulosic bioenergy crops. We anticipate that the geographic location, community size, and respondent demographics, especially the level of education, will affect the types and locations of social values perceived by the respondents. We further anticipate that the current dominant land use surrounding respondents will affect how alternative future land uses are valued. Because the UMRB covers a large geographic area and produces food, feed, and energy for the region and beyond, changes in land use in this region are likely to have broad impacts influenced by the social values held by its residents.

## LANDOWNER WILLINGNESS TO PARTICIPATE IN A GRASSLAND CONSERVATION PROGRAM FACILITATING ECOSYSTEM SERVICES

*Tharaka A. Jayalath<sup>1</sup>, Robert K. Grala<sup>2</sup>, Stephen C. Grado<sup>2</sup>, David L. Evans<sup>2</sup>, and Marzieh Motallebi<sup>1</sup>*

<sup>1</sup>Department of Forestry and Environmental Conservation; College of Agriculture, Forestry and Life Science; Clemson University, Clemson, SC, USA

<sup>2</sup>Department of Forestry, College of Forest Resources, Forest and Wildlife Research Center, Mississippi State University, USA

Grasslands represent unique ecosystems providing humans with ecological, social, and economic benefits, often extending beyond grassland's geographical location. However, only few of these benefits have an economic value within existing markets. Despite importance of provided benefits, native grasslands have continuously been cleared and degraded at a high rate mainly due to economic factors, undesirable habitat changes because of fire exclusion, improper grazing management, and encroachment of invasive plant species. Thus, lack of information on monetary value of grassland ecosystem services has become one of the factors contributing to grassland conversion.

The research objective was to quantify the cost of increasing provision of ecosystem services from grasslands in the Gulf Coastal Plains and Ozarks (GCPO) Landscape Conservation Cooperative geographic area in the United States. A contingent valuation method (CVM) was used to estimate landowner willingness to accept (WTA) compensation in exchange for implementing best management practices preserving their grassland ecosystems and promoting production of ecosystem services. Primary data were collected using a mail survey sent to 2,000 randomly selected landowners in GCPO region, whereas secondary data related to geospatial attributes in the region were collected from various public online sources. A probit model was constructed to estimate parameters affecting landowners' probability of enrolling in a conservation program facilitating ecosystem services.

The mean WTA compensation required by landowners to manage their grasslands for ecosystem services using sustainable land management practices was \$290 per acre per year during a 10-year contract period. WTA was affected by income, age, frequency of contact with state wildlife agencies, proximity to the nearest local park, and percentage change in grassland area. Mean WTA was relatively higher than estimates from similar studies focusing on landowner willingness to manage forests and wetlands for ecosystem services most likely due to potentially higher profitability of converting grasslands to alternative land uses such as agricultural crop production. Based on the estimated WTA and the total area grassland in the region, the total cost of preserving ecosystem services was estimated at US\$3 billion per year and was 57 times larger than the 2016 CRP budget allocation of US\$50 million. However, the total cost would vary from US\$1.7 million to \$1.3 billion depending upon the level of ecological attributes to be preserved. Therefore, grassland conservation efforts might have to focus on priority grassland ecosystems by restoring and preserving ecosystems with a high ecological value that will be crucial in achieving long-term conservation goals and feasible to achieve within existing budget constraints. Results can be used to develop guidelines for protecting and restoring native grasslands, quantifying budgets needed to achieve specific conservation objectives, and identifying the most effective and financially feasible conservation strategies.

## QUANTIFYING HOUSEHOLD RELIANCE ON ECOSYSTEM SERVICE DERIVED INCOME IN THE GREATER SERENGETI-MARA ECOSYSTEM

*Carsten Smith-Hall<sup>1</sup>, Janemary Ntalwila<sup>2</sup>, Xi Jiao<sup>1</sup>, Martin Reinhardt Nielsen<sup>1</sup>, Solomon Zena Walelign<sup>1</sup>, and Angela Mwakatobe<sup>2</sup>*

<sup>1</sup>Department of Food and Resource Economics, University of Copenhagen, Frederiksberg, Denmark

<sup>2</sup>Tanzania Wildlife Research Institute, Arusha, Tanzania

Despite the growing conceptual recognition of ecosystem services and their importance, the value of these services in supporting livelihoods in developing countries is generally still not included in national economic accounts and hence not well addressed in political decision making. Greater Serengeti-Mara Ecosystem (GSME) is one of the key iconic areas in Africa where ecosystem services are under siege. Access to natural resource utilization is typically particularly important for poorer sections of communities. The general understanding and the sustainable management of the coupled natural-human system of the Serengeti-Mara requires the quantification of how exactly, and on which ecosystem services people in the region depend most. This study operationalizes the Millennium Ecosystem Assessment framework using a cross-sectional data from a structured survey of 1000 households in 25 villages in the GSME in Tanzania and Kenya, and employs confirmatory factor analysis and multiple regression models, for quantifying household reliance on ecosystem services derived income and human well-being and investigating their interactions. Results documented high reliance on environmental income and livestock income across the study areas; demonstrated the variation in environmental reliance across regionals, income and well-being quintiles; identified the main contextual factors and household characteristics influencing ecosystem services related income sources. Key findings include: (i) poorer households have higher share of their total income from environmental products, while well-off households earn higher environmental income in absolute terms; ii) households residing in the conservation area have lower absolute environmental income but high reliance; and iii) households living closer to the protected area are likely to have higher environmental income and reliance. These findings provide key policy implications for conservation and poverty alleviation where deterioration of ecosystem service provisioning will negatively affect particularly the poor, and implies that sustainable management is important also from a human welfare perspective.

## **INCORPORATING AN ECOSYSTEM SERVICES PERSPECTIVE IN PLANNING AND URBAN DESIGN AS A TOOL TO DEVELOP LIVEABLE CITIES**

**Lars Johansson<sup>1</sup>, Anneli Jonsson<sup>2</sup>, Lottie Carlsson<sup>3</sup> and Ingrid Boklund<sup>4</sup>**

<sup>1</sup>Project Management, Ramboll, Sweden

<sup>2</sup>Landscape & Planning, Ramboll, Sweden

<sup>3</sup>Landscape & Planning, Ramboll, Sweden

<sup>4</sup>Environment and health, Ramboll, Sweden

There is a need for evidence-based, integrated and holistic models to support landscape planning and urban design to manage the complex social and ecological challenges currently facing our cities and the built environment. Introducing an ecosystem services perspective in landscape planning and urban design provides a strong framework for multidisciplinary work and holistic understanding. Introducing the ecosystem services as core framework helps to better promote the links between urban living, ecology and individual health and well-being and develop liveable cities.

In this presentation, we describe case studies from the Swedish cities of Norrtälje and Kiruna and the Norwegian city of Stavanger where the ecosystem services perspective have been applied as a tool to develop liveable cities. Each study provides a slightly different perspective on the connections between ecosystem services and a liveability framework. Collectively, these case studies offer several experiences and lessons learned about how to introduce and integrate an ecosystem services perspective to urban master planning and landscape planning. We demonstrate how an ecosystem service perspective can help to map, identify and value the status quo of existing or proposed urban development projects, and to compare and visualize different plausible planning and design strategies that will optimize human well-being, health and quality of life. The case studies also demonstrate the need at a high level for evidence-based thinking and comparability because our understanding of ecosystem services continues to evolve in the international research community. The ecosystem service perspective is anthropocentric by default and, hence, has a strong connection to urban concepts of liveability. In this context, we define liveability as describing the cultural, social and ecological conditions necessary for a safe and healthy life for all inhabitants of cities, regions and communities. Liveability is based on the principle of sustainability and is sensitive to the natural environment and the protection of ecological resources.

An important insight from the Swedish and Norwegian case studies described in this presentation is how successful incorporation of ecosystem services and urban liveability into planning programs is achievable and greatly enhanced by involvement of stakeholders representing cross- and multi-disciplinary perspectives. The ecosystem services perspective can increase the capacity of urban and landscape planners to identify complex ecological challenges in urban developments. Ecosystem services and liveability are frameworks with strong connections to research and can bolster the legitimacy of planning efforts aimed at sustainability and effective management of our built environment.

## **BARRIERS TO PES PROGRAMS IN INDIGENOUS COMMUNITIES: A LESSON IN LAND TENURE INSECURITY FROM THE HOPI INDIAN RESERVATION.**

**Michael K. Johnson<sup>1</sup>, Aaron Lien<sup>1</sup>, Natalya Robbins Sherman<sup>1</sup>, and Laura López-Hoffman<sup>2</sup>**

<sup>1</sup>School of Natural Resources and the Environment, University of Arizona, AZ, USA

<sup>2</sup>School of Natural Resources and the Environment and Udall Center for Studies in Public Policy, University of Arizona, AZ, USA

Payed for Ecosystem Service programs such as the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) have largely been unsuccessful on American Indian reservations. We hypothesize that mismatches between the traditional land tenure regimes and institutional arrangements of Indigenous communities on one hand, and government sponsors of PES programs on the other hand, result in the lack of success of these programs. To test this hypothesis, we conducted a qualitative study of a PES program, the Environmental Quality Incentives Program (EQIP) on the Hopi reservation in the United States. We answered two questions: (1) What barriers prevent Hopi ranchers and farmers from participating in incentive-based programs? (2) What institutional changes are necessary to permit Hopi farmer and rancher participation in EQIP? We analyzed primary documents and conducted key informant interviews. We conclude that land tenure is at the forefront of problems associated with administering PES programs on American Indian reservations. We suggest new approaches in addressing the land tenure regimes in Indigenous communities. If land tenure issues and institutional mismatches are not addressed then PES programs such as EQIP will continue to struggle on Indigenous lands not only in American but around the world.

## EXTENDING THE USE OF META-ANALYSIS FOR ECOSYSTEM SERVICES VALUATION

**Robert J. Johnston**

Clark University, Worcester, MA, USA

The demand for information on ecosystem service values combined with a lack of time and resources required to conduct primary valuation studies has led to an increasing use of benefit transfer to quantify these values. Benefit transfer is the use of pre-existing empirical estimates from primary studies at one or more sites or valuation contexts where research has been conducted (called study sites) to predict welfare estimates such as willingness to pay (WTP) at other, typically unstudied sites or policy contexts (called policy sites). The demand for ecosystem service benefit transfers is particularly acute among government agencies (such as USDA and EPA in the US) seeking to characterize the benefits of regulations or programs that affect large geographic areas. Among the various approaches to benefit transfer, meta-analysis is gaining increased attention due to its capacity to synthesize information from prior valuation studies in ways that can enable more flexible, valid and reliable estimates of ecosystem service value, particularly over large spatial scales. Most commonly, meta-regression models (MRMs) are used to generate parameterized functions that can be used to predict values at sites where original valuation studies have not been conducted.

Like all benefit transfer methods, the capacity of meta-analysis to provide valid and reliable estimates depends on multiple factors, including the ability of the model to accommodate fundamental patterns expected in economic value estimates such as sensitivity to scope, scale and spatial dimensions. For example, with rare exceptions, theory and empirical evidence suggest that ecosystem service values should be sensitive to scope (larger gains are more highly valued than smaller gains), consistent with downward-sloping demand (each successive unit of a service is worth progressively less), and responsive to spatial dimensions such as distance (closer services are valued more than distant ones, *ceteris paribus*). This presentation summarizes recent advances in valuation meta-regression modeling that have enabled the provision of more flexible, valid and reliable estimates of ecosystem service value that can accommodate core patterns such as these. Particular attention is given to specifications of MRMs and metadata that enable greater flexibility to incorporate spatial dimensions of ecosystem service value, including a capacity to model the direct effect of distance (between households and ecosystem service changes) on WTP, along with other theoretically expected patterns such as scope and diminishing marginal utility. Illustrations are used to demonstrate how such approaches can be used to provide more accurate estimates of ecosystem service values related to large-scale government programs, and can avoid biases prevalent in simpler forms of benefit transfer. The presentation concludes with a discussion of the opportunities and challenges associated with large-scale application of such meta-analytic approaches to evaluate public and private programs.

## **SELECTING BIOPHYSICAL INDICATORS FOR ECONOMIC VALUATION OF NONUSE ECOSYSTEM SERVICES**

***Robert J. Johnston***

Clark University, Worcester, MA, USA

Nonuse values (or benefits) are an important component of the total economic value associated with changes in ecosystem services. They are defined as values that cannot be measured using data on observed human behavior. Common examples include existence, bequest and altruistic values. Because nonuse values are not limited to beneficiaries who use an ecosystem or service in observable ways (either actively or potentially), these values can be realized by large populations. Hence, even when nonuse values are small on a per capita basis, they can be very large in the aggregate. Although nonuse values are among the largest components of value generated by some types of ecosystem services, they also pose challenges for measurement. Considerable attention has been paid to the development of stated preference methods able to provide valid and reliable estimates of ecosystem service values, including nonuse value. However, less attention has been paid to the specification of the biophysical quantities and qualities that are potentially valued by nonuse beneficiaries. As a result, there is ambiguity concerning “what should be measured” (particularly by natural scientists) when seeking to quantify the features or outputs of ecosystems that generate nonuse value, and what measures should be used within stated preference questionnaires to elicit responses that accurately capture nonuse components of willingness to pay (WTP) or willingness to accept (WTA). This presentation reviews the concept of nonuse ecosystem service values and introduces the unique challenges that these values pose for valuation, with a particular emphasis on indicator development. The presentation will emphasize lessons learned from past work on nonuse value estimation, including the types and characteristics of biophysical measures that are well suited to nonuse value estimation. It will also review procedures that can be used to identify these indicators in particular cases, and discuss differences between the types of indicators that might be most salient to trained scientists versus those that provide the best candidates for nonuse valuation with the public. The presentation will include discussion of topics such as the degree to which these indicators can be generalized across different regions and ecosystem types and the potential role of multimetric indicators, and will conclude with suggestions for future research that is required to inform large scale data collection efforts such as the National Aquatic Resource Surveys and non-market valuation.

## **EXAMINATION OF ADIVASI WOMEN'S PERSPECTIVES ON GENDER THEORIES AND ECOSYSTEM VALUES ASSOCIATED WITH HUMAN-FOREST INTERACTIONS**

*Helina Jolly, Terre Satterfield and Milind Kandlikar*

Institute for Resources Environment and Sustainability, University of British Columbia, Vancouver, BC, Canada

70% of world poverty is believed to have the face of a woman, which makes women in any society more vulnerable than its men. Women's vulnerability is mostly linked to their natural resource dependency, poverty, lack of assets and limited access to resources. Moreover, lack of literacy, decision-making rights, and alternative livelihood opportunities make women in poor rural household bear the brunt of environmental degradation disproportionately. Despite the evidence of gendered impacts of ecosystem degradation, policymakers have failed to pay adequate attention to the understanding of how women in natural resource-dependent communities identify and value ecosystems. This paper examines how gender theories advance our knowledge of gender-nature interactions. It studies these theories through the position of Adivasi (indigenous) women and demonstrates that Feminist Political Ecology is more suitable than ecofeminism and ecological feminism in learning the historical and contemporary associations of Adivasi women and nature. This paper further illustrates that due to the gendered socialisation, the division of labour, property rights and access to natural resources Adivasi men and women may have developed separate preferences and value attributes to ecosystem services. It briefly discusses these gendered value attributes and suggests ways to make valuation gender inclusive. The paper highlights the need for development policies and programs to be genuinely democratic by making valuation approaches more sensitive to marginalised societies like women, Adivasis. It recommends future natural resource management studies and programs to have an Adivasi women's outlook while planning, designing, implementing and monitoring these initiatives.

## ECOSYSTEM SERVICES IN NATURAL RESOURCE LIABILITY CLAIMS

**Carol Adaire Jones**

Environmental Law Institute, Washington, D.C., USA

This presentation will highlight how the United States has valued harm to public resources in natural resource liability laws and practice, an early legal application of the ecosystem-services conceptual framework. Our primary focus is on valuing harm to the difficult-to-value resources and ecological services that provide indirect or passive human uses, for which revealed preference valuation methods (based on observable behavior) are not applicable. We concentrate on the past 25 years of U.S. experience with the innovative, restoration-based framework established in regulations implementing the Oil Pollution Act of 1990. This framework has subsequently been adopted for use with other US statutes and with the EU Environmental Liability Directive. By reframing the damage claims as the cost of both “primary” restoration (to promote recovery of injured resources) and “compensatory” restoration (to account for interim losses pending recovery), the regulations deflected some of the controversy surrounding valuation methods.

The restoration-based compensation framework provides two basic approaches for calculating the scale of compensatory restoration projects. A *service-to-service* approach, which does not require valuation, applies to projects that provide resources and ecosystem services of the same type, quality, and comparable value as those harmed. A *valuation approach*, intended for a broader range of applications, relies on survey-based stated preference methods.

For injuries to ecological services, we found trustees have relied almost exclusively on habitat equivalency analysis (HEA), a service-to-service approach, and have adapted its use to applications where restoration projects make resource or ecosystem services substitutions. We explore how the trustees address the challenge of characterizing the equivalency between injury and restoration resources and ecosystem services through their choices of restoration projects and of ecosystem service metrics.

## **MINELAND RESTORATION ON THE MONONGAHELA NATIONAL FOREST, RANDOLPH COUNTY, WV, USA: SOMETHING IN IT FOR EVERYBODY**

***Shane C. Jones<sup>1</sup>, Jack Tribble<sup>1</sup>, Dr. Chris Barton<sup>2</sup>, Scott Eggerud<sup>3</sup> and Rob Tallman<sup>4</sup>***

<sup>1</sup>Greenbrier Ranger District, Monongahela National Forest, Bartow, WV USA

<sup>2</sup>University of Kentucky Appalachian Center, Green Forests Work, Lexington, KY USA

<sup>3</sup>Office of Surface Mining, Reclamation and Enforcement, Ona, WV USA

<sup>4</sup>West Virginia Division of Natural Resources, Wildlife Resources, Elkins, WV USA

During the Industrial Logging Era (1880s-1940s), the vast majority of Appalachian forests, including the areas once dominated by red spruce, were cleared of trees. Wildfires followed logging, making reforestation the primary land management challenge of the 1930s-1940s. While fueling the energy needs of our Nation from the 1960s to present day, the practice of surface mining for coal extraction has removed over one million acres of these precious native forests throughout Appalachia. Greatly reduced by industrial logging and subsequent wildfires during the Industrial Logging Era (early 20th Century) and further decimated by the more recent coal extraction, current extent of spruce-influenced forests throughout the central Appalachians is roughly  $\frac{1}{4}$  of former distribution. As such, spruce-influenced forests are considered one of the ten most threatened ecosystems in North America.

Approximately 2,000 acres of former spruce-influenced forest on the Monongahela National Forest have been mined for coal in the last 50 years. Mining and reclamation efforts have left these areas dominated by nonnative grasses, shrubs or trees. The legacy effects of natural resource extraction on National Forest in areas previously dominated by red spruce provide a unique opportunity for the Forest Service to work with partners to take actions towards spruce restoration and ancillary ecosystem services for the consumer and non-consumer alike.

In their natural state Appalachian forests are some of the richest in the world and provide ecosystem services for everybody. These forests are important and useful to the people of Appalachia. A functioning forest provides short and long term economic benefits from timber, recreation, and food production. Intact forests provide environmental benefits that make those areas healthier and safer places to live, protecting residents from poor water quality, flash flooding and cleaning the air for everyone. In an undisturbed state, the forests located along the spine of the Appalachians were once dominated by red spruce. By virtue of the dominance of red spruce, naturally acidic soils and a cool, wet climate more akin to Canada, above ground and below ground ecological processes favored the development of deep organic soil horizons and a cool, moist microclimate. A spruce-influenced forest has incredibly high conservation value because numerous ecosystem services, including but not limited to cleaner air and water; natural flood retention (headwater sponge); quality recreation opportunities; carbon sequestration and wildlife habitat for rare species are dependent on a functional spruce-influenced forest.

## **MAINSTREAMING GREEN INFRASTRUCTURE PROJECTS AT THE WORLD BANK**

*Denis Jean-Jacques Jordy*

World Bank Global Facility for Disaster Reduction and Recovery

This presentation will give an overview of the World Bank's Nature-based Solutions Program and provide insights on how green infrastructure projects can align with the World Bank's objectives.

Nature-based Solutions (NBS) that strategically conserve or restore nature to support conventionally built infrastructure systems (also referred to as gray infrastructure) can reduce disaster risk and produce more resilient and lower-cost services in developing countries. From 2012 to 2018, 76 of the 681 DRM projects approved by the World Bank utilize NBS in project subcomponents. This represents a relatively small but growing percentage of the Bank's DRM portfolio.

As more disaster risk managers understand and integrate well-designed NBS into disaster risk management projects, more finance can be routed to nature-based projects. With that goal in mind, the World Bank's Nature-based Solutions Program aims to inform and enable the World Bank operational teams and clients to adopt NBS as part of natural hazards risk reduction and water security measures, and to achieve other development objectives.

The World Bank NBS Program will advance the knowledge frontier in three ways. It will build capacity within the World Bank and partner organizations to understand the potential of green infrastructure and engage developing country clients. It will promote the testing and integration of green-gray assessment tools and approaches in their internal processes. And, it will help overcome knowledge gaps that act as barriers to scaling green infrastructure by investing in performance monitoring and in widely communicating results and real-world experience.

## **AGRICULTURAL BEST MANAGEMENT PRACTICES IN CORN-SOYBEAN SYSTEMS: TRADEOFFS AND SYNERGIES BETWEEN CROP YIELD AND ECOSYSTEM SERVICES**

***Andrew N. Kadykalo<sup>1</sup>, Kris Johnson<sup>2</sup>, and C.S. Findlay<sup>3</sup>***

<sup>1</sup>Ottawa-Carleton Institute for Biology, Carleton University, Ottawa, ON, Canada

<sup>2</sup>The Nature Conservancy, Minneapolis-St. Paul, Minnesota, USA

<sup>3</sup>Department of Biology, Institute of Environment & Institute for Science, Society and Policy; University of Ottawa, Ottawa, ON, Canada

Agricultural “best management practices” (BMPs) have emerged to mitigate agro-environmental resource challenges but may also enhance non-provisioning ecosystem services. In part, the enthusiasm for adopting BMPs will depend on evidence that doing so will lead to agro-environmental benefits while not substantially reducing crop productivity. We survey the existing literature to: (a) document the prevalence of crop yield and ecosystem service co-benefits and tradeoffs associated with implementation of agricultural BMPs; and (b) develop empirical models that predict the likelihood of co-benefits relative to tradeoffs. In the literature sample, reporting of co-benefits of BMP implementation (i.e. maintaining or increasing crop yields while increasing regulating and supporting ecosystem services) was more prevalent than reporting of tradeoffs between crop yields and ecosystem services. Our results are a step towards identifying those contexts where co-benefits of BMPs are more likely to be realized, as well as the impact of specific practices on specific ecological services.

## **AGRICULTURAL BEST MANAGEMENT PRACTICES IN CORN-SOYBEAN SYSTEMS: TRADEOFFS AND SYNERGIES BETWEEN CROP YIELD AND ECOSYSTEM SERVICES**

**Andrew N. Kadykalo<sup>1</sup>, Kris Johnson<sup>2</sup>, and C.S. Findlay<sup>3</sup>**

<sup>1</sup>Ottawa-Carleton Institute for Biology, Carleton University, Ottawa, ON, Canada

<sup>2</sup>The Nature Conservancy, Minneapolis-St. Paul, Minnesota, USA

<sup>3</sup>Department of Biology, Institute of Environment & Institute for Science, Society and Policy; University of Ottawa, Ottawa, ON, Canada

Agricultural “best management practices” (BMPs) have emerged to mitigate agro-environmental resource challenges but may also enhance non-provisioning ecosystem services. In part, the enthusiasm for adopting BMPs will depend on evidence that doing so will lead to agro-environmental benefits while not substantially reducing crop productivity. We survey the existing literature to: (a) document the prevalence of crop yield and ecosystem service co-benefits and tradeoffs associated with implementation of agricultural BMPs; and (b) develop empirical models that predict the likelihood of co-benefits relative to tradeoffs. In the literature sample, reporting of co-benefits of BMP implementation (i.e. maintaining or increasing crop yields while increasing regulating and supporting ecosystem services) was more prevalent than reporting of tradeoffs between crop yields and ecosystem services. Our results are a step towards identifying those contexts where co-benefits of BMPs are more likely to be realized, as well as the impact of specific practices on specific ecological services.

## **PREDICTING FRESHWATER FLOW FUNCTIONS OF WETLANDS AND POSSIBLE IMPLICATIONS FOR WETLAND VALUATION**

**Andrew N. Kadykalo<sup>1</sup>, and C.S. Findlay<sup>2</sup>**

<sup>1</sup>Ottawa-Carleton Institute for Biology, Carleton University, Ottawa, ON, Canada

<sup>2</sup>Department of Biology, Institute of Environment & Institute for Science, Society and Policy; University of Ottawa, Ottawa, ON, Canada

Wetlands potentially provide a range of ecological functions and services including ground water recharge, nutrient retention, waste assimilation, shoreline stabilization, and carbon storage. One of the most cited and valuable ecosystem services potentially provided by wetlands are their influence on flow regimes, especially flood attenuation and augmentation of low flows. I will present the results of a meta-analysis of twenty-eight studies, including fifty-nine associated effect sizes, that have investigated the flow regulation services of wetlands. We found that, consistent with conventional wisdom, on average wetlands reduce the frequency and magnitude of floods and increase flood return period; augment low flows; and decrease runoff and streamflow. However, our results also indicate gross wetland characteristics have little predictive power with respect to the observed variation in the level of flow regulation services. Our results also indicate that the magnitude of the estimated wetland effect on flow regimes depends on the study type and study design. This implies that in the absence of detailed site-specific information, estimates of flow regulation services provided by wetlands will generally have large uncertainty, as will any associated estimate of their economic value. Therefore, ascribing general flow regulation functions and services to specific wetlands or wetland complexes of management interest is probably unjustified.

## **ESTIMATION OF THE BENEFITS OF SOLAR POLLINATOR HABITAT IN THE CONTERMINOUS US**

***Shruti K Mishra<sup>1</sup>, Minjia Zhu<sup>2</sup>, Cristina Negri<sup>1</sup>, Lee Walston<sup>1</sup>***

<sup>1</sup>Argonne National Laboratory, Lemont, IL, USA

<sup>2</sup>University of Chicago, Chicago, IL, USA

In the context of increasing growth rate of installed capacity of solar energy globally and in the US in the past two decades, the competition between land for solar energy generation and food production may increase further in scarce land resources. Creating and maintaining pollinator habitat in locations such as solar facilities offers a practical solution to address increasing pollination demand in agriculture thereby transforming the two competing sectors into complimentary. Scientists have focused independently on the impacts of solar energy installations, understanding of declining pollinator populations, and dwindling food security; however an integrated assessment of the sectors may support in identifying practices that improve the energy, food, and conservation nexus.

We developed and employed an integrated assessment framework coupling the principles of agronomy and ecology with economics and integrating national-scale data on crops, pollinators, and solar facilities to examine the benefits of pollinator-habitat creation in the US. The value of pollination is estimated as a function of the pollinator species, land use, the crops' dependency on native and managed pollinators, yields of the crops, and the prices of the pollination-dependent commodities. The equation is developed building upon the production function method (Winfree et al., 2011) and proportional dependence of crops on pollinators (Klein, 2007, Hein, 2009; Calderone, 2012). Our preliminary estimates show that the value of pollination across the coterminous United States is \$43 billion. If 10% to 50% of existing and planned solar facilities were used for pollinator habitat, they would produce \$1.9 to 5.7 billion worth pollination benefit annually. We will present the integrated assessment framework and the results during this session.

## MODELING OF ECOSYSTEM SERVICES ON GREEN INFRASTRUCTURE

**Gunwoo Kim**

Landscape Architecture Program, North Carolina A&T State University, Greensboro, NC, USA

Quantifying ecosystem services in urban areas is complex. However, existing ecosystem service typologies and the i-Tree model can provide a means towards understanding some key biophysical links between urban forest and ecosystem services. i-Tree model is designed to use standardized field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects.

This project aims to quantify and demonstrate the multiple ecosystem services provided by Phoenix's green infrastructure (urban parkurban park system), including its air pollution removal values, carbon sequestration and storage, avoided runoff, structural value, and the energy savings it provides for city residents hot urban climate.

Bottom-up (field inventory) approach provides detailed management information, such as No. trees, spp. Composition, tree sizes and health, tree locations, and risk information. This approach provides better means to assess and project ecosystem services and values. This is the approach and foundation that i-Tree Eco was utilized on this study.

The analysis of Phoenix's green infrastructure revealed around 517,000 trees on urban park, a tree cover of 7.20%. These trees remove about 3,630 t of carbon (\$285,000), and about 272 t of air pollutants (\$1.16 million) every year. Trees on urban park are estimated to reduce annual residential energy costs by \$106,000 and their structural value is estimated at \$692 million.

This study thus has implications for both policy and practice, contributing to a better understanding of the multiple benefits of green infrastructure and improving the design of green spaces in hot arid urban climates such as, Arizona's.

**BIQ:** Dr. Gunwoo Kim is an Assistant Professor of Landscape Architecture at North Carolina A&T State University. Passionate about sharing ecological design approaches and models. His interest here is to explore the role of landscape architecture in supporting urban sustainability to improve environmental quality and human health and well-being.

## **PUGET SOUND PARTNERSHIP HUMAN WELLBEING FRAMEWORK**

***Leah A. Kintner***

Regional Manager, Ecosystem Recovery Team, Puget Sound Partnership, Tacoma, WA, USA

Puget Sound is the largest estuary by volume in the United States, home to wide-reaching waters, iconic salmon, and killer whales. The Puget Sound region supports over four million people with a thriving, versatile economy and the expectation of at least another million people in growth over the next two and a half decades. Anthropomorphic environmental changes have already done lasting damage to this area, but a new model for considering human wellbeing and ecosystem services in environmental management offers a holistic decision support framework for considering the best steps forward.

The Puget Sound Partnership (Partnership) is the Washington State agency tasked with leading the region's collective effort to restore and protect Puget Sound while ensuring vibrant, enduring natural systems and communities. The Partnership relies on tracking and reporting of a defined set of "Vital Signs" as the foundation of the shared measurement system used to track progress and demonstrate collective impact. Both biophysical and human wellbeing Vital Signs and indicators are employed to track and measure progress toward recovery. This holistic framework supports the integration of human wellbeing throughout the planning and evaluation stages of Puget Sound recovery actions. Indicators of human wellbeing offer an innovative tool to better inform discussions around Puget Sound ecosystem recovery. Indicators are particularly important for identifying multi-benefit approaches to restoration and environmental management. By examining the tradeoffs of proposed strategies, we can more completely inform our decision making around sustaining healthy ecosystems, while promoting strong communities and economies and supporting diverse cultural practices and livelihoods.

The presentation offers a current example of how one framework utilizes ecosystem services and human wellbeing to focus ecosystem recovery and management actions at the local and regional levels. The speaker explores the current status of the Partnership's eleven human wellbeing Vital Signs: Economic Vitality, Cultural Practices, Sense of Place, Outdoor Activity, Local Foods, Good Governance, Shellfish Beds, Onsite Sewage, Air Quality, Drinking Water, and Sound Stewardship. This work includes output and employment trends in natural resource industries and a baseline data summary for six new and revised subjective Human Wellbeing Vital Signs. The presentation offers initial steps to integrate these concepts and related data into ecosystem recovery, planning, and monitoring, drawing from examples of successful integration in progress at the local watershed and regional estuary scales. This analysis further illustrates the importance and utility of tradeoff analyses, multi-attribute assessments, and adaptive management in ecosystem management.

## **FOREST CARBON MANAGEMENT AND INCENTIVES FOR NON-INDUSTRIAL FORESTS: LESSONS FROM THE PACIFIC NORTHWEST**

*Will Price<sup>1</sup>, Brian Kittler, Josh Fain*

<sup>1</sup>Pinchot Institute for Conservation

Nearly half of all U.S. forestland is comprised of family forests that are 5,000 acres or less. While these forests are a crucial part of the nation's carbon sink, they also represent some of the most vulnerable carbon stocks. Forest carbon offsets are an important way to monetize the ecosystem service of carbon sequestration and storage in forests. To date, developing forest carbon projects on family forests has proven difficult. The moist forests of the Pacific Northwest United States (PNW) are among the most naturally carbon-rich ecoregions in the world. However, regional in-forest carbon storage levels are currently well below ecological potential. Recently proposed climate policies in the PNW has renewed and deepened debates over forest sector climate strategies. Developing strategies for engaging family forests in the growing carbon market is a strategic opportunity. This talk will present the results of a multi-year program in the PNW focused on engaging family forest owners in markets for improved forest management (IFM) carbon offsets and related incentives. The project has resulted in the leveraging of public conservation funding programs of USDA NRCS to reduce transaction costs, the development of tools for quantifying carbon stocks and analyzing forest carbon management options, and recommendations for broader application of program results.

## **BIOPHYSICAL METRICS FOR QUANTIFYING NONUSE VALUES: EXAMPLES FROM THREE ECOSYSTEM TYPES IN THE UNITED STATES**

*Amanda Nahlik<sup>1</sup>, Colin Phifer<sup>2</sup>, Jeffrey Kline<sup>3</sup>, Paul L. Ringold<sup>1</sup>, Andrew Gray<sup>3</sup>, Tim Canfield<sup>4</sup>, Kim Schuerger<sup>4</sup>*

<sup>1</sup>Western Ecology Division, Office of Research and Development, Environmental Protection Agency, Corvallis, OR, USA

<sup>2</sup>ORISE Fellow, Western Ecology Division, Office of Research and Development, Environmental Protection Agency, Corvallis, OR, USA

<sup>3</sup>Pacific Northwest Research Station, Forest Service, Department of Agriculture, Corvallis, OR, USA

<sup>4</sup>Ground Water and Ecosystems Restoration Research, Office of Research and Development, Environmental Protection Agency, Ada, OK, USA

Nonuse values are the values people place on nature's goods and services that they do not directly use, appreciate, or enjoy now or in the future. Metrics of nonuse aspects are an essential part of the total economic valuation of ecosystem goods and services. However, there is little agreement on what biophysical metrics from the environment can or should be used to quantify nonuse values from many ecosystems. The lack of accepted metrics for ecosystems limits analysts' ability to quantify changes in benefits resulting from policy decisions. This session is part of a broader symposium addressing nonuse valuation. Our objective is to advance our understanding concerning nonuse values and present ecosystem-specific biophysical metrics that can be used to assess terrestrial and wetland ecosystems at regional and national scales. We present a process for conceptualizing and developing preliminary metrics of nonuse value based on causal-chains, including results, for three common systems in the United States, wetlands, forests and agricultural systems. As a first step in this process, we identified existing datasets from government agencies that were publicly available with broad regional and nationwide spatial coverages. For wetlands and forests ecosystems, we drew upon existing, field-based ecological datasets to represent the ecological integrity of the ecosystems as a whole. For wetlands, we determined that the nonuse metric was best captured by the biological indicator of condition, which was calculated using a Vegetation Multimetric Index (VMMI), and developed and measured for the Environmental Protection Agency's National Wetland Condition Assessment (NWCA). Similarly, for forest ecosystem integrity, we applied the Forest Services' Terrestrial Health Assessment values, as our metric for nonuse values. For agricultural systems, where the line between natural inputs and human activity is more ambiguous, we considered a site appeal index to assess nonuse values. Results from this project demonstrate the value of the causal chain approach. We present case studies where these metrics have been used, including ways to visualize complex datasets as useful figures and numbers amenable to cost-benefit analysis, especially as it relates to evaluating policy changes. Continued testing and refinement of the proposed nonuse metrics for these three ecosystems and closer collaborations between natural and social scientists will ensure the inclusion of the nonuse perspective in evaluations.

## DEVELOPING AND DEMONSTRATING A CARBON SEQUESTRATION PERFORMANCE METRIC FOR EVALUATING USDA POLICIES

*R.G. Haight<sup>1</sup>, R. Bluffstone<sup>2</sup>, J.W. Coulston<sup>3</sup>, J.D. Kline<sup>4</sup>, D.N. Wear<sup>5</sup>, and K. Zook<sup>6</sup>*

<sup>1</sup>USDA Forest Service, Northern Research Station, St. Paul, MN

<sup>2</sup>Portland State University, Portland, OR

<sup>3</sup>USDA Forest Service, Southern Research Station, Asheville, NC

<sup>4</sup>USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR

<sup>5</sup>USDA Forest Service, Southern Research Station, Research Triangle Park, NC

<sup>6</sup>USDA Office of Chief Economist, Washington, DC

Current USDA policy includes an intention to lead national efforts to mitigate and adapt to climate change, drought, and extreme weather in agriculture and forestry, by encouraging conservation of sensitive lands, private forest growth and retention, and federal forest stewardship. Suggested approaches involve increasing stored carbon via USDA incentive programs to retain land in agriculture and forest, increasing afforestation of marginal agricultural lands, and altering management of nonindustrial private forestlands, among other alternatives. Evaluating the potential effects of such policies and programs on stored carbon depends on developing appropriate performance metrics for tracking the amount of stored carbon increase (or decrease) resulting from USDA policies and programs. We present a conceptual framework and demonstrate a method for evaluating stored carbon in response to USDA policies and programs. We draw on existing data and models to develop a national-level measure of forest carbon and its value (in dollars). We use the data and models to estimate future changes in forest carbon and its value likely to result under land use and forest disturbance (e.g., wildfire) policy scenarios, including (1) reduced development, (2) private land afforestation and public land restoration, and (3) reduction in high severity wildfire.

Our results demonstrate a high value associated with forest carbon under our current (baseline) and three modeled policy and program scenarios. The baseline scenario, characterized by a gradual decline in forest area through 2050, yields a forest carbon value of \$517 billion (3% discount rate). Our results show that changes in USDA policy could yield substantial increases in the value of carbon stored in U.S. forests, with the greatest incremental carbon gains over the baseline scenario obtained from afforestation and reforestation (\$94 billion increase), followed by reduced development (\$38 billion increase). Such policies and programs have long played a role in USDA conservation efforts and would now seem to offer a viable approach for increasing stored carbon in the U.S. The smallest incremental carbon gains over the baseline scenario would result from reduction in high severity wildfire (\$11 billion increase). Rough estimates of the afforestation subsidy and reforestation costs necessary to implement an afforestation and reforestation policy suggest that total policy costs would be a fraction of resulting carbon sequestration benefits. However, our analysis has not considered the full fiscal costs associated with the policies and programs that define our scenarios nor has it considered potential co-benefits, such as enhancement of other ecosystem services. Both would be necessary to provide a more complete policy recommendation.

## THE FUNDING MECHANISM: EMPOWERING PRODUCERS AND INDUSTRY

**Bruce Knight**

Strategic Conservation Solutions, Washington D.C., USA

FAO's Global Soil Partnership estimated that 75 billion tons of agricultural soil is lost each year on a global basis. This equates to a financial impact of \$400 billion each year. Significant investment is needed to support farmers as they shift to conservation agricultural practices. Alyssa Charney of the National Sustainable Agriculture Coalition has stated that, "Developing a more sustainable agriculture system that will protect our natural resources, improve family farmers' bottom lines, and enhance our nation's food security is the most important business at hand for the next farm bill." However, demand from farmers far outpaces supply of conservation funding from the current Farm Bill. EQIP [the Environmental Quality Incentives Program], CSP [the Conservation Stewardship Program], and CRP (Conservation Reserve Program) are USDA's three largest programs. Just 6% (\$56 billion) of the bill's funding is allocated to advance conservation practices. Balancing the pursuit of economic and environmental outcomes is challenging for farmers in the face of a changing policy and market landscape. Noble Research Institute's (NRI) Ecosystem Services Market (ESM) program will include a large scale funding mechanism independent of government subsidies. The financing mechanism will secure its returns based on the environmental performance of investing in soil health. The ESM program will mobilize billions in private capital that is comfortable with repayment horizons of 10 -15 years. This funding will be offered to farmers wishing to enroll in the ESM program on a pay-for-success basis; as the conservation impacts (carbon sequestration, water quality, and water quantity) are created and verified, farmers are paid. The ESM program is establishing a Buyers Club for corporate members who wish to support this national conservation effort. These impacts will then be sold to members of the Buyers Club who are seeking differentiation and alignment with supply chain and internal environmental targets (Scope I, II, & III). These transactions will offer the financial investment returns to the capital markets. This holistic program will unlock the vast potential of our nation's soils and empower our agricultural producers.

## **APPLYING THE FOREST RESILIENCE BOND – FINANCING FIRE MANAGEMENT FOR WATER BENEFITS THROUGH CONSERVATION FINANCE APPROACHES**

**Zach Knight**<sup>1</sup>, *Todd Gartner*<sup>2</sup>, *Tommie Herbert*<sup>3</sup>, *Marcus Selig*<sup>4</sup> and *Willie Whittlesey*<sup>5</sup>

<sup>1</sup>Blue Forest Conservation

<sup>2</sup>World Resources Institute

<sup>3</sup>US Forest Service

<sup>4</sup>National Forest Foundation

<sup>5</sup>Yuba Water Agency

The Forest Service, and other land managers across the West, face extraordinary challenges in reducing the longstanding buildup of ladder fuels in national forests in California and across the US. While the Forest Service currently treats approximately 200,000 acres annually to restore forest conditions, it is estimated that the need is up to 2.5 times that amount in the Sierra Nevada Mountain Region alone to begin to reduce the wildfire risk and disease impacts currently experienced by so much of the region. Unfortunately, National Forest budgets are not nearly large enough to plan for, treat, and monitor these badly needed treatments. The USFS fire suppression spending has ballooned from 16% in 1995, to over 57% in 2017. This steady increase in suppression spending continues to siphon funds away from the restoration work that could prevent these fires from occurring, creating a vicious cycle that not only strains USFS budgets, but also puts homes, habitats and lives at risk each year.

What if the Forest Service could access capital from the private sector to accelerate the pace of forest restoration? A new financial instrument under development, called the Forest Resilience Bond (“FRB”), enables private capital to invest in natural resources by placing a value on ecosystem services (such as reduced wildfire risk and augmented water quality and quantity). By aligning risk and incentives to the appropriate stakeholders, the FRB can leverage capital markets to significantly scale investment in natural resources conservation projects, including and especially forest restoration in western watersheds. The first FRB pilot projects will launch in 2018 with the full cohort of pilot projects (3-4 in total) will be launched in 2019 on National Forest System land across CA as well as a public and private land project in CO.

In this session, we will focus on the development of a pilot FRB to finance forest restoration treatments (in partnership with state agencies, utilities, and other stakeholders), so that private capital can be used to leverage additional agency funds through a cost sharing agreement. The development of the FRB will benefit from forming a coalition of diverse stakeholders, including, but not limited to the USFS, State agencies, utility partners, and academic experts and investors to structure this investment and bring it to market.

## MONETIZING CARBON, WATER QUALITY AND OTHER CO-BENEFITS

**Gary Knoblock**

Senior Program Officer (Environment), S. D Bechtel, Jr. Foundation, San Francisco, CA, USA

California is in the midst of a unique experiment that involves monetizing beneficial ecosystem services to enable conservation. Markets typically fail to monetize (or ‘internalize’) environmental externalities: consequences that are enjoyed (positive) or endured (negative) by third parties to an economic transaction. By monetizing environmental externalities, economic incentives are created that encourage action. Cap-and-trade is one example: producer behavior is regulated through monetization of air pollution. The monetization of beneficial ecosystem services can also encourage behavior aimed at ecological preservation. A number of partners are exploring the potential of new policy tools to monetize beneficial ecosystem services, including carbon sequestration, water quality and quantity, climate resilience and adaptation.

One example where experiments are underway to monetize beneficial ecosystem services is the Tahoe Central Sierra Initiative (TCSI-[restoresierra.org/tahoesierra](http://restoresierra.org/tahoesierra)), which is a partnership between state, federal, and non-governmental partners to increase the pace and scale of forest restoration in a large landscape. The goal is to improve forest resilience to fire, drought, disease, and climate change, to protect biodiversity, and reduce threats to human well-being. The partnership addresses a 2.4 million-acre landscape that encompasses three National Forests and a patchwork of private and state forests. TCSI partners include a broad range of agencies and organizations, including the U.S. Forest Service, the Sierra Nevada and Tahoe Conservancies, The Nature Conservancy, the National Forest Foundation, Sierra Forest Legacy, CA Forestry Association, and the University of California.

The initiative is producing:

- **Opportunity Areas:** An analysis of high-benefit opportunity areas for forest restoration treatments within the TCSI landscape in the next 10-20 years based on current and future threats to resilience and associated ecosystem services: carbon, fire risk within the wildland-urban interface, fire dynamics, wildlife habitat, biodiversity, and wood product yields;
- **Carbon Accounting:** Estimates of the carbon storage and greenhouse gas emissions resulting from forest restoration activities at a landscape scale within the TCSI landscape; and
- **Economic Analysis:** Estimates of the economic value of the biomass that is expected to be removed through forest restoration activities and the bioenergy and milling capacity that will be required to process that supply.

Using these outputs, the next step will be to monetize them so that actions that conform to a validated protocol to enhance forest resilience can be turned into credits. Buyers such as infrastructure agencies could purchase these credits to offset their negative impact on habitat or carbon emissions. Sellers such as landowners or state agencies would be continually incentivized to implement forest management actions and improve the suite of beneficial ecosystem services.

## **INTEGRATING MITIGATION, CARBON SEQUESTRATION, AND ECOSYSTEM SERVICES AT COMMUNITY-RELEVANT SCALES**

**Steve Kohlmann<sup>1</sup> and Mark Mondik<sup>2</sup>**

<sup>1</sup>LSA Associates; Point Richmond, CA, USA

<sup>2</sup>3Degrees Inc.; San Francisco, CA, USA

We present an innovative conceptual framework of multifaceted and interconnected sustainability planning that explicitly considers ecosystem services (e.g., habitat, carbon, water, climate, etc.) while mitigating for habitat impacts, to benefit local communities, including marginalized segments of our society and disadvantaged communities in highly urbanized counties in California. Our framework addresses sustainability of urban ecosystem services in a comprehensive and regional manner to create a more livable environment, greater environmental equality, and a climate-resilient urban landscape. We describe the current and potential opportunities for synergies between advance mitigation planning, soil carbon sequestration, green infrastructure, and disadvantaged community support

## **CULTURAL ECOSYSTEM SERVICES IN MICHIGAN, USA: CONCEPTS AND MECHANISMS OF CULTURAL HERITAGE, CULTURAL IDENTITY, AND SPIRITUALITY**

*Erika B. Kraus<sup>1</sup>, Emily S. Huff<sup>1</sup>, Robert B. Richardson<sup>2</sup>, Laura Schmitt Olabisi<sup>2</sup>*

<sup>1</sup>Michigan State University, Department of Forestry, East Lansing, Michigan, USA

<sup>2</sup> Michigan State University, Department of Community Sustainability, East Lansing, Michigan, USA

Research on cultural ecosystem services (CES) in Michigan, USA, addresses the need to better understand concepts of CES, as well as how these services are generated by the biophysical ecosystem. Cultural ecosystem services concepts and origins are poorly understood, yet CES are the least likely to be replaced by technology among all types of ecosystem services. What are the cultural ES people identify as benefitting their well-being, how do people articulate these services, and how does the biophysical ecosystem generate them? Improving knowledge of cultural ecosystem service concepts and mechanisms increases the relevancy of the Ecosystem Service science framework in natural resource decision-making.

This research uses structured interviews, including a causal loop diagram (CLD) exercise, to capture stakeholder perceptions of ecosystem services associated with private and communally owned land in Michigan, USA. Qualitative data analysis highlights support of existing cultural ES categories, with modifications, and suggests additional types. Responses to CLDs used in the interviews are analyzed to understand how forested-land stakeholders perceive these non-material benefits coming from nature. Forest transects measuring density and species richness characterize the biophysical system from which stakeholders identify CES. Results show cultural heritage, cultural identity, and spirituality are interconnected, and social processes instruct the provision of cultural ecosystem services, in addition to ecological elements.

Results of this study demonstrate how different groups of people identify CES of heritage, identity, and spirituality, in addition to others. This knowledge is critical to the application of ES science to decision-making and conservation policy. Research from portions of the Michigan, USA, population further contributes to concepts of CES, while stakeholder responses to causal loop diagrams expand theories about how these services are provided to the benefit of human well-being. This research increases the capacity for ES science to address how people affect nature, and how nature benefits human well-being in innumerable ways.

## THE INTENTION OF COMPANIES TO INVEST IN BIODIVERSITY AND ECOSYSTEM SERVICES THROUGH AN ONLINE-MARKETPLACE IN GERMANY.

*Marlen Krause and Bettina Matzdorf*

Leibniz Centre for Agricultural Landscape Research (ZALF), Muencheberg, Germany

This research investigates the potential demand of German businesses to invest in biodiversity and ecosystem services credits (BES credits) that will be offered through an open-access online-marketplace, called AgoraNatura ([www.agora-natura.de](http://www.agora-natura.de)). The online-marketplace can be understood as an 'online-shop' for BES credits with the goal to increase private funds for nature conservation, especially in agricultural landscapes. On the one hand, the online-marketplace will be used by providers of BES credits, who are land owners (e.g. farmers, conservation associations, municipalities), willing to provide more biodiversity and ecosystem services through diverse types of conservation projects (e.g. flower strips, extensification of production fields or buffer strips around water bodies). On the other hand, corporate investors and private individuals will be able to pay for biodiversity and ES by voluntarily purchasing BES credits online. BES credits will certify and communicate the maintained or improved level of biodiversity and ecosystem services that can be achieved through the investment.

Payments for Ecosystem Services (PES) schemes have increasingly been seen as an opportunity for new financial conservation sources. However, privately-funded PES schemes rarely exist in practice. Thus, only little research has been done so far to investigate companies' potential interests in voluntary, non-governmental PES schemes. It is not yet well understood, which types of companies would be willing to participate in such PES schemes, including factors that influence their investment intentions. Therefore, we investigate the following research questions:

Which factors influence the intention of companies to buy BES credits through an online-marketplace?  
Which type of companies state a potential interest in buying BES credits and what are their investment preferences?

Our results are based on face-to face and telephone interviews with 26 company representatives from various sectors and regions in Germany. We did a structured content analysis of the transcribed interview data by conducting an inductive-deductive coding process, supported by MaxQDA text analysis software. The data analysis is based on the Theory of Planned Behavior model, developed by Ajzen (1991).

Our results show that image and communication gains are the most important benefit expectations of companies from a voluntary purchase of BES credits. Other business case drivers are in many cases lacking. Also the intrinsic motivations of responsible decision-makers play an important role. However, most companies do not perceive pressures from external stakeholders (e.g. customers, general public) to support nature conservation. Our research provides evidence that an online-marketplace for BES credits might reduce barriers for companies to financially support BES protection: The quantification of BES effects is perceived to improve the transparency, which supports the company in its internal and external communication. Also, the interviewees valued that an online-marketplace would enable an easier engagement by reducing effort and time for project searches, organization and monitoring, as well as the increase of financial flexibility. Out of the 26 interviewed companies, 12 stated a potential interest in buying BES credits through an online-marketplace, 3 were undecided and 11 had no interest in the purchase of BES credits. Numerous company characteristics seemingly influence whether or not a company intends to buy BES credits. These characteristics include the business sector, ownership and management type, customer type, ownership of natural areas, as well as partnerships with environmental organizations.

## **SOCIAL VALUE OF ENHANCING ECOSYSTEM SERVICES ON PRIVATE FOREST LANDS IN THE SOUTHEASTERN US**

**Melissa M. Kreye<sup>1</sup>, Damian C. Adams<sup>2</sup>, and Jose R. Soto<sup>3</sup>**

<sup>1</sup>Department of Ecosystem Science and Management, Pennsylvania State University, University Park, PA, USA

<sup>2</sup>School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

<sup>3</sup>School of Natural Resources and the Environment, The University of Arizona, Tucson, AZ, USA

Private forestlands provide many important ecosystem services that enhance environmental quality and support local economies. However, government subsidies and market forces tend to incentivize forest owners to enhance timber provision on their lands over other services. Policies and programs that promote clean water supply and healthy wildlife populations are significantly underfunded and often rely on the good will of forest owners to assume much of the costs of managing for these benefits (e.g., voluntary best management practices, cost-share). Moreover, government interventions are often implemented with little understanding of public demand for the ecosystem services provided by private lands, and public support for the policy strategies used to encourage their provision.

To identify potential market failures associated with the provision of forest ecosystem services we used an innovative choice modeling approach, Best-Worst Choice, to estimate public demand for increased timber provision, clean water supply, and healthy wildlife populations on private forest lands in the southeastern US (i.e., Florida, Georgia, Mississippi, and South Carolina). We also compared public support for payments for ecosystem services (PES) strategies with conservation easement strategies, which are conventionally used to conserve rural lands. Public attitudes towards timber harvesting and government involvement in private land management decisions were also investigated.

Preliminary results indicate that public demand for increases in the health of wildlife populations and clean water supply often exceeds demand for increases in timber provision. Estimates also revealed when increases in water and wildlife services were bundled, the value of forest land was double compared to increases in timber provision alone. The type of conservation strategy used also had an important impact on choice behaviors, and often added value to the conservation policy. Conservation easement strategies were generally preferred, however, some states expressed indifference between the PES or conservation easement strategy. We also found willingness to pay was generally higher among non-white respondents, respondents who supported government interventions (both landowner assistance programs and regulatory approaches), and respondents who expressed negative attitudes towards harvesting.

Findings suggest there is a significant amount of unrealized demand for healthy wildlife populations and clean water supply that is not being captured by existing government interventions and markets in the southeast. An increase in the allocation of government funds to private land programs that are not timber-focused are likely needed to address existing market failures and help safeguard forest ecosystems and social welfare.

## **MEASURING WELLBEING AT DIFFERENT SPATIAL SCALES FOR INDIVIDUALS SATISFIED AND DISSATISFIED WITH LIFE**

*Ida Kubiszewski<sup>1</sup>, Nabeeh Zakariyya<sup>2</sup>, and Diane Jarvis<sup>3</sup>*

<sup>1</sup>Crawford School of Public Policy, The Australian National University, Australia

<sup>2</sup>Research School of Economics, The Australian National University, Australia

<sup>3</sup>College of Business, Law & Governance, James Cook University, Australia

Indicators that attempt to gauge wellbeing have been created and used at multiple spatial scales around the world. The most commonly used indicators are at the national level to enable international comparisons. When analysing subjective life satisfaction at multiple spatial scales in Australia, variables that are significantly correlated to life satisfaction at smaller scales become less significant at larger sub-national scales. The reverse is seen for other variables, which become more significant at larger scales. Regression analysis over multiple scales on three groups [1] all individuals within the sample, [2] individuals with self-reported life satisfaction as dissatisfied ( $LS \leq 5$ ), and [3] individuals self-reporting life satisfaction as satisfied ( $LS > 5$ ), show that variables critical for life satisfaction differ between subgroups of the sample as well as by spatial scale. Wellbeing measures need to be created at multiple scales appropriate to the purpose of the indicator. Concurrently, policies need to address the factors that are important to wellbeing at those respective scales and segments of the population.

## **HISTORICAL ECOLOGY INDICATORS AS ECOSYSTEM SERVICE MEASURES AND ASSESSMENTS**

*Julianna Kurpis<sup>1</sup> Frank Dirrigl<sup>2</sup>*

<sup>1</sup>University of Texas Rio Grande Valley, Department of Earth, Environmental, and Marine Sciences, Edinburg, TX, USA

<sup>2</sup>University of Texas Rio Grande Valley, Department of Biology, Edinburg, TX, USA

Historic and current human land-use activities and changes affect ecological functions and ecosystem services quality. The clearing of native Tamaulipan scrub, mesquite, and riparian forests for agricultural use and expansion followed by rapid urbanization and population growth resulted in profound ecological impacts to the Lower Rio Grande Valley (LRGV), Texas. Our study used historical ecology indicators to compare past and present land use (agriculture, residential, and commercial or industrial) impacts to measuring ecosystem services. We compared a site sample for each of these land use designations to baseline sites representing native ecological conditions in the LRGV. Indicators of habitat type, vegetation, surface conditions and visual and noise characteristics were measured at sample sites to generate ecosystem service measures of carbon uptake, aesthetics, air quality, climate regulation, and erosion control. We used the field application of Ecosystem Services Identification & Inventory Tool (ESII Tool) (EcoMetrix Solutions Group, Portland Oregon) to 1) collect ecological data and measure percent ecological performance and ecological function and service acres and 2) document historic and contemporary land use changes by producing heat map graphical representations. Our use of historical ecology indicators to compliment current site ecological conditions generated important ecosystem service measures useful to assessments and conservation land-use planning and management.

## **TRADITIONAL FIRE KNOWLEDGE AND CULTURAL BURNING: HUMAN SERVICES FOR ECOSYSTEMS**

***Frank K. Lake***

USDA Forest Service, Pacific Southwest Research Station, Fire and Fuels Program, Orleans, CA.

Traditional Fire Knowledge of the Indigenous Peoples of western North America guides tribal stewardship practices that form the foundation of teachings that the purpose of cultural burning is a form of Human services for Ecosystems. Historically, and in a modern context today-Traditional Fire Knowledge coupled with Cultural Burning was and can be once again an influential coupled socio-cultural and ecological process that affects the maintenance and production of Ecosystems Services generated from landscapes. The scale and scope of such burning results from a range of tribal resource objectives: Maintaining water quantity and quality, enhancing foods, fiber/basket materials, medicinal plants and fungi, wildlife habitat, and other habitat specific functions for a range of Natural and Cultural resources. Interdisciplinary approaches and multiple methods are used to describe and define Traditional Fire Knowledge and the effects of Cultural Burning and tribal stewardship practices on Ecosystem Services. These methods integrate Indigenous and Western Scientific approaches to evaluating how tribal-human services affect ecosystem services. The results of collaborative research and landscape restoration management strategies associated with the Indigenous Peoples Burning Network and the Western Klamath Restoration Partnership among tribes, tribal organizations, non-governmental organizations, agencies and academic partnerships will be presented. Conclusions regarding the findings and results of research and monitoring of fire effects, fuels reduction, and forestry treatments coupled with the scaling up of cultural burning to address tribal community and the public's interest and values of ecosystem services will be discussed. Recommendations for creating the best available science in partnership with tribes to inform policy development and to guide management will be featured. At the core of the recommendations are the teachings of Traditional Fire Knowledge, findings and lessons learned for how Cultural Burning can be a form of human services for ecosystems.

## **THE ENVIRONMENTAL VALUATION REFERENCE INVENTORY (EVRI) 2.0**

***Jean-Michel Larivière***

Economic Analysis Directorate, Environment and Climate Change Canada, Gatineau, Quebec, Canada

Over the past decades, the volume of published literature on the economic value of ecological goods and services has significantly expanded, and environmental considerations are being increasingly integrated into policies and decision-making. One arising challenge for academic researchers, economists, and policy analysts is to quickly and efficiently find relevant references of valuation studies amidst the growing volume of available information. Jointly developed in the 1990s by the United States Environmental Protection Agency and Environment Canada and continuously expanded ever since, the Environmental Valuation Reference Inventory (EVRI) is an online, searchable compendium containing indexed summaries of environmental and health valuation studies. These summaries provide detailed information about the study location, the specific environmental assets being valued, the methodological approaches and the estimated monetary values along with proper contextualization. With nearly 5,000 valuation study summaries available online, the EVRI is the largest database of its kind in the world.

The primary objective of EVRI is to facilitate literature review, meta-analysis, and the application of value transfer techniques for research and policy analysis. The EVRI website has recently been revamped, allowing for more efficient faceted search and data extraction features, within a streamlined, user-friendly interface. In addition, database access is now free of charge for any users across the globe.

The presentation will provide an overview of:

- what is in the database and why it is useful;
- how to search the website for relevant study summaries;
- how to extract information for literature review or meta-analysis purposes.

## HOW THE ENDANGERED STATE ACTS: REVERSE REGULATORY THREAT AND MARKET-BASED CONSERVATION POLICY

*Daniel Large and Steven Wolf*

Cornell University

Environmental non-profits, private interests, and state actors continue investing in offsetting (i.e., compensatory mitigation) despite uncertain payoffs and continued environmental losses. Proponents argue that market-based approaches will produce (i) conservation benefits at least aggregate cost and (ii) garner more political support than an appeal for regulation. In this view, market mechanisms outperform traditional state-centered regulation. To date, however, promises outweigh results. We argue, that the distinction between state- and market-based forms of environmental governance is more fuzzy than is popularly understood. In the absence of regulatory mandates or credible threat of regulation, market-based approaches to conservation premised on voluntarism appear to be incapable of producing conservation at scale. In this paper, we analyze ongoing efforts to develop habitat Exchanges—platforms for trading biodiversity credits to offset habitat disturbance—to investigate this phenomenon. Through analyzing development of Exchanges for greater sage-grouse in Colorado and Nevada, we explore how *reverse regulatory threat* fueled the emergence, development, and crisis of Exchanges. Reverse regulatory threat emphasizes a perversion of traditional models of governance in which credible public regulatory threats structure private actors' investment and management decisions and put a floor under negotiations. We observe a situation in which state regulatory capacity itself has become an endangered resource within environmental policy. Reverse regulatory threat refers to a governance context in which regulators – both government and NGOs - are unable or unwilling to constrain private interests and economic activity. In analyzing the construction and administration of Exchanges, we identify processes that serve to maintain legitimacy of Exchanges and their sponsors as a coherent and attractive conservation strategy, despite a lackluster record of achievement. Based on our findings, we argue for assessing market-based policy strategies such as Exchanges as environmental management platforms that require a muscular public regulatory mechanism. Without political will and capacity to regulate private economic actors market-based schemes are likely hollow.

## **INCENTIVIZING ECOSYSTEM SERVICES - PRESUMPTION TO PRACTICE TO POLICY**

***Stephanie Larson<sup>1</sup>, Dan O'Connell<sup>2</sup>, Adam Livingston<sup>3</sup>***

<sup>1</sup>University of California Agriculture and Natural Resources, Santa Rosa, CA, USA

<sup>2</sup>University of California Agriculture and Natural Resources, Fresno, CA, USA

<sup>3</sup>Sequoia River Land Trust, Visalia, CA, USA

Since the Millennial Ecosystem Assessment (2005), efforts to value and protect ecosystem services have advanced at various local, state, national and international levels. Many case studies and success stories have documented a variety of spatial and temporal scale opportunities that recognize ecosystem services benefits. However, these ecosystem services are often taken for granted, leading to underinvestment in the natural systems that sustain them – a market failure that hits particularly hard in rural areas.

From clean water and nutritious food to climate stability and outdoor recreation, California's working landscapes provide essential benefits to our economy, health and quality of life. These lands include: farmlands, ranches, forests, wetlands, mines, water bodies and other natural resources lands, both private and public. The public does not always have a good understanding of ecosystem services or the management that is required to maintain them. As a step towards increasing understanding of ecosystem services and working landscapes, modeling tools, including InVEST, have been applied. Tools provide quantitative assessments of the ecosystem services provided by working landscapes, a practice that is frequently used.

The University of California Agriculture and Natural Resources (UCANR), along with two consultants developed a white paper at the 2017 California Economic Summit. It documented current and potential markets for water provisions, agricultural production, climate stability, outdoor recreation, and biodiversity. It assesses the prospects for a statewide system to map and model these services across the landscape. Policy recommendations included: (1) use Enhanced Infrastructure Financing District's (EIFDs); (2) expand existing markets for farmlands and rangelands conservation; (3) expand the market for habitat conservation and carbon sequestration markets; (4) expand and integrate markets for agricultural practices that provide multiple ecosystem services; (5) provide regulatory incentives to support market participation; (6) provide technical assistance to help farmers and ranchers participate in ecosystem services markets; and (7) support mapping technology integration.

While "ecosystem services" is an accepted concept, there are few practical methodologies created to incentivize payment for such services. Education and research is needed to increase awareness of the interdependence of ecosystem services and human well-being. A stronger framework for mapping, valuing and investing in ecosystem services can help to protect California's working landscapes and narrow the economic divide between its urban and rural regions. Science must be used in decision-making policies that affect these landscapes. Through education, research and collaborative determination, landowners, managers and policymakers can forge partnerships to respond to threats such as water scarcity and climate change, and address the growing economic divide between the public that use ecosystem services and rural areas that produce them. A process that moves from presumption to practice to policy will link decisions on natural capital and ecosystem services to human well-being and an overall resilient ecosystem.

## VALUATION OF THE FLOOD ATTENUATION ECOSYSTEM SERVICE IN DIFFICULT RUN, VA, USA

**Collin Lawrence<sup>1</sup>, Emily Pindilli<sup>1</sup>, Dianna Hogan<sup>2</sup>**

<sup>1</sup>US Geological Survey, Science and Decisions Center, Reston, VA, USA

<sup>2</sup>US Geological Survey, Eastern Geographic Science Center, Reston, VA, USA

Floodplains and riparian wetlands provide several ecosystem services that directly benefit people. A major ecosystem service is flood attenuation, the ability of floodplains to retain water and reduce flow velocity, which reduces downstream flooding. We present a methodology for valuing the flood attenuation ecosystem service in Difficult Run, a suburban watershed with extensive natural floodplains in northern Virginia. High-resolution lidar-derived data were combined with GIS modeling techniques to produce estimates of flood inundation. We combined the modeled estimates with parcel-level property and primary economic data to estimate the magnitude of flood attenuation and associated property damage impacts. To derive the value of this ecosystem service for floodplains, we considered flood inundation and associated costs under current conditions (the “baseline” scenario) and with a hypothetical scenario which removes all floodplain capacity (the “counterfactual” scenario). We estimated the annualized avoided losses in terms of property damage due to flooding for the 200-, 100-, 50-, and 20-year flood events for both scenarios. The annualized values take into account the severity of the flood event based on hydrologic information, the property damages that would be expected in the case of each event, and the probability of a flood event. By annualizing the data, we estimate the benefits of Difficult Run floodplains for a single year. The difference in the baseline and counterfactual scenario provides the marginal benefit of floodplains. We estimate that the total annualized value of the flood attenuation ecosystem service in Difficult Run is \$73,412. The framework that was developed for this analysis integrates data and tools that are available for many areas of the country and could be deployed at larger spatial scales and/or in other locations. The results may be used to inform land use decision making on the impacts of development in and surrounding floodplain areas.

## **A LIFE-CYCLE ANALYSIS OF THE GREENHOUSE GAS EMISSIONS OF CORN-BASED ETHANOL**

*Jan Lewandrowski<sup>1</sup>, Jeff Rosenfeld<sup>2</sup>, and Diana Pape<sup>2</sup>*

<sup>1</sup>U.S. Department of Agriculture, Office of Energy and Environmental Policy, Washington, DC, USA

<sup>2</sup> ICF, Washington, DC, USA

Biofuel production and use can affect ecosystem services, biodiversity and human wellbeing; the efficiency of ethanol production is directly linked to the degree and direction of the effects. Our analysis shows that greenhouse gas (GHG) emissions associated with producing corn-based ethanol in the United States are about 43 percent lower than gasoline when measured on an energy equivalent basis. The reductions in GHG emissions were driven by a variety of improvements in ethanol production, spanning from the corn field to the ethanol refinery. Farmers are producing corn more efficiently and using conservation practices that reduce GHG emissions, including reduced tillage, cover crops, and improved nitrogen management. Both corn yields and the efficiency of ethanol production technologies are also improving. We project that the GHG profile of corn ethanol will be almost 50 percent lower than gasoline in 2022 if current trends in corn yields, process fuel switching, and improvements in trucking fuel efficiency continue. If additional conservation practices and efficiency improvements are pursued, such as powering refineries with sustainably produced biomass, the GHG benefits of corn ethanol over gasoline are even more pronounced —over 70 percent.

## **A NEW APPROACH TO EVALUATING THE EFFECT OF PES PROGRAM DESIGN ON OUTCOMES**

***Aaron M. Lien***

School of Natural Resources and the Environment, University of Arizona, Tucson, AZ

There are a wide range of program models available to PES program proponents depending on the ecosystem of interest, community preferences, and management goals. Decisions about how to structure a program; who can participate as buyers, sellers, or intermediaries; who has access to information about the prices of ecosystem services; and a wide range of other factors can have a significant impact on the eventual success and failure of a PES program as it relates to conservation outcomes, economic efficiency, and equity for participants. Here, I present a new approach for rigorously characterizing the governance arrangements of PES programs using a rapid assessment methodology. This method is then applied to the evaluation of water quality trading programs in the United States to determine the impact of program design decisions on outcomes. The rapid assessment methodology is grounded in common pool resource theory and draws on a modified application of the Institutional Grammar Tool (IGT). The IGT was designed to enable detailed policy evaluation by characterizing the individual components of rules, laws, and regulations. A simplification of the IGT is used to enable rapid characterization and classification of the individual rules that make up PES institutions. The rapid assessment tool is applied to water quality trading programs and then similarities and differences in program design are evaluated using qualitative comparative analysis (QCA), a method for assessing differences in qualitative datasets. The results of this work highlight key program design elements held in common by successful programs, as well as design features that respond to the unique needs of individual communities. By identifying essential program design features and rules, the outcomes of this work provide proponents of water quality trading programs with valuable new information about what governance arrangements are commonly associated with successful implementation and the critical gaps often present in stalled or unsuccessful programs.

## CHRONIC NITROGEN ADDITION ALTERS PLANT-HERBIVORE INTERACTIONS AFFECTING SALT MARSH DIEBACK AND ECOSYSTEM SERVICES

*Jewel Lipps, Edward Lopez, Stephanie Perez, and Gina Wimp*

Department of Biology, Georgetown University, Washington, DC, USA

As human activities impose new disturbance regimes onto ecosystems, species interactions and ecological functioning are altered. The type, timing, and loading of disturbances on an ecosystem may in turn alter biophysical production of ecosystem services. Atlantic coastal salt marshes generate diverse ecosystem services (storm and shoreline protection, nutrient removal, fish and shrimp nurseries, recreational fishing) which have been broadly assessed for their monetary value, but the delivery of these services hinges on the vitality of *Spartina alterniflora*, the dominant grass species that accretes the marsh foundation. Nonetheless, salt marshes are exposed to numerous human impacts, including sea level rise, urbanization, and nutrient pollution. In natural marshes that remain, landscape-level loss of *S. alterniflora* has occurred sporadically across the North American Atlantic coast, a conservation problem referred to as salt marsh dieback. When salt marsh dieback occurs, all ecosystem services are lost.

Our study examines how human-derived nutrient inputs interact with native insect herbivory to affect *S. alterniflora* mortality and salt marsh dieback. We determine how the timing and loading of nitrogen affects the *S. alterniflora* population's susceptibility to attack by stem-boring insect larvae. In the natural salt marsh in the Great Bay Boulevard Wildlife Management Area in New Jersey, we established experimental plots to compare six treatments: three levels of nitrogen (low-16 g/m<sup>2</sup>, medium-32 g/m<sup>2</sup>, and high-64 g/m<sup>2</sup>) crossed with nutrient input timing where fertilizer was either applied in equal increments over two growing seasons (press treatments) or one growing season (pulse treatments). The experiment began in May 2016 for press treatments and May 2017 for pulse treatments, and concluded in August 2017 for all treatments. We sampled 20-40 *S. alterniflora* stems for dissection in the lab to identify stem-boring insect larvae and determine insect attack rates on stems. For each plot we evaluated percent dieback. We found that stem-boring insect attack rates in the medium press and high press treatments were significantly greater than control plots. Nutrient inputs did not lead to greater percent dieback; however, percent dieback among high press treatment plots was highly variable, from 8% to 80%, while control plots varied from 4% to 22% dieback.

Our results indicate that multi-year anthropogenic nitrogen inputs in salt marshes increase rates of stem-boring insect herbivory such that salt marsh dieback occurs. *S. alterniflora* populations appear resilient to herbivory during nitrogen pulse disturbance, yet they collapse under herbivory pressure during chronically high nutrient loading. More broadly, our findings provide evidence that multi-year nutrient loading into natural ecosystems amplifies consumption effects of native insect herbivores and degrades biophysical ecosystem services production.

## **MARINE ECOSYSTEM SERVICE VALUES AND VALUATION IN THE U.S.**

*Daniel K. Lew, Kristy Wallmo, Leif Anderson, Denise Johnson, **Doug Lipton**, Michelle McGregor, and Tammy Murphy*

In the U.S., there is momentum building towards increasing usage of ecosystem-based management (EBM) approaches, which require understanding the multiplicity of ecosystem goods and services and how they affect and are affected by human users of the environment. To assess the trade-offs involved between competing users and components of an ecosystem, which are at the core of an EBM framework, decision-makers often need information on the economic value and preferences users have for ecosystem goods and services. Numerous ecosystem service values provided by marine environments have been measured using stated preference (SP) valuation approaches. In this presentation, we review the literature on U.S. marine ecosystem service values that employ SP methods and evaluate it with respect to a recent best practices guidance to identify weaknesses and strengths of the accumulated studies. Our focus is on U.S. studies for ecosystem service values of most significance to federal fisheries management, and we identify numerous gaps in the literature and challenges to valuing marine ecosystem services, as well as discuss several areas for potential improvement and inquiry.

## ASSESSING RECREATIONAL FINAL ECOSYSTEM GOODS AND SERVICES (FEGS) SUPPORTED BY TAMPA BAY, FL COASTAL HABITAT FEATURES

*Chanda Littles<sup>1</sup>, Theodore H. DeWitt<sup>2</sup>, Matthew C. Harwell<sup>3</sup>*

<sup>1</sup>ORISE Postdoctoral Fellow, US Environmental Protection Agency, Newport, OR, USA

<sup>2</sup>US Environmental Protection Agency, Newport, OR, USA

<sup>3</sup>US Environmental Protection Agency, Gulf Breeze, FL, USA

Coastal habitats contribute to numerous final ecosystem goods and services (FEGS), although assessing the value of cultural services they provide can be challenging. Fortunately, social media outlets have facilitated an innovative way to obtain data on what people value and how they interact with various coastal habitats. Flickr is one such platform that allows users to share geotagged images on a public platform, and from an ecosystem services perspective, provides the ability to measure value through revealed preference methods. Increasingly, researchers are using this type of information to assess and map cultural values, specifically recreational EGS, on the landscape. We took a similar approach to evaluate recreational use of coastal wetland habitats in Tampa Bay, FL. Tampa Bay is a prominent estuary on Florida's Gulf coast that has seen steady improvements in water quality and vegetation coverage over the last two decades. We combined data from visitor surveys, the Natural Capital Project's INVEST model for recreation, and Flickr imagery analysis to get a holistic view of the recreational FEGS supported by coastal habitat features. We evaluated FEGS depicted in Flickr photos that overlapped coastal habitats (e.g., salt flats, mangroves, beaches, marshes, seagrass beds). We then compared those revealed preference results to those from visitor surveys (i.e., stated preference) summarizing the average person-trips spent on various activities. We hypothesized recreational swimmers and boaters would be the most dominant recreational FEGS users in Tampa Bay. Interestingly, while recreational swimming was indeed the most prominent FEGS represented in visitor surveys, followed by general recreational experiences and views (e.g., hiking, birding, camping), preliminary results of revealed preferences through Flickr imagery analysis identified the same two dominant FEGS uses, but in reverse order. Results from these complimentary datasets identify key recreational FEGS that align with Tampa Bay coastal habitats and may serve as a resource for local stakeholders evaluating land-use decisions in the context of FEGS.

Note: Any mention of trade names, products, or services does not imply an endorsement or recommendation for use.

## ENGAGING THE PUBLIC IN ECOSYSTEM SERVICES THROUGH OPEN INNOVATION

*Sophia B Liu<sup>1</sup>, Jake Weltzin<sup>2</sup>, Michelle Tamez<sup>3</sup>, Nathaniel (Than) Hitt<sup>4</sup>, and Cassie Hoffman<sup>5</sup>*

<sup>1</sup> Innovation Specialist, Science and Decisions Center, U.S. Geological Survey (USGS), Reston, VA, USA

<sup>2</sup> Ecologist and Program Manager, U.S. Geological Survey (USGS); Director, USA National Phenology Network; Tucson, AZ, USA

<sup>3</sup> Inventory, Monitoring & Assessment Specialist, Ecosystem Management Coordination, USDA Forest Service, Washington, DC

<sup>4</sup> Research Fish Biologist, Leetown Science Center, U.S. Geological Survey (USGS), Kearneysville, WV, USA

<sup>5</sup> Social Scientist and Director of Field Operations, Conservation X Labs, Washington, DC, USA

Open innovation is a paradigm that solicits contributions from external volunteers, users, and other stakeholders. Crowdsourcing, citizen science, and civic hacking are all forms of open innovation that recognize and leverage the public as valuable resources. The ubiquity of internet access, mobile devices, and low-cost sensors has enabled citizens to be human sensors, collect and analyze data, and validate scientific models at unprecedented scales. Crowdsourcing and citizen science are participatory approaches for gathering ideas, content, or services by soliciting contributions from a large group of people with relevant skills, resources, and/or experiences. Civic hacking is a creative and collaborative approach to problem solving and soliciting innovative solutions and fresh ideas from the public in an accelerated fashion. Tapping into the wisdom of the crowd and emerging networks of volunteers, on the ground and online, can enhance scientific research, address societal needs, and increase scientific literacy at much broader scales in more efficient ways. For the ecosystem services community, it is even more vital to engage the public in the widest sense to understand the variety of ways people use and value the natural environment. More discussions are needed to mitigate conflicts of interests when ecosystem service providers are also the ones monitoring and evaluating the provisioning.

This panel aims to discuss how open innovation can and has enhanced the field of ecosystem services and natural resource management. Dr. Jake Weltzin will describe the implementation and operation of the USA National Phenology Network, which provides a platform for agencies, organizations, and citizen scientists to collect, store, manage, and display data, maps and other products related to seasonal plant and animal activity at local to national scales. Michelle Tamez will describe U.S. Forest Service citizen science projects related to recreation, culturally important plants, and other topics, as well as explain how engaging in collaboration with partners and diverse communities including tribes, youths, and non-profit organizations is creating opportunities for shared stewardship of public lands. Dr. Than Hitt will discuss a case study demonstrating how citizen science improved climate change forecasts for streams in Appalachia, and a new crowdsourcing project with New York state schools to estimate fish abundance using 360-degree video and virtual reality applications. Dr. Cassie Hoffman will describe open innovation approaches used by Conservation X Labs to inspire new approaches to conservation and ecosystem management. Conservation X Labs uses inducement prizes and challenges, maker competitions, and its collaborative innovation platform to identify and source new ideas and projects for conservation and support these ideas through development. During the discussion, panelists will discuss how open innovation can enable the identification, measurement, and analysis of ecosystem services; when it is (in) appropriate to engage the public; and the opportunities and challenges with engaging the public.

## THE MONONGAHELA NATIONAL FOREST PILOT GIS ECOSYSTEM SERVICES DECISION AID

*Christopher Haberland<sup>1</sup> and Luanne Lohr<sup>2</sup>*

<sup>1</sup>Department of Linguistics, University of Washington, Seattle, WA, USA

<sup>2</sup>USDA Forest Service, Research and Development, Washington, DC, USA

Ecosystem services vary across a forested landscape. Typically a single geographic unit offers multiple potential benefits to users. Managers often have to choose among competing uses when making site investments and landscape plans. Various factors including scientific support, public input, expert opinion, and planning directives inform the choices made. While the cost of making a site or landscape investment is relatively easy to calculate, the value of the benefits associated with the investment may be difficult to estimate. For national forest managers and planners, the tradeoffs inherent in making choices that affect all users is a daily consideration. The Multiple-Use Sustained-Yield Act of 1960 requires that “In the administration of the national forests due consideration shall be given to the relative values of the various resources in particular areas.” (SEC. 2. 16 U.S.C. 529).

Characterizing ecosystem services and their valuation spatially offers several benefits. The variability in ecosystem services across a landscape is captured visually in maps. In evaluating projects for a particular landscape, managers can use map layers to compare benefits and costs in terms of ecosystem services. When siting a project, managers can quickly compare ecosystem services impacts of the project on different site choices. Combining map layers demonstrates tradeoffs within a landscape, indicating the interaction of ecosystem services that can be considered when making investments or siting projects. Additionally, map layers offer a consistent description of forest resources so that teams can rapidly familiarize themselves with ecosystem services, even if they are new to the forest.

The pilot GIS decision tool was developed in collaboration between Forest Service Research and Development and the Monongahela National Forest (MNF) as a way to consolidate national databases, forest level data, and manager and researcher expertise into a visual format. The approach produced map layers that describe values of ecosystem services across the MNF, where both market and nonmarket values are assigned to areas based on their underlying biophysical characteristics. The final map layers can be overlain to aid in visualizing the tradeoffs associated with management decisions. For example, an area of water quality degradation might seem a good candidate site for restoration, until the endangered species layer is added, and it is apparent that an endangered salamander is prospering in that habitat. Another example is using map layers when choosing a location for a timber sale to consider the value of lost ginseng value that might be associated with the cut at each candidate location. It is also possible to identify “hot spots” where there are so many values accruing to a site that extra investments might be warranted to enhance and protect the sites.

The method and examples will be presented, with special attention to a new tool for recreation valuation mapping. Recreation value is particularly difficult to capture, so seeing relative valuation presented spatially can highlight where investments can be most beneficial.

## **THE ECOSYSTEM SERVICES POTENTIAL AND OUTCOMES OF PUBLIC OPEN SPACE IN RESIDENTIAL SUBDIVISIONS: A STUDY OF MONTGOMERY COUNTY, PA**

***Amy J. Lynch***

Department of Geography, Ohio University, Athens, OH, USA

Most local governments in the United States require that developers set aside open space when subdividing land for residential development. Regulations commonly include provisions intended to maximize the environmental and recreation benefits of the space, for example by encouraging developers to connect public open space to other local green spaces. But the impact of these types of regulations on on-the-ground open space characteristics and configurations is unclear. While residential open space has the potential to support a variety of ecosystem services, there is little research on the contents of the regulations and the size, use, and connectivity of the resulting open spaces. This research seeks to understand the characteristics of residential open spaces in Montgomery County, Pennsylvania over the past 30 years, their relation to the recommendations of local subdivision regulations, and the degree to which they include characteristics that support biodiversity and ecosystem services. Using GIS analysis of tax parcel data, satellite imagery, and interviews, I examine the size, use, management, and configuration of over 100 public open spaces across Montgomery County. The data elucidates the characteristics of residential open space in the county and the connection between on-the-ground open spaces and their associated subdivision regulations. Informal interviews with planners working in Montgomery County clarify the potential reasons for the observed outcomes. The study finds that the provisions that are most supportive of the natural environment – use and connectivity regulations – are advisory and not strictly enforced, and that the level of success varies dramatically between communities. This research suggests that public open spaces are often environmentally underutilized, but provide an opportunity for planners and decision-makers to support the natural environment in areas where functional systems and connectivity are in short supply.

## **DOES ENERGY SECTOR GENERATE SIGNIFICANT ECOSYSTEM SERVICES BENEFITS? BENEFITS OF AGRICULTURAL INTERCROPPING IN SOLAR FACILITIES**

***Jordan Macknick***

Ohio University

Many agricultural operations have high energy requirements and ample land availability that could be utilized without negatively affecting agricultural productivity, providing an excellent opportunity for solar technology deployment. There are also opportunities to co-locate agricultural production underneath and in between solar infrastructure under a variety of configurations. Such approaches can lead to various benefits and tradeoffs of both solar energy output and crop production. In some configurations, solar PV output can be increased due to cooler microclimate conditions underneath the solar arrays that boost system efficiency. Agricultural output and water use efficiency can also be improved by the partial shading of the crops, especially in arid environments. There is still uncertainty regarding the overall market potential, rural economic development capability, and specific solar configurations that best accommodate agricultural needs.

## **ECOSYSTEM SERVICES: FACILITATING GREEN CLEANUPS AND THE BENEFICIAL REUSE OF CONTAMINATED SITES**

***Michele Mahoney<sup>1</sup>, Carlos Pachon<sup>1</sup> and Frank Avvisato<sup>2</sup>***

<sup>1</sup> Technology Innovation and Field Services Division, Office of Superfund Remediation and Technology Innovation, United States Environmental Protection Agency, Washington, DC, USA

<sup>2</sup> Superfund Redevelopment Initiative, Office of Superfund Remediation and Technology Innovation, United States Environmental Protection Agency, Washington, DC, USA

In the post-industrial revolution era, communities worldwide are endeavoring to address contamination and waste as it impacts both public health and the environment. With the push for greener, more sustainable technologies, we still are addressing legacy contamination that impacts ecosystem services – from regulating services that facilitate water purification, air quality, water availability and erosion, to provisioning services that provide food, fuels, fresh water and other basic resources. Cultural ecosystem services are also negatively impacted in historic mining communities, indigenous heritage lands and other areas where the sense of place has been impacted by contamination.

The United States Environmental Protection Agency (EPA) has the mission of protecting human health and the environment, addressing contamination and restoring formerly contaminated properties to support reasonably anticipated future uses. Ecosystem services play a vital role in cleanup of these sites, both to achieve cleanup and as a restoration end point signaling cleanup is complete. This session will share how EPA considers ecosystem services in the site assessment and remedial phases, as well as how restoration of ecosystem services via cleanup is bringing about the beneficial reuse of formerly contaminated lands.

Best management practices for incorporating ecosystem services into remedy selection and implementation will be shared through experiential examples at various stages of the conceptual process for considering ecosystem services during cleanup activities. Examples will focus on remedial projects at Superfund sites, some of the most hazardous contaminated sites in the United States, and the lessons learned about incorporating consideration of ecosystem services into remedial action. Cleanups facilitate the beneficial reuse of these sites, restoring ecological function and re-establishing ecosystem services that had been disrupted by contamination.

Reuse and restoration of ecosystem services leads to both tangible and intangible reuse benefits for the community from economic assets and recreational amenities to pollinator habitat and flood control. These results have striking impacts at the local, regional and national levels and illustrate the importance of considering ecosystem services in future federal, state and local government decision-making. Resources, references and site examples providing greater detail about EPA's consideration of ecosystem services in remedial projects and in providing beneficial reuse can be found on the Technology Innovation and Field Services Division's Ecosystem Services Web area at: <https://clu-in.org/ecotools/ecosystem.cfm>

## **URBAN FOREST INVENTORY - DATA FOR QUESTIONS WE DON'T YET KNOW TO ASK**

### ***Mark A Majewsky***

USDA Forest Service, Northern Research Station, Forest Inventory & Analysis, Tofte, MN

The Forest Inventory and Analysis (FIA) Program of the USDA Forest Service reports on the status and trends in forest land health, growth, area, location, and ownership. The 2014 Farm Bill instructs FIA to “Implement an annualized inventory of trees in urban settings, including the status and trends of trees and forests, and assessments of their ecosystem services, values, health, and risk to pests and diseases.” FIA met this mandate by collaborating with the Northern Research Station’s i-Tree unit to expand FIA’s monitoring efforts to include all trees and ground cover within Census-defined urban areas. Program implementation started in Baltimore, MD, and Austin, TX, during the 2014 field season and has expanded into 35 cities in 25 States; 12 of which have both their proposed cities as well as all urban areas active as of the 2018 field season.

UFIA provides a continuous flow of long-term monitoring data across both rural and urban ecosystems on both public and private property. The program focuses on the census defined 68 million acres of Urban Areas / Urban Clusters (UAUC) throughout the nation while also applying special emphasis on about 100 cities throughout the nation. The plots are annualized based on a specific cycle length with an annualized remeasurement starting immediately after the initial cycle of plots is completed. This process will then provide of rolling average of updated forest change data moving forward. In this session, I will provide a program update and focus on the past 5 years of collaboration, partnerships, and progress while exploring the approaches that are being used to complete field work as well as share how our cooperators are adding value to the base program.

## **HIGH WATER: FLOOD MANAGEMENT AS AN EMERGING DRIVER FOR ECOSYSTEM SERVICES INVESTMENT**

*Sara O'Brien*

Willamette Partnership, Portland, Oregon, USA

*Presented by: Nicole Maness*

Climate change and continuing development of flood-prone areas are coming together to make flood management a major concern for many US cities. At the same time, local governments and their stakeholders are gaining a greater awareness of the role more naturally functioning floodplains can play in reducing flood damages and providing other ecosystem services. As a result, cities are increasingly developing more integrated and comprehensive approaches to flood and floodplain management that include protection and restoration of natural floodplain functions.

As a driver for investment in ecosystem services, flood management looks quite different from other traditional models. The motivations and incentives informing decisionmaking, including the policy and economic drivers involved, are different. So too are the desired end goals and the tools – policy, technical, and financial – available to achieve those goals. This presentation will explore all of these differences, as well as some similarities, and suggest ways for those in the ecosystem services community to tap into this rich vein of interest in ecosystem services investment by another name.

## **ECOHYDROLOGY MODELING TO PREDICT EFFECTS OF ENVIRONMENTAL CHANGE ON RIVER INFLOWS AND ASSOCIATED ECOSYSTEM SERVICES IN TILLAMOOK BAY, OREGON, USA**

*Darryl E. Marois<sup>1</sup>, Theodore H. DeWitt<sup>1</sup>, Robert McKane<sup>2</sup>, Hilmar A. Stecher<sup>1</sup>, Cheryl A. Brown<sup>1</sup>, Paul Pettus<sup>2</sup>, Patrick Clinton<sup>1</sup>*

<sup>1</sup>U.S. EPA Western Ecology Division, Pacific Coastal Ecology Branch, Newport, OR USA

<sup>2</sup>U.S. EPA Western Ecology Division, Ecological Effects Branch, Corvallis, OR USA

Estuarine river watersheds provide valuable ecosystem services to their surrounding communities including drinking water and habitat for fish and wildlife; they also affect estuarine water quality. However, the provisioning of these services can be affected by changes in the quantity and quality of river water, such as those caused by altered landscapes or shifting temperature and precipitation trends. We used the ecohydrology model, VELMA, in the Trask River watershed to simulate the effects of environmental change scenarios on estuarine river inputs to the Tillamook Bay (Oregon) estuary. The Trask River watershed is 453 km<sup>2</sup> and contains extensive agriculture, silviculture, urban, and wetland areas. VELMA was parameterized using existing spatial datasets of elevation, soil type, land use, air temperature, precipitation and river flow. Water quality samples were gathered in the lowlands and forested areas of the Trask River watershed to calibrate the biogeochemical portion of the model. Hydrology calibrations using USGS river flow data achieved a Nash-Sutcliffe Efficiency of 0.85 for the period of 2007 to 2016. Simulated land use change scenarios include wildfire events and comparisons of varying timber harvest plans. Other scenarios simulated include a 5 °C increase in air temperature, which resulted in a 13% decrease in annual flow volume compared to baseline conditions. Our research demonstrates the utility of ecohydrology models such as VELMA to aid in watershed management decision-making related to ecosystem goods and services. Model outputs of river water flow, temperature, and nutrient concentrations can be linked with other models to predict effects on ecosystem services such as the provision of drinking water, habitat for valued salmonid populations, and improvement to estuarine water quality (important for recreation and aquaculture). This modeling effort is part of a larger framework of connected models being developed to simulate the networked hydrology and ecology of the estuary, the coastal waters, and the estuarine watersheds. This framework ultimately aims to provide a more complete model of the many factors influencing estuarine ecosystem functions and the services they provide to their associated communities.

## **INCORPORATING THE SOCIAL BENEFITS OF ECOLOGICAL RESTORATION INTO PLANNING, DECISION MAKING, AND MONITORING**

**David M. Martin<sup>1</sup>, Marisa Mazzotta<sup>1</sup>, Justin Bousquin<sup>2</sup>**

<sup>1</sup>U.S. Environmental Protection Agency, Narragansett, RI, USA

<sup>2</sup> U.S. Environmental Protection Agency, Gulf Breeze, FL, USA

Ecological restoration has traditionally been planned by evaluating ecosystem conditions, biodiversity, and production of ecosystem services, whereas evaluating the social benefits of restoration is uncommon. We present a decision-making approach to evaluate the social benefits of restoration, in terms of who benefits and by how much, to aid in comparing multiple courses of action in urban areas. Our approach was developed through a collaborative case study in the Woonasquatucket River watershed, which spans rural land to the urban city center of Providence, Rhode Island. We partnered with a non-profit watershed organization to prioritize dozens of candidate wetland restoration sites in terms of potential flood water retention, scenic landscape, education, recreation, bird watching, and social equity benefits. We developed 24 benefit indicators based on several site characteristics: potential beneficiaries, site access, complementary landscape features that potentially enhance benefits, landscape features that may substitute for site benefits, social vulnerability to stressors, and how reliably benefits will be provided into the future. We applied conceptual modeling and spatial analysis to estimate indicator values for each candidate restoration site. Lastly, we developed a decision support tool to quantitatively aggregate the indicator values and help the organization prioritize the restoration sites for writing grant applications to fund restoration in the watershed. Results indicate that restoration sites in urban areas can provide greater social benefits than sites in less developed areas. This research provides an alternative way of planning for ecological restoration to that of traditional planning studies. We close by emphasizing the need for research into monitoring the social benefits of ecological restoration.

## **DO TAKE IT PERSONALLY: BUILDING PUBLIC SUPPORT FOR NATURE-BASED SOLUTIONS THROUGH VALUES-BASED MESSAGING**

***Jessie Martin***

Program Director, Earth Economics, Tacoma, WA, USA

For most public investments to move forward, the benefits need to outweigh the costs. So, if we want our leaders to invest in nature, we need to give them the tools that make those benefits clear to everyone. But making the jump from upstream water filtration as an ecosystem service to a lower water utility bill for downstream households requires some mental gymnastics, and clearly explaining that concept to others once you've grasped it yourself is even more complex. Through storytelling language and values-based messaging, we can make the benefits of nature clearer and more memorable, and we can present investment in natural assets as a shared interest for diverse communities.

## SANITATION FOR AND BY NATURE

*Katharine Cross<sup>1</sup>, Rob McDonald<sup>2</sup>, Nathan Karres<sup>3</sup>, Sara Mason<sup>4</sup>*

<sup>1</sup>Basins of the Future Program, International Water Association

<sup>2</sup>Global Cities Program, The Nature Conservancy

<sup>3</sup>Global Freshwater Program, The Nature Conservancy

<sup>4</sup>Nicholas Institute for Environmental Policy Solutions, Duke University

There are 2.4 billion people living without sufficient sanitation. For another 2.1 billion, wastewater drains directly into surface waters. Despite improvements over past decades, unsafe management of fecal waste and wastewater still presents a major risk to public health and the environment. There are various nature-based solutions (NBS) which can be part of wastewater treatment systems, supporting the removal of wastewater contaminants such as bacteria, heavy metals and high levels of nutrients. These NBS include: constructed and natural wetlands, wastewater treatment ponds and soil infiltration systems, and green roofs and vertical gardens.

A Science for Nature and People Partnership (SNAPP) working group, with support of the Bridge Collaborative, is developing an evidence based guidance document and decision-support tool to help wastewater utilities and their partners determine which NBS could work for their communities, and to identify and quantify important ecosystem based co-benefits of NBS. The guidance assesses both the technical feasibility and practicality of placing effective nature-based sanitation solutions in diverse local and cultural contexts. The decision-support tool will enable utilities and municipal governments to input the wastewater needs of their communities, as well as preferences about co-benefits, and will provide output on which NBS options are feasible. The aim is to provide information which can inform investment and resource use in operation and maintenance of sanitation services which serve both human and ecosystem health.

This guidance and decision-tool represent a unique informational product that discusses NBS options while putting human health, habitat, and livelihoods co-benefits at the forefront. It aims to put valuable NBS information in the hands of utilities and municipal governments who are making decisions about wastewater treatment. We hope it can also enable local environment, public health, and economic development organizations to partner with wastewater utilities to achieve goals related to important NBS co-benefits for habitats, public health, and human well-being.

## **MAKING CARBON PAYMENTS WORK FOR BIODIVERSE HABITATS: LESSONS FROM CALIFORNIA'S CLIMATE INVESTMENTS PROGRAM**

***Virginia Matzek***

Department of Environmental Studies and Sciences, Santa Clara University, Santa Clara, CA, USA

Programs that pay landowners for greenhouse gas (GHG) emissions reductions resulting from ecological restoration offer both promise and peril for biodiversity conservation. Conservationists have rightfully raised concerns about a narrow focus on carbon sequestration leading to “bio-perverse” outcomes, such as monoculture plantings, use of non-native species, and inappropriate site choices. This talk describes the development of carbon accounting protocols for ecological restoration under the State of California’s Climate Investments Program (also known as the Greenhouse Gas Reduction Fund). Policy features of the Climate Investments program permit the design and implementation of funding mechanisms that can better safeguard habitat quality and non-carbon ecosystem services than typical market-based carbon offsets programs.

Relying on case studies from riparian/floodplain forests and oak woodlands on range, I first describe the process of quantifying carbon stocks in these ecosystems, which have been little studied for their GHG impacts. I then describe how to construct a typology of conservation interventions for these systems based on the level of conservation threats and what is known about best practices for restoration; perform consultations aimed at improving the likelihood of stakeholders adopting the measures; address the possibility of perverse outcomes for GHG reduction and for habitat if interventions occur; and evaluate the efficiency of this climate investment against other potential investments in GHG reduction. This set of recommendations from the experience of designing protocols for the California system can be instructive for others working in the California Climate Investments space, as well as for those designing other carbon payment mechanisms focused on land-use change.

## **NATIONAL POLICY UPTAKE AND IMPLEMENTATION OF NATURE – HUMAN WELL-BEING CONCEPTS IN AFRICA, ASIA-PACIFIC, EUROPE, AND THE AMERICAS**

*Simone Maynard<sup>1,2</sup>, Hans Keune,<sup>3,4</sup> and Roger Keller<sup>5</sup>*

<sup>1</sup>Simone Maynard Consulting, Australia

<sup>2</sup>Australian National University, Australia

<sup>3</sup>Belgian Biodiversity Platform, The Research Institute for Nature and Forest (INBO), Belgium

<sup>4</sup>University of Antwerp, Faculty of Medicine and Health Sciences, Belgium

<sup>5</sup>University of Zurich, Department of Geography, Switzerland

This research aims to stimulate much needed discussion on national policy uptake and implementation of concepts that link nature with human well-being (e.g. ecosystem services). A key goal of global environmental science-policy interfaces (SPIs) such as the Millennium Ecosystem Assessment (MA) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is to inform and improve national policy uptake and implementation of such concepts. Results from our 2016 online global survey of IPBES National Delegates (n = 83 respondents from 54 countries) show after the uptake of nature – human well-being concepts in policies on nature conservation and protected area management, uptake in others is variable by policy type and ecosystem services included.

To date SPIs have focused mainly on ‘gathering existing knowledge and data’ for regional and global assessments of nature and human well-being relationships. Independent academic literature has focused more on the ‘process’ underpinning SPIs. Less attention has been given to the “link” between science and policy essential to identifying and addressing barriers and opportunities to countries uptaking and implementing such concepts. It is here at the goal of IPBES this research has focused. Specifically, the challenges, gaps, needs and opportunities nations face when attempting to uptake and implement nature - human well-being concepts (as presented to them through scientific outcomes of SPI regional and global assessments). Although some barriers and opportunities to uptake and implementation will be unique to a country or region (i.e. context dependent), others will not.

All countries can learn from other countries’ national policy experiences in uptaking and implementing nature – human well-being concepts, including by listening to the current perspectives of their experts.

This presentation will provide findings of our survey by IPBES region: Africa, Asia-Pacific, Europe and the Americas. It reveals what definitions are most commonly used by countries to describe nature - human well-being concepts in national policy (e.g. ecosystem services, nature’s benefits); which national policies nature - human well-being concepts are incorporated into (e.g. protected area, energy); what nature - human well-being concepts are being managed under a range of different national policies (e.g. forestry, wetlands); and the current perspectives of national representatives to IPBES on the challenges, needs, gaps and opportunities their nation has faced in trying to uptake and implement these. Further refining and expanding of this survey over time will provide information for national governments to learn from each other, a tool for measuring uptake and implementation of nature – human well-being concepts, and to monitor the influence of SPIs such as IPBES.

## **THERE'S CARBON IN THEM THERE WILDERNESS AREAS**

*Daniel W. McCollum, Pamela M. Froemke, **Michael S. Hand**, Christopher Huber*

USDA Forest Service

Carbon sequestration is an important service provided by forest and rangeland ecosystems. Wilderness Areas, largely comprised of forest and rangeland ecosystems, are one source of carbon sequestration services, but what do we know about them? How much sequestration occurs in Wilderness Areas, and how is it distributed across the country? Are there particular geographic concentrations of Wilderness carbon sequestration? Is carbon sequestration in Wilderness different than carbon sequestration in other areas depending on ownership, management, habitats, or susceptibility and response to disturbances? Are there discernible trends in the status of Wilderness Areas as sinks or sources of carbon? We consider these questions, and others, by using Forest Inventory data and USGS carbon flux data to map amounts and concentrations of carbon sequestration across different regions of the country. We then overlay those maps with GIS layers such as land ownership, habitat types, reserved use status, and disturbance patterns, among others, to characterize carbon and how it ebbs and flows depending on where it is located. We are then left to consider: Is there anything we can do to supplement and/or enhance Wilderness carbon sequestration?

## THE SPATIOTEMPORAL INFLUENCE OF URBAN DEVELOPMENT PATTERNS ON FLOOD MITIGATION ECOSYSTEM SERVICES

*Kelsey McDonough<sup>1</sup>, Jia Liang<sup>2</sup>, Stacy Hutchinson<sup>1</sup>, Trevor Hefley<sup>2</sup>, Shawn Hutchinson<sup>3</sup>*

<sup>1</sup>Department of Biological and Agricultural Engineering, Kansas State University; Manhattan, KS, USA

<sup>2</sup>Department of Statistics, Kansas State University; Manhattan, KS, USA

<sup>3</sup>Department of Geography, Kansas State University; Manhattan, KS, USA

Urbanization is a detrimental influence on the hydrologic streamflow regime by compromising the ability of the natural landscape to absorb, store, and slowly release water. However, the hydrologic response of a watershed to urbanization impacts is spatially heterogeneous and is not well understood over space and time, largely due to the individual nature of the watershed in question. This research utilizes landscape metrics to examine spatiotemporal patterns of land cover change across a developing watershed in the central U.S. to assess the influence of changing land cover patterns on flood mitigation ecosystem services. Expected outcomes include the identification of land cover categories that significantly influence flood mitigation ecosystem services and quantification of the level of influence. The authors hypothesize that high connectivity and density of impervious land cover classes will result in a loss of flood mitigation services, while the same patterns of forested land cover classes will enhance flood mitigation services.

## **INNOVATIVE TOOLS FOR APPLYING THE NEVADA CONSERVATION CREDIT SYSTEM WITHIN THE SAGEBRUSH ECOSYSTEM**

***Kelly McGowan***

Nevada Sagebrush Ecosystem Program, Department Of Conservation And Natural Resources, Carson City, NV, USA

The State of Nevada has developed the Conservation Credit System (CCS) to appropriately offset anthropogenic disturbances within the Sagebrush Ecosystem, primarily addressing Greater Sage-grouse habitats. One of the innovative aspects of the CCS is that it uses a single metric to evaluate both the benefit and detriment of conservation areas (credits) and proposed developments (debits), respectively. The single metric, or Habitat Quantification Tool (HQT), is being used to measure credits and debits, and prioritize state seed-funded projects. It is incentivizing debit projects to minimize impacts and influencing the location and design of cred projects.

The HQT incorporates multiple scales to ensure important landscape, local and site-scale factors are considered. The landscape-scale factors are primarily used to evaluate overall habitat and population goals and to target management actions. The finer scales (Local and Site) are more specific to analyzing and evaluating life stage needs in close proximity of the site, and cover and forage needs on the site.

A robust metric with multiple spatial scales and parameters is critical to achieving the behavior change desired, and credit buyers have the technical capability to use the GIS tools created to apply the HQT.

However, for ranchers, whom are a key source of credits, the lack of technical capabilities can be a barrier for participation. To address this issue, the State invested in an online Site-Screening Tool, which allows anyone to quickly gain a coarse understanding of the credit value of a potential credit site without any technical capabilities. The tool has been paramount in generating interest among landowners with minimal understanding of the program or technical capabilities. This tool and others that we hope to have developed will allow our Program to continue to expand participation, and increase understanding of good conservation for sagebrush ecosystems.

The State is also pursuing the use of other technology solutions to scale and streamline the CCS. Those include field data collection using mobile handhelds, remote sensing for vegetative data collection, migrating to an entirely online HQT interface, and an online registry for enrolling and tracking projects.

## **A SCIENCE-GOVERNANCE PARTNERSHIP FOR INTEGRATING ECOSYSTEM SERVICES INTO PUGET SOUND RESTORATION PLANNING**

**Robert McKane<sup>1</sup>, Brad Barnhart<sup>1</sup>, Paul Pettus<sup>1</sup>, Jonathan Halama<sup>1</sup>, Allen Brookes<sup>1</sup>, Kevin Djang<sup>2</sup>, Tarang Khangoankar<sup>3</sup>, Isaac Kaplan<sup>4</sup>, Chris Harvey<sup>4</sup>, Hem Nalini Morzaria Luna<sup>4</sup>, Michael Schmidt<sup>5</sup>, Emily Howe<sup>6</sup>, Phillip Levin<sup>6</sup>, Tessa Francis<sup>7</sup>, Joel Baker<sup>7</sup>, Stephen Stanley<sup>8</sup>, Colin Hume<sup>8</sup>**

<sup>1</sup>U.S. Environmental Protection Agency, Western Ecology Division, Corvallis, OR, USA

<sup>2</sup>Inoventures LLC, Corvallis, OR, USA

<sup>3</sup>Pacific Northwest National Laboratory, Seattle, WA, USA

<sup>4</sup>NOAA Northwest Fisheries Science Center, Seattle, WA, USA

<sup>5</sup>Long Live the Kings, Seattle, WA, USA

<sup>6</sup>The Nature Conservancy, Seattle, WA, USA

<sup>7</sup>University of Washington Tacoma, Puget Sound Institute, Tacoma, WA, USA

<sup>8</sup>Washington Department of Ecology, Lacey, WA, USA

Numerous studies have established that impacts from mounting population and climatic pressures are decreasing the capacity of coastal watersheds and estuaries to provide services essential to human health and well-being – clean drinking water, flood protection, habitat for fish and wildlife, and many other economic, social and health benefits (e.g., Barbier et al. 2011). The Puget Sound National Estuary in Washington State, USA, is one example of this global problem and search for solutions. Puget Sound communities, tribes, state and federal governments have committed substantial resources to restoring terrestrial and marine ecosystem services. However, jurisdictional barriers have often promoted a fragmented approach to restoration planning, and decision makers often do not have access to scientific information and tools for anticipating environmental, economic and social tradeoffs associated with different decision choices.

Here we describe an example of a Puget Sound science-governance partnership aimed at bringing together ecosystem scientists and restoration planners representing local communities and tribes. The goal of this partnership is to more tightly integrate ecosystem service concepts and modeling into estuarine and coastal watershed planning and management. Currently, local planners and managers face the difficult challenge of extrapolating impacts of their restoration actions over time and space and across jurisdictional boundaries. Similarly, ecosystem scientists find it difficult to accurately model large coastal watersheds such as Puget Sound (>31,000 km<sup>2</sup>) without the detailed on-the-ground knowledge that local planners and managers possess. Therefore, our partnership seeks to integrate the expertise of both groups.

Together, we are using a state-of-the-art, coupled terrestrial-marine ecosystem modeling framework to help local planners visualize how effects of their decisions will propagate downstream with far reaching benefits and tradeoffs for terrestrial and marine ecosystem services. We will briefly describe this framework and examples of its ecosystem service applications within the Puget Sound ecosystem.

## **NATIONAL MONETIZATION OF ECOSYSTEM SERVICES IN URBAN FORESTS**

**Mark McPherson**

City Forest Credits, Seattle, WA, USA

Inadequate funding and increased urbanization have exacerbated the loss of urban tree cover: 174,000 acres lost per year in the U.S. despite the documented triple bottom line benefits of a city's canopy. Almost 80% of the U.S. lives in urban areas, and these areas will increase by 8%, the size of Montana, by 2050.

City Forest Credits, a non-profit, national registry, assembled a national board and protocol drafting group in 2016 to develop two protocols for urban-forestry: one for planting and one for preservation. The scientists at City Forest Credits developed a unique Carbon+ Credit that includes a metric ton of CO<sub>2</sub> and quantified resource units of storm water runoff reduction, air quality improvement, and energy savings. These completed protocols and the bundled Carbon+ Credits are the missing links between city forest projects that need funding and private-sector credit buyers.

City Forest Credits is now working with 10 Early Adopter local groups that are developing tree preservation and planting projects in cities from Miami, FL to Pittsburgh, PA and Austin, TX to King County, WA. The majority of these projects have secured buyers for their Carbon+ Credits. Several of these Early Adopters are past the planning stage with trees in the ground or easements drafted. Some envision continuing programs, not just one-off projects. King County, for example, is preparing several pilot parcels for preservation, and intends to utilize the Preservation Protocol to preserve urban forest on over a thousand acres over a decade or more.

Locally-sourced City Forest Carbon+ Credits allow the buyers' dollars, along with triple bottom line benefits, to stay in those buyers' communities. Buyers can report the quantified benefits in resource units, and buyers will receive favorable media in the cities where their customers and employees live and work. The media opportunities will grow with time, as the trees planted or preserved will transform neighborhoods, stream sides, or parks.

Through the Early Adopter projects and buyers, City Forest Credits aims to demonstrate success with key pilot projects and programs. This work has the potential for implementation in many cities, in the U.S. and globally. It contributes toward a goal long sought by ecosystem advocates for years: bringing in much-needed private-sector dollars to fund green infrastructure and ecosystem services. As noted at the last ACES conference, these conference halls should be filled not only with environmental organizations, but also impact investors, investment bankers, and private-sector funders.

## NATIONAL PET HEALTH SURVEY: HEALTHY PETS, HEALTHY PEOPLE

*Megan Mehaffey, Jessica Daniel, Marsha Morgan, and Michael McDonald*

Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

As a society, we are interested in living in a clean and safe environment which protects and enhances our health and the health of those under our care. The interaction of chemical and non-chemical stressors from indoor and outdoor environmental exposures can result in unintended consequences such as increased spread of vector borne disease, antimicrobial resistant bacteria, and asthma. Working across disciplines, the One Health framework, provides a network of knowledge for tackling these complex health issues for not only humans, but domestic animals, wildlife and the environment. Recent epidemiological studies have reported comparable exposure and health responses in humans and domestic pets, such as, levels of heavy metals in the blood due to ingestion of lead or exposure to mercury, respiratory ailments from inhalation of particulates (wildfire smoke), common lymphomas, and infectious diseases. In this study, ecologists, veterinarians and health scientists from the One Health Commission (OHC), U.S. Environmental Protection Agency (EPA), and the U.S. Centers for Disease Control and Protection have developed a short (6-minute) online survey on pet cats and dogs with questions related to their indoor and outdoor environments, behavior and health issues. The intent of the survey is to shed light on pet health and disease issues across the US. The survey collection began in October 2017 and as of April 2018 over 2000 complete participant responses have been collected. Preliminary results show that 70% of respondents' cats and dogs spend most of their life at their current residence. Also, pets spent ~80% of their time inside the home and ~4% of their time outdoors at state or local parks. Half the homes were located within suburban neighborhoods, with low to moderate traffic and smoke exposure. Forty-five percent of the respondents reported using pesticides at their homes. The most frequently reported pet non-cancer illnesses were obesity, respiratory, stomach and bladder disease. Only 6% of the respondents reported any type of cancer occurring in their pets; the most frequently reported cancers were lymphatic and skin. Initial exploration of the spatial distribution of the survey respondents indicated that at least one complete survey has come from each of the 48 states of the conterminous U.S. The survey will continue for another two years or until 300,000 surveys have been completed. By combining the survey results with indicator data from the EPA's EnviroAtlas we will be able to explore spatial differences in pet health and diseases that have potential associations with ecosystem stressors such as pesticide use and impervious surface, drivers of change such as population density and climate, and ecosystem services such as nearby water bodies and natural areas. This abstract has been reviewed and approved by the U.S. Environmental Protection Agency. Its contents do not necessarily reflect the views and policies of the Agency.

## ESTIMATING ECOSYSTEM DAMAGES FROM WILDFIRE: COMPARISON OF TWO VALUATION METHODS

*James R. Meldrum<sup>1</sup> and Rebecca Moore<sup>2</sup>*

<sup>1</sup> Research Economist, Fort Collins Science Center, U.S. Geological Survey, Fort Collins, CO, USA

<sup>2</sup> Senior Economist, Bureau of Land Management, Fort Collins, CO, USA

Wildfires cost billions of dollars to suppress annually, yet they still often devastate lives, communities, and ecosystems. Motivated by the example of fire trespass on federally-managed lands, this presentation will compare two valuation methods for understanding the economic losses associated with the ecosystem damages from large wildfires in sagebrush ecosystems.

Fire trespass refers to the occurrence of unauthorized fire on federally-managed lands, in which the source of ignition is a result of human activity and there is evidence of negligence or intent. Agencies undertake action to recover damages in select trespass fires; such action serves both for cost recovery and as a deterrent to attempt to prevent future damage to public lands. Recoverable damages include the cost of suppression activities, emergency stabilization and rehabilitation treatments, and damages to the resources and improvements. Damages to the resources can include the loss of ecosystem services (e.g. wildlife, wildlife habitat, watershed conditions, recreational and aesthetic value); however, calculating these damages is complex and could be conducted in multiple ways.

Developing a transparent and theoretically consistent approach to calculating the damages to resources resulting from trespass fires is essential to effective decision-making about trespass action. Further, most of the relatively sparse literature on the value of natural resource damages from wildfire focuses on wildfire in forested landscapes, yet more than 40% of all U.S. federal lands are considered shrub/scrub, and these ecosystems also experience large wildfires.

This presentation will review academic and applied literature relevant to valuing resource damages resulting from large fires in sagebrush ecosystems on federally-managed lands. Specifically, it will compare two different approaches to valuing these resource damages, not only theoretically but also applying both methods to two recent case study fires. One approach, habitat equivalency analysis (HEA), focuses on estimating the cost of restoring the lost benefits, whereas the other, ecosystem service (ES) valuation, focuses on estimating the value of the lost benefits. The case studies demonstrate benefits and shortcomings from both approaches, with promise from considering a hybrid approach as dictated by circumstances of the resources affected by fire. Regardless, either method demonstrates that the ecosystem damages from large wildfires on sagebrush lands can represent a substantial loss of economic benefits to the public, for whom the lands are managed.

## **DEVELOPING A MARKET FRAMEWORK FOR AG WATER QUALITY CREDIT TRADING IN IOWA AND LAYING THE GROUNDWORK FOR EXPANSION TO THE MISSISSIPPI RIVER BASIN**

***Dustin Miller***

Attorney at Nyemaster Goode P.C. representing the Iowa League of Cities, Des Moines, IA, USA

### 1) Purpose

Following the release of the Iowa Nutrient Reduction Strategy (INRS) in 2013, the Iowa League of Cities' began exploring the development of a Water Quality Credit Trading (WQCT) program. The League received a USDA-NRCS Conservation Innovation Grant in 2015 that provided an opportunity to develop a WQCT framework as a means to advance the goals of the INRS.

### 2) Scope

Iowa has seen an increased amount of public sector investment in watersheds over the past decade. The project recognizes that motivations to reduce nutrient loading vary between municipal stakeholders (investing in wastewater as well as stormwater infrastructure improvements) and agricultural stakeholders. Though nutrient load reduction is a key motivation, other goals to accommodate economic growth, flood mitigation, source water protection, habitat development or increased farm productivity ultimately may drive stakeholder participation. The [project framework will capture these important outcomes by developing program structures that can reliably track and account for nutrient reductions, as well as other watershed or environmental improvements. To this end, the Project Team has developed the concept of a "Nutrient Reduction Exchange" (NRE) to capture these metrics.

### 3) Methods Used

The NRE will serve as a tracking system that will allow nutrient sources across the State to register and track nutrient reductions resulting from the installation and implementation of best management practices (BMPs) that target NRS goals. Iowa stakeholders have expressed interest in an Exchange capable of tracking projects and reductions in a reliable and transparent manner to gain experience with various components of a potential future WQCT program.

### 4) Results

The project has generated interest across the State from municipalities and industries to determine the final incentives but the final transition of the NRE to the Iowa Department of Natural Resources offers a chance for near term reductions to be catalogued for current and future benefit.

### 5) Conclusions

The League and the Project Team are currently focusing on finalizing details and transitioning to the Iowa DNR to show success but the Project offers the potential to leverage additional motivations to spur watershed investment while tracking the nutrient reduction of the investments.

### 6) Recommendations

The makeup of nutrient loading in Iowa, and much of the Midwest, should push for innovation that leverages multiple benefits to increase investment in watersheds and also reduce nutrient loading.

## **WETLANDS BY DESIGN: A WATERSHED APPROACH TO WETLAND RESTORATION FOR PEOPLE AND NATURE**

**Nick Miller<sup>1</sup>, Joanne Kline<sup>2</sup>, Tom Bernthal<sup>3</sup>, John Wagner<sup>1</sup>, Chris Smith<sup>3</sup>, Max Axler<sup>3</sup>, Matt Matrise<sup>3</sup>, Michele Kille<sup>1</sup>, Matt Silveira<sup>4</sup>, Patricia Moran<sup>1</sup>, Sally Gallagher Jarosz<sup>3</sup>, Josh Brown<sup>3</sup>**

<sup>1</sup>The Nature Conservancy, Madison, WI, USA

<sup>2</sup>Conservation Strategies Group, West Bend, WI, USA

<sup>3</sup>Department of Natural Resources, Madison, WI, USA

<sup>4</sup>The Nature Conservancy, Boulder, CO, USA

Wetlands provide habitat for fish and wildlife, as well as ecosystem services for people and communities. The Nature Conservancy collaborated with the Wisconsin Department of Natural Resources (WDNR) to create an online mapping decision support system—the *Wetlands by Design Explorer* ([www.WetlandsByDesign.org](http://www.WetlandsByDesign.org))—that ranks wetland preservation and restoration opportunities across Wisconsin based on potential to abate floods, improve water quality, protect shorelines, maintain streamflow, store carbon, and provide habitat. In addition to ranking individual sites based on service potential, the *Explorer* ranks watersheds at the 8-, 10-, and 12-digit HUC scales based on the relative amount of ecosystem service loss resulting from historical wetland conversion and degradation. Through *Wetlands by Design*, users may: 1) start with a site, evaluating it against the service rankings of other sites in the same watershed and watershed-scale service losses; or 2) start with a watershed, progressively zooming in through prioritized subwatersheds to identify sites with the greatest potential to meet watershed service-based needs. Created to support site identification, planning, and review for WDNR's in-lieu fee wetland mitigation program, *Wetlands by Design* was also developed to support decisions of a broad range of users with different goals, including municipalities and industries aiming to restore water quality, outdoor enthusiasts interested in fish and wildlife, and municipalities working to abate floods. *Wetlands by Design* is a product of GIS analysis and has been validated, using an independent field-based wetland functional assessment methodology, in the Milwaukee River Basin of southeastern Wisconsin. The *Wetlands by Design Explorer* identifies top-tier opportunities to protect and restore watershed health and resilience and, combined with field reconnaissance, can increase the watershed-relevance, ecosystem service delivery, and sustainability of wetland conservation efforts.

## **MANAGING WITH LOGIC: A RAPID ASSESSMENT USING BCN ANALYSIS AND THE CRITICAL LIST OF VARIABLES FOR SUSTAINING THE COMMONS**

***Miramanni Mishkin***

UNAM-CIGA Morelia, Mexico

Accessible and practical tools for informing common pool resource (CPR) management are important considering the dynamic nature of local management, particularly since the literature shows the importance of systematic yet flexible design principles that consider situational nuances for each CPR management system. This study tested an integrative method using the critical list of variables for sustaining the commons as the parameters for the Bayesian modeling in four case-studies in the Monarch Butterfly Biosphere Reserve. The results support the assertion by Agrawal (2003) and Young (2002) that critical variables are in fact comparable and their presence/absence does indeed result in specific outcomes regardless of other contextual variables. This is based on their individual and conditional impacts on the category models shown by the BCN analysis and their consistency with the findings reported by Baggio et al. (2016) in their meta-analysis. The results also support an assertion made by Baggio et al. (2016) that the same single variable cannot explain why some are successful and some are not for all cases. No single variable was the difference between compliance and noncompliance in the category models or in the meta-model. It was more the conditional influences that had the greatest impact in determining compliance. I was also able to answer the question of whether a particular variable had a greater impact than others in the mini BCN models. It was also interesting that this analysis does show that there is one variable that influences the value of a category more than the others, which was distinct from the findings in Baggio et al. (2016), though this is likely due to the difference in scale. This is a case study versus a meta-analysis and the results speak to the utility of thorough case studies as they suggested and, analyzed this way, could greatly facilitate the comparison of significant variables across cases and scales to elucidate finer dynamics present in different CPR governance systems. Moreover, with this level of detail, perhaps even finer patterns between and among CPRs. Both functions provide important information for immediate interventions and theoretical insights into CPR management and crisis mitigation in those systems.

## **NONLINEAR META-REGRESSION FOR BENEFIT TRANSFER**

***Klaus Moeltner***

Department of Agricultural and Applied Economics, Virginia Tech, Blacksburg, VA, USA

Benefit transfer is a methodology used by environmental economists and government agencies, especially the EPA, to predict dollar-valued benefits or losses to the public related to a planned environmental policy or intervention, using only existing evidence from completed studies. Generally, this evidence is quantified and compiled in a spreadsheet-type secondary data set. These data then feed into a predictive regression model, usually referred to as "meta-regression."

In recent years numerous meta-regression models for benefit transfer in the context of environmental quality changes have been proposed by the academic literature. We examine a set of popular specifications in terms of consistency with some basic utility-theoretic considerations, including the adding-up condition that is currently under much scrutiny by benefit transfer practitioners. Adding up stipulates, quite rationally, that total benefits from a large improvement in environmental quality should be equal to the sum of benefits from incremental improvements that sum up to the total change. Existing linear-in-quality meta-regressions can violate this condition by a large margin, which hampers their usefulness and adoption for policy making.

We propose a Bayesian Nonlinear Meta-Regression Model (BNL-MRM) that satisfies adding-up and other fundamental economic-theoretical properties. We compare this model to existing specifications based on econometric ease of estimation, fit with underlying data, and ability to generate meaningful and efficient benefit transfer distributions, using recent meta-data on water quality benefits employed by the EPA to inform Steam Electric Power Generating guidelines, and wetland ecosystem services, respectively.

We find that our BNL-MRM produces benefit estimates that are comparable in efficiency to those flowing from better fitting, but theoretically flawed linear models that do not satisfy adding-up.

Overall, we conclude that our methodology constitutes a viable compromise between theoretical rigor, econometric tractability, and fit with data. Given the serious practical ramifications of violating the adding-up condition we believe that the BNL-MRM opens the door for the next generation of meta-regression models tailored for benefit transfer that will be acceptable to policy makers.

## **PRACTICE, POLICY AND PROFIT: THE BUSINESS CASE FOR WORKING LANDS CONSERVATION**

**Maggie Monast<sup>1</sup>, Nicole Maness<sup>2</sup>, Kari Cohen<sup>3</sup>, Wood Turner<sup>4</sup>**

<sup>1</sup>Environmental Defense Fund, Raleigh, North Carolina, USA

<sup>2</sup>Willamette Partnership

<sup>3</sup>U.S. Department of Agriculture, Natural Resources Conservation Service

<sup>4</sup>Agriculture Capital

Working lands provide a range of ecosystem services from provision of fish and wildlife habitat, to protection of important habitat types such as wetlands and prairies to the recreational and cultural benefits that promote public health and wellness. Most of the literature on working lands describes the value of conservation-based activities to landowners in terms of their opportunity to generate additional revenue through government sponsored conservation programs or payments for ecosystem services, or describes the social and cultural value of working lands conservation in terms of land protection and/or sustaining farming and ranching as a way of life.

But how do conservation practices benefit commodity production? There is an argument to be made that protecting or restoring native intact habitat and functioning ecosystems is good for the bottom line of farms, forest and ranching systems. For example, removing invading conifer trees has been shown to improve not only the health of sagebrush ecosystems as habitat for wildlife, but also the quality of forage for livestock. Healthy populations of pollinators are considered essential to the commercial production of seed crops and fruit crops. And soil management techniques such as conservation tillage or use of cover crops help to conserve water while potentially increasing yield of agricultural crops. Articulating the value proposition of conservation to working lands could be even more important given increased uncertainty around the availability of funds at the federal level to support conservation-based programs targeted at private landowners.

This panel will describe how ecosystem services quantification and valuation can be used to make the business case for conservation on working lands – one that one that measures the value of conservation practices and outcomes to agricultural, range and forest producers and to the local communities they are part of. It will help to define terms such as *triple bottom line*, *return on investment* and *impact investing* within the context of private lands conservation and will identify options for tools, policies, and incentive programs that could make conservation an essential part of business planning for working landowners.

## **SOCIOECONOMIC ASPECTS OF NEPA ANALYSIS AT THE BLM: INTEGRATING ECOSYSTEM SERVICES INTO A LARGER STORY**

*Rebecca Moore and Josh Sidon*

Bureau of Land Management, Fort Collins, CO, USA

The BLM's socioeconomic program has worked since 2008 to assess the utility and challenges of integrating ecosystem services principles and tools into BLM's management and decision processes. Much of this work has been accomplished through several pilot studies with specific, but varied, objectives. However, ecosystem services are not the only consideration that must be evaluated in a NEPA analysis. This presentation describes efforts to incorporate ecosystem services into broader analysis of socioeconomic effects that are considered in the NEPA process.

As the program develops guidance on the socioeconomic aspects of planning and NEPA, we have drawn from many of the principles central to an ecosystem services approach. One central theme of our approach is values, or the things people care about that are affected by public lands management. Clearly, ecosystem services represent many of these values, but values are not limited to ecosystem services. Additional values may relate to market commodities, social structure, individual economic opportunity and stability, and other concepts not traditionally included in an ecosystem service framework. Borrowing from the ecosystem services literature, the approach emphasizes the connections between potential management actions and expected changes to these values. Tools such as means-end diagrams are an incredibly useful way of identifying and describing these links efficiently. Also borrowing from the ecosystem services literature, the approach strives to synthesize changes in multiple values that are likely to be measured with different metrics. Some values are fairly simple to measure quantitatively, or even monetarily. Others are more difficult to quantify, and are often described qualitatively.

Drawing on these key ecosystem service principles will allow us to more rigorously assess the variety of socioeconomic effects of potential planning or management decisions. Even more, we aim to present these effects in an integrative and cohesive story. In addition to describing the overall socioeconomic framework for planning and NEPA, this presentation will describe ongoing efforts to develop examples and documentation to assist BLM staff and contractors as they implement this framework.

## **INFORMING INVESTMENT & POLICY FOR URBAN GREEN-GRAY WATER SOLUTIONS**

***Gabriela Morales***

WRI (Word Resources Institute) México, Ciudad de México, México

Mexico City faces serious development constraints due to potentially insufficient water supply and flood risk. The corporate investors hoping to redevelop city districts are seeking practical solutions to this challenge. These urban investors have an opportunity to implement and institutionalize the best available urban water management technologies and practices in these districts, including green infrastructure; however, they also face the complex challenge of identifying the most suitable and cost-effective strategies that fit local physical, social, and legal conditions. The solutions they select should be, for example, compatible with zoning laws, feasible to implement in light of local regulations, cost-effective, and designed to provide multiple benefits to local neighborhoods. These decision makers are asking: which water management options should we adopt, where, how much will they cost, and what are their benefits, tradeoffs and financial alternatives for implementation and long-term sustainability.

To guide urban development and water management decisions in Mexico City and throughout Latin America, WRI and its partners are developing a Green-Gray Urban Water Solutions Framework. The framework helps (a) identify environmental risks and water challenges of urban development, (b) design cost-effective interventions to maximize benefits of green and gray management strategies, and (c) enable authorities to integrate these solutions into land use policies. The framework has been applied to Mexico City's Tacubaya District, and has identified solution sets that utilize green and gray infrastructure in combination.

This presentation will discuss the framework utilized to map these solutions, how decision makers have reacted to these findings, and the alternatives being explored to resolve how these 21st century urban water management solutions could be financed in Mexico City.

## **WHAT DO INVESTORS LOOK FOR IN GREEN INFRASTRUCTURE PROJECTS?**

***David Moreno***

FEMSA Foundation, Monterrey, Mexico

What are impact investors and philanthropists looking for in investible green infrastructure projects? A solid business case for investment is clearly needed, but that alone may not always be enough. Innovative financing models, such as “pay for success” and “green bonds for water,” are gaining traction to scale up investments in promising natural infrastructure projects.

Being the largest beverage bottler in Latin America and a founding partner of the Latin American Water Funds Partnership, FEMSA has been exploring opportunities to utilize green infrastructure to enhance water supply for decades. Building on this work, the FEMSA Foundation is exploring ways to catalyze investment in green infrastructure through innovative finance models. Currently, the FEMSA Foundation and World Resources Institute are partnering to facilitate natural infrastructure transactions on the ground in Latin America. They are exploring opportunities to blend investments from the FEMSA Foundation, as well as the water sector, government programs, and others to create optimal returns for project stakeholders.

The presentation will (a) provide insights and critique of the business cases presented in the first part of the session, then (b) share first-hand lessons learned on the opportunities and challenges associated with building natural infrastructure deals to provide local water security, climate resilience, and economic benefits.

## **ECOSYSTEM SERVICES FROM ENDANGERED SPECIES: ESTIMATES FROM CANADIAN DATA**

***Peter Morrison***

EcoEcoAnalysis, Ottawa, Ontario, Canada

As populations of many species drop and as little progress is made in arresting or reversing biodiversity losses, managers need to understand the implications of declining populations for the provision of ecosystem services. For species supplying provisioning services, fewer individuals generally means a decline in the services provided. For other services, such as cultural or scientific benefits, a change in the population size may have little effect. In some cases, species may be more highly valued if they are rarer. In this study, I ask four questions. The first two are

1. How does the mix of ecosystem services attributed to a given species change as its population size drops? For example, non-consumptive services may become relatively more important than direct or indirect use services.
2. How does the net value of the ecosystem services change as a species becomes more endangered? I identify the possibility of a “value pit”, in which the net value of the services is lowest just above the threshold for legal protection.

To put this analysis in a practical context, I used the sequence of assessments of the status of wild species in Canada, a recent toolkit for ecosystem services (Value of Nature to Canadians Study Taskforce, 2017), and related information to identify which groups of species are at increasing risk, to match them to the ecosystem services they provide, and then to estimate the resulting changes to net values. This leads to the last two study questions:

3. What are the implications of the observed changes in Canadian species at risk? They include shifts among groups of species and among geographic regions in terms of the ecosystem services provided.
4. What are the possible policy responses? One key management response is changes to priority setting, in terms of the timing for conservation actions, resources allocated relative to other conservation priorities, emphasis on different land owners (i.e. public vs private), and who is involved in the decision processes.

## NATURAL RESOURCE POLICYMAKERS' UNDERSTANDING AND APPLICATIONS OF CULTURAL ECOSYSTEM SERVICES

*Joshua Morse<sup>1,2</sup> and Rachelle K. Gould<sup>1,3</sup>*

<sup>1</sup>Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington VT, USA

<sup>2</sup>Gund Institute of Environment, University of Vermont, Burlington VT, USA

<sup>3</sup>Environmental Program, University of Vermont, Burlington VT, USA

The ecosystem services framework, and cultural ecosystem services in particular, aspire to help policymakers understand and effectively manage the wide range of human interests in healthy ecosystems. However, evidence of policy-uptake of ecosystem services knowledge is at best mixed, and alarmingly scarce where CES knowledge is concerned. Although many CES studies make claims to the policy relevance of their findings, little evidence exists to support the assumption that CES research is, in fact, valued and used by policymakers.

We interviewed policymakers across Vermont's natural resource community including elected officials, agency staff, non-profit advocates, and industry lobbyists, to assess their understanding and application of ecosystem services broadly and CES specifically. Our semi-structured interview protocol assessed policymakers' understanding of ES and CES conceptually, sources of information concerning CES, use or lack of use of CES information in their decisionmaking, and perceptions of their colleagues' awareness and use of CES information. Although our data are drawn from a single U.S. state, we consider Vermont a valuable case study because of its strong industrial and cultural orientations towards natural resource stewardship, and its generally robust environmental policies.

Our findings reveal varied awareness of and attitudes towards CES by Vermont's natural resources community. While most interviewees reported considering non-material benefits from ecosystems in their policy work, attitudes about empirical research to assist such efforts ranged from excitement about the potential to systematically assess non-material values linked to natural resources to skepticism about the need for scientific treatment of these hard-to-quantify values. Interviewees also reported diverse perspectives on the relationship between CES and more traditional, easily quantified and monetized ecosystem services in policy. Most interestingly, nearly all interviewees reported that stories and anecdotes – rather than empirical research – were their main sources of information about the non-material benefits of healthy ecosystems in Vermont.

Our findings suggest that policy uptake of CES knowledge in Vermont is variable, fraught with conflicting opinions on the place of empirical science in decisions involving non-material values, and grounded in narrative. Our findings also indicate that non-traditional data sources, such as stories, could be a trusted and effective vehicle for presenting CES information alongside traditional sources like surveys or geospatial assessments, and should be investigated in future studies. In light of these findings, we call for closer collaboration between the CES community and policymakers to actively identify policy priorities where CES knowledge would clearly aid in the decision process.

## **GREEN INFRASTRUCTURE AND ECOSYSTEM SERVICES ASSESSMENT IN URBAN ENVIRONMENT**

*Leila Mosleh, Masoud Negahban-Azar, and Mitchell Pavao-Zuckerman*

Department of Environmental Science and Technology, University of Maryland-College Park, MD, USA

Green infrastructure (GI) in highly urbanized environment can bring high opportunities and new settings for people to benefit from ecosystem services. Urbanized area is recently recognized as social-ecological systems that provide primary and secondary ecosystem services to human being. One of the highlights of GI especially in region with extreme climates are the ability to reduce the effect of stormwater and high intense precipitation. Although we focus on flood control and pollution reduction as a primary ecosystem services in this research, there are secondary services such as provisioning, cultural, and supporting services human can gain from GI. To ensure that we achieve proper ecosystem services we need to have an evaluation. This evaluation has to be comprehensive considering the various components affecting the performance and output of GI. Thus, the purpose of this research is developing an assessment tool and check the applicability of the assessment tool by case studies. We selected five different indicators including policy plans and strategies, system design and planning, operational and maintenance, financial, and community. For each of these indicators sets of questions were designed in the form of checklists for evaluation of GIs based on various types. Types of GIs that we considered in this research are infiltration practices, vegetated open channel, filtering practices, detention ponds, retention ponds, wetlands, and sloped vegetated area. The results demonstrate the significance and complexity of GI assessment especially when we plan to rank the resilience of a GI. Key findings demonstrate that we cannot expect gaining ecosystem services when we do not see GI in a whole system that has different component affects the performance. Maintenance is one of the neglecting features in real-world GI examples. That shows managers are more concern in building GIs compare to keeping them maintain well. In conclusion, applying the assessment tool to different types of GI was helpful to improve the assessment tool that was developed initially in terms of selecting more realistic criteria. Establishing assessment tool with assessing their applicability will assist decision makers to determine the level of resiliency in GI and promotes fault finding and seeking the solution for current shortcomings. The future for GI evaluation needs to focus on addressing the issues after evaluation, and providing periodically audit to make sure GIs are performing in an appropriate manner.

## **TOWARD ONE BILLION ACRES: A VISION FOR GROWING THE CARBON SINK**

*James Mulligan<sup>1</sup>, Debbie Reed<sup>2</sup>, Pipa Elias<sup>3</sup>, Jad Daley<sup>5</sup>, Alexander Rudee<sup>1</sup>*

<sup>1</sup>World Resources Institute, Washington DC, USA

<sup>2</sup>Coalition on Agricultural Greenhouse Gases, Washington DC, USA

<sup>3</sup>The Nature Conservancy, Arlington VA, USA

<sup>4</sup>Carbon180, Oakland CA, USA

<sup>5</sup>American Forests, Washington DC, USA

America's forests and farms are capable of sequestering hundreds of millions of metric tons of additional carbon dioxide per year. But achieving that scale would require widespread changes in the use and management of public and private lands. Overcoming this challenge may be an imperative for global climate stability, and presents an opportunity to drive investments in rural vitality and a wide range of ecosystem services.

This panel aims to build momentum, new ideas, and new partnerships for a broad-based coalition to accelerate carbon storage and other ecosystem services in natural and working lands. Panelists are each engaged in a portfolio of initiatives, partnerships, and investments geared to address key dimensions of the land carbon challenge. Building on these experiences, the panel will explore challenges and opportunities across both the forest and agricultural sectors, linkages to ecosystem services and the profitability of working lands, and near-term strategies to catalyze long-term transformation.

Specific topics include scientific uncertainty, measurement, and monitoring in the land sector; innovative mechanisms for landowner incentives and support; state policy frameworks; and public-private and intergovernmental partnerships.

## **SOCIAL ACCEPTANCE AND GOVERNANCE CHALLENGES OF ALTERNATIVE TECHNOLOGIES TO REDUCE NITROGEN ON CAPE COD**

***Kate Mulvaney<sup>1</sup>, Nathaniel Merrill<sup>1</sup>, Sarina Lyon<sup>2</sup>, Marisa Mazzotta<sup>1</sup>, Marnita Chintala<sup>1</sup>***

<sup>1</sup>U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, RI, USA

<sup>2</sup>Student Services Contractor, U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, RI, USA

Cape Cod, Massachusetts is a coastal vacationland for visitors and residents who receive many benefits from ecosystem services provided by its coastal waters. Similar to other coastal areas in New England, the ability of many of these estuaries to provide ecosystem services is being impacted by nutrient over-enrichment, as well as a number of other challenges. The state of Massachusetts, Cape Cod Commission, and town governments of Cape Cod are actively developing plans to mitigate nutrient loadings to more than 30 estuaries that have been identified in exceedance of federal and state water quality standards. Traditional sewerage efforts are being considered as well as a number of newer, alternative technologies for reducing nutrient loadings. The technologies under consideration range from source-control efforts like alternative septic systems and urine-diverting toilets to in situ reduction efforts through aquaculture or shellfish seeding for recreational harvest. The various technologies differ in social acceptance, as well as perceived costs, uncertainty in the effectiveness of the technologies for contributing to nitrogen reduction, and ecosystem service benefits. This makes their potential use challenging for those charged with meeting nitrogen reduction goals. To better understand the barriers and opportunities to implementing these technologies, we conducted 27 semi-structured interviews with participants from local, state and federal governments, regional planning bodies, and technology contractors. Overall, there is active consideration about the feasibility and possibility of using alternative technologies, but they are almost always viewed as a supplement to traditional sewerage. Identified reasons to incorporate alternative technologies included perceived reduction in costs, aesthetic or recreational ecosystem service benefits, and faster implementation. Participants highlighted the importance of framing these expectations appropriately. Barriers to the use of alternative technologies included uncertainty related to both the cost and the effectiveness of the technologies in reducing nitrogen, as well as unclear permitting, maintenance, and monitoring processes. Understanding social acceptance and perceptions of alternative technologies can inform the selection and framing of solutions that are appropriate to support ecosystem service benefits to meet local needs in Cape Cod.

## **CONSERVATION CREDIT FOR AGROFORESTRY PRODUCTION (C-CAP): BALANCING AGRICULTURAL PRODUCTION AND NUTRIENT CREDIT TRADING IN THE CHESAPEAKE BAY WATERSHED**

*John Munsell, Benjamin Addlestone, Kelly Cobourn, Sam Scott*  
Virginia Tech, Blacksburg, GA, USA

Sediment, nutrients, and chemicals from upstream farming affect the health of the Chesapeake Bay. Governmental agencies incentivize riparian plantings and other conservation measures on farms to reduce the amount of farm pollutants entering Chesapeake Bay Watershed creeks and streams. Such plantings are generally uncommon despite the best efforts of these programs. Even when adopted, long-term retention is uncertain. It is well known that landowners often hesitate to use conservation measures such as woody riparian buffers because they compete with agricultural production. One strategy for overcoming this barrier is multifunctional agroforestry, which balances nutrient management and farming activities. A public/private partnership in Virginia is studying how agroforestry practices generate phosphorus credits in the state's nutrient trading market. Agroforestry runs counter to the prevailing tendency for program participants to retire farmland by using high-density tree planting. The C-CAP project includes several initiatives: 1) research plantings on two Virginia farms; 2) modeling the relationship between TMDL goals and the rate and type of agroforestry adoption; and 3) studying tradeoffs between agroforestry farming returns and water quality benefits using a production possibilities frontier. Farm plantings demonstrate agroforestry practices and conduct empirical studies of tree-tube effectiveness, site preparation strategies, plant-water relations on contour, and nitrogen fixer intercropping. The planting also recorded all financial costs for use in economic analysis. A set of hypothetical property-level BayFAST facilities representing agroforestry conversions across a large parcel sample frame depicts the impacts of BMP adoption at the sub-basin scale. Integration of economic and biophysical models estimates a production possibilities frontier that captures tradeoffs between various rates of tree plantings and agriculture. This presentation covers these C-CAP initiatives and early findings.

## **POLICY SUCCESS FACILITATING INVESTMENTS IN NATURE**

***Sarah Murdock***

U.S. Government Relations Dept., Arlington, VA, USA

### *Purpose*

Flooding, storms, droughts, fires, managing stormwater, poor air quality, lack of access to nature for recreation. There are no shortages of challenges communities face. Nature provides a suite of so called ecosystem services or benefits that can address these challenges.

There is growing recognition and support for investing in so called natural infrastructure to solve multiple community challenges. We're seeing such provisions advance at in federal policy. We're also seeing many great examples of this through advancements in state policy.

Natural Infrastructure (a more general term related to use of nature and nature-based work to address a range of challenges) and green infrastructure (referring to more urban/suburban work to abate stormwater pollution and localized flooding) have grown in use over the past several years and are now terms commonly used and appearing in federal legislation.

### *Results*

Success in advancing federal legislative and regulatory measures comes when we can provide overall quantification of a benefit that ecosystems play in providing a benefit. Success has come when we compile specific case studies demonstrating the effectiveness and cost effectiveness of nature to solve specific challenges. We need to be able to cite the cost effectiveness of investing in nature and nature combined with more traditional grey infrastructure as compared to grey infrastructure alone.

The Nature Conservancy and other NGOs have made an effort to build the body of evidence over the past several years by publishing science and compiling case studies based on the work of the Conservancy and others.

Recent examples of this include:

In the Water Resources Development Act (WRDA) in 2016 and this year's WRDA bill, provisions advancing consideration of natural infrastructure have been and are included. This year, Chairman Carper made it one of his biggest priorities for the bill.

The Federal Emergency Management Agency has also taken strides to recognize natural infrastructure in its cost benefit methodology and as a preferred project type in its PreDisaster Mitigation grant program.

Washington State's Floodplain by Design program is an excellent example of a state appropriating funds to address multiple challenges: flooding, restoring salmon habitat, improved recreation, general community enhancements.

### *Conclusions and Recommendations*

To continue to advance the benefits of investing in natural infrastructure (conservation and restoration of natural systems), we need to document and communicate in easily accessible formats, the effectiveness and cost effectiveness of natural infrastructure. These case studies need to be from geographies around the country, in varied ecosystems, and addressing a variety of challenges. We also need to continue to gain support of influential private sector and trade associations to demonstrate the broad support for advancing efforts to mainstream investments in natural infrastructure.

## **ECOSYSTEM SERVICES MAPPING IN NORDIC COMMUNITIES – MERGING URBAN PLANNING WITH NATURE**

***Kaisa Mustajärvi***

Environment and Health, Ramboll, Finland

Incorporating ecosystem services in an urban master planning framework provides the opportunity to join nature to human activity and bring concepts of sustainable development into city and community planning. The same holds true for redevelopment of brownfield properties, where the social and ecological footprint of the built environment can be reimagined to create or restore ecological value and ecosystem services. Spatial and landscape planning, for example, can help create alternative urban patterns that protect ecosystems and thus support the provision of needed services they provide. And, brownfield properties offer great potential for preserving biodiversity as an element of green infrastructure for implementing ecosystem services into densely populated and urban environments.

The challenge in general, however, is land use dedicated to residential and economic use is becoming independent from local ecological conditions and increasingly driven by large scale processes, which results in a loss of traditional landscapes. Although land use policies have been used for decades to manage the expansion of settlement areas and transport infrastructure, spatial planning has only recently started focusing on the design of alternative urban patterns that secure the provision of essential ecosystem services. The value of Urban Nature is currently being acknowledged - there is solid and increasing evidence about the health benefits of Urban Nature to the inhabitants of the cities, the nature based solutions are valued in stormwater treatment and flood control and the value of Urban Biodiversity to City image is arising – but how to merge these factors in practice into city planning to restore the ecosystem functions and thus ecosystem services?

In this presentation we will introduce case studies to illustrate concepts and emerging practices, how Urban Nature is brought in to the city planning practices in Nordics. We will introduce City forest management plan for City of Lahti where design thinking and ecosystem services approach was used to involve citizens and create new approaches to manage stakeholder conflicts. We will also present the new approaches and pilots of Nature Based solutions developed in UnaLab project, in brownfield area of Hiedanranta and highly blue and green branded area of Vuores. The project focuses on developing co-creation processes for Nature Based solutions and also the monitoring of the functionality of these systems also in terms of the additional, ecosystem services values and using citizen sensors and continuous monitoring .

## ECOSYSTEM SERVICES AND SPATIOTEMPORAL MOSQUITO-BORNE DISEASE MODELING ACROSS A GRADIENT OF URBANIZATION

**Mark H. Myer<sup>1</sup> and John M. Johnston<sup>2</sup>**

<sup>1</sup>ORISE Research Fellow, U.S. Environmental Protection Agency, Office of Research and Development, Athens, Georgia, USA

<sup>2</sup>U.S. Environmental Protection Agency, Office of Research and Development, Athens, Georgia, USA

Vector-borne diseases are increasing in geographic extent and incidence in the United States and worldwide. Municipalities allocate resources to control arthropod vectors to protect human health using the best available information. The combined impacts of human-mediated ecosystem change and a changing climate provide new habitats for disease vectors, enable the rapid spread of infectious disease, and alter the dynamic ecosystem services that govern interactions between vector, reservoir, host, and disease agent. Understanding those processes is an important part of efforts to identify, predict, and prevent vector-borne disease.

We worked with two municipalities to utilize mosquito-borne disease surveillance datasets and develop models to forecast spatiotemporal disease incidence. In Suffolk County, New York and Nassau County, New York we obtained West Nile Virus surveillance data from 2008-2015 and 2001-2015 respectively. Suffolk and Nassau Counties, on Long Island, New York, represent a gradient of development from rural to urban land cover, allowing us to examine the differences in West Nile Virus incidence and the ecosystem services differences between those development types.

We used the INLA SPDE (Integrated Nested Laplace Approximations, Stochastic Partial Differential Equations) Bayesian method to fit spatiotemporal models of West Nile Virus incidence in *Culex* spp. in Suffolk and Nassau counties. These methods allowed us to identify spatial and temporal patterns and more accurately model disease incidence and mosquito abundance. In each municipality we began with a substantial pool of remote-sensed and publicly available datasets including land use/land cover, vegetation indices, and census data.

Our results indicated that in the more rural and exurban Suffolk County, on-site septic disposal was a significant predictor of West Nile incidence, while the presence of woody wetlands was associated with a reduction in disease incidence. Septic systems in the area are a major contributor to nitrogen pollution and eutrophication, which may have a connection to reduction in healthy wetland habitat. In suburban and urban Nassau County, we found that areas with both high vegetative index and high intensity development had lowered disease incidence, indicating that areas of intermediate development are at risk in suburban areas. Emergent herbaceous wetlands were associated with a reduction in incidence, paralleling results in Suffolk County. A further study in Brownsville, Texas is in preliminary stages, examining *Aedes aegypti* and *Albopictus* populations in an urban area of concern for the spread of Zika virus.

This research highlights the differences in variables that influence mosquito-borne disease dynamics across a gradient of urbanization, in addition to ecosystem services. In rural and exurban areas, disease incidence was affected by woody wetlands and the presence of septic systems that can adversely affect water quality, while suburban and urban areas provided ample habitat for mosquitoes and disease reservoirs in locations of medium-intensity development. We conclude that human development is a primary driver of West Nile virus incidence, while ecosystem services deriving from healthy wetland ecosystems and surface water habitats can have a protective effect.

## NUTRIENT DISTURBANCE INFLUENCES FOOD WEB RESILIENCE AFTER HURRICANE EVENT

**Melissa Naugle<sup>1,2</sup>, Shannon Murphy<sup>3</sup>, Shweta Bansal<sup>1</sup>, Danny Lewis<sup>1</sup>, Kayleigh Hauri<sup>1,4</sup>, Israel Teru<sup>5</sup>, Gina Wimp<sup>1</sup>**

<sup>1</sup>Department of Biology, Georgetown University, Washington, DC, USA

<sup>2</sup>School of Natural Sciences, California State University, Monterey Bay, Seaside, CA, USA

<sup>3</sup>Department of Biological Sciences, University of Denver, Denver, CO, USA

<sup>4</sup>Department of Entomology, Michigan State University, East Lansing, MI, USA

<sup>5</sup>Department of Economics, Pomona College, Claremont, CA, USA

Natural and anthropogenic disturbances have significant impacts on trophic groups, food webs, and ecosystem services. Since ecosystems rarely experience single or temporally isolated disturbances, it is important to examine them in concert and over different temporal regimes. Nutrient disturbance in particular can be highly variable, with nutrient deposition occurring over different temporal scales and originating from different sources. Research has shown that nutrient disturbance affects plant biomass and species abundances, but less is known about feedbacks that occur over multiple years. Further, there is evidence that consistent nutrient disturbance can promote herbivore outbreaks, which may reduce food web resilience and leave ecosystems more vulnerable to future disturbances. In this study, we examine long-term nutrient presses and short-term nutrient pulses on salt marsh food webs and their resilience after an environmental perturbation. Our study uniquely tests the effects of temporal variability in nutrient disturbance while controlling for the total amount of nutrients such that nutrient amount is not confounded with the timing of nutrient inputs. We make use of an unplanned hurricane event to measure stability in the form of resilience (recovery) after environmental perturbation. We perform a network analysis to study how the food web structure responds to nutrient disturbance and environmental perturbation. Food web network analysis provides insight into the effects of disturbance that may be overlooked by other ecological metrics. We found that food webs in all treatments were negatively affected by disturbance, but food webs in fertilized plots recovered from the hurricane more quickly than control plots, as measured by number of links and linkage density. Unexpectedly, press and pulse nutrient regimes produced no significant differences. Instead, food webs that were fertilized in the year before or after the hurricane recovered more quickly than controls and food webs that were not recently fertilized. This differential resilience is important to consider as nutrient disturbance becomes more widespread and intense storms become more frequent. Understanding food webs under temporally heterogeneous disturbance is crucial to understanding how food webs will respond to future environmental perturbations. Further, food web resilience is especially important to consider in salt marsh ecology since changes in the food web structure can affect biomass of the dominant primary producer, *Spartina alterniflora*. As the sole basis of the live food web, *Spartina* supports most of the ecosystems services provided by salt marshes including coastline protection, nutrient cycling, habitat for fish and shrimp nurseries, and recreation. Since salt marshes are experiencing major losses, often coinciding with a loss of ecosystem function, it is crucial that we understand how nutrient disturbance affects food web interactions and resilience after environmental perturbation.

## **ECOSYSTEM SERVICES IN THE CHESAPEAKE BAY WATERSHED THROUGH THE LENS OF ENVIROATLAS**

***Anne Neale, Megan Mehaffey, & Jeremy Baynes***

US Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC, USA

**EnviroAtlas** is an online collection of geospatial data, tools, and other resources related to ecosystem goods and services (EGS). Each of over 160 data layers available for the nation and each of the 100 data layers available for select communities can be tied to at least one of seven general EGS benefit categories: clean and plentiful water; clean air; food, fuel, and fiber; hazard mitigation; climate stabilization; biodiversity conservation, and recreation, culture, and aesthetics. In this presentation, we will give an overview of EGS provided by the Chesapeake Bay watershed by highlighting some of the data layers and tools available through EnviroAtlas. We will also highlight some of the drivers of change (stressors) of EGS in the watershed as well as demonstrate where ecosystem markets have been implemented. We will showcase tools that allow users to explore relationships between data layers and allow users to combine multiple data layers into index values for specific assessment endpoints (e.g., how well are fresh and coastal water quality being protected/controlled (e.g., filtration, pollutant loads, land use, protection, etc) for each 12-digit watershed.

## VALUATION OF BENEFITS FROM ALTERNATIVE BIOENERGY LANDSCAPE

*Cristina Negri, Shruti Mishra, Julian Cacho, and John Quinn*

Argonne National Laboratory, Lemont, IL, USA

Placement of bioenergy crops in marginal land of a landscape is found to contribute towards minimizing the competition for cropland by the food, feed, and energy sectors and addressing nutrient loading downstream. The environmental benefits of the alternative landscape include sediment reduction, creation of habitat for pollinators, carbon sequestration, and recreational services including freshwater recreation and hunting. Valuation of these positive externalities may create an impetus for a wider adoption of alternative bioenergy landscape.

We developed and used an integrated assessment framework that couples biophysical modelling with environmental valuation techniques to estimate the value of incremental ecosystem services attributed to alternative bioenergy landscape scenario as compared to business as usual scenario. We quantified the benefits of these scenarios based on modeled crop yields, soil conservation, and water quality improvements, as well as several other ecosystem services including carbon sequestration, freshwater recreation, wildlife viewing, and ring-necked pheasant and white-tailed deer hunting. We identified the marginal areas, which are the portions of the field where high soil water nitrate losses, susceptibility to soil erosion, water stress (too dry or wet for food crops), etc. are likely to be observed (Ssegane et al., 2015; Ssegane and Negri, 2016; Zumpf et al., 2017) using SWAT model. We estimated the benefits of incorporating switchgrass in the row-crop landscape in marginal land by first quantifying the change in ecosystem services associated with the incorporation of switchgrass and then monetizing the benefits. We will present the results for our study sites in Kaskaskia watershed in Illinois. Our preliminary results for the ecosystem services for the watershed ranges from \$290 to 733 attributed to nitrate reduction service of alternative bioenergy landscape, \$13 million for carbon sequestration, and \$28 million for wildlife viewing.

## TRENDS IN PROTECTED AREA REPRESENTATION OF BIODIVERSITY AND ECOSYSTEM SERVICES IN FIVE TROPICAL COUNTRIES

**R.A. Neugarten<sup>1</sup>, K. Moull<sup>2</sup>**

<sup>1</sup>Conservation International, Arlington, VA, USA

<sup>2</sup>University of Poitiers, France and University of Coimbra, Portugal

1. Purpose: Increasingly, protected areas (PAs) are expected to fulfill the dual role of biodiversity conservation and ecosystem services (ES) provision. Commitments by countries under the Convention on Biological Diversity in 2002 and World Parks Congress in 2003 resulted in an expansion of PA networks in many countries. Understanding whether countries are achieving protection targets requires understanding how well PAs are spatially representing important areas for biodiversity and ES.
2. Scope: Our analysis included five tropical countries (Cambodia, Guyana, Liberia, Madagascar, and Suriname). These countries are all characterized by globally significant biodiversity and a high level of human dependence on natural ecosystems, but represent different geographic contexts, levels of historic forest cover loss and human population density.
3. Methods: We analyzed the spatial representation of biodiversity priority areas, forested areas, and ES within terrestrial PAs in Cambodia, Guyana, Liberia, Madagascar, and Suriname in 2003 and 2017. We analyzed whether spatial representation of biodiversity and ES has improved over time, and whether additional gains would be possible if the existing PA network were reconfigured.
4. Results: We found that four of the five countries expanded their terrestrial PA networks during the study period. In both time periods, PAs spatially represented biodiversity priority areas, forests, and forest carbon stocks as well as, or better than, would be expected if they were randomly configured. For other ES, PA representation was no better than or worse than would be expected by chance, and trends over time were mixed.
5. Conclusions: Improved spatial representation would be possible if PAs were reconfigured to optimize for biodiversity or ES.
6. Recommendations: This indicates that countries could protect the most important places for biodiversity or ES without necessarily expanding their PA networks.

## **EPA'S ECOSERVICE MODELS LIBRARY (ESML): A NEW TOOL FOR QUANTIFYING AND VALUING ECOSYSTEM SERVICES**

**Tammy A. Newcomer-Johnson<sup>1</sup>, Randall JF Bruins<sup>1</sup>, Gregg Lomnicky<sup>2</sup>, John Wilson<sup>2</sup>, Theodore H. DeWitt<sup>3</sup>**

<sup>1</sup>US EPA, Office of Research & Development, Systems Exposure Division, Cincinnati, OH, USA

<sup>2</sup>CSS, Corvallis, USA

<sup>3</sup>US EPA, Office of Research & Development, Western Ecology Division, Newport, OR, USA

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

## **METHODS FOR VALUATION OF ECOSYSTEM SERVICES WHEN DESIGNING BLUE GREEN INFRASTRUCTURE - CASE STUDY, SWEDEN**

*Ingrid Nilsén Boklund<sup>1</sup>, Lottie Carlsson<sup>2</sup>, Lars Johansson<sup>3</sup>, Karin Skantze<sup>1</sup>*

<sup>1</sup>Environment and Health, Ramboll, Sweden

<sup>2</sup>Urban Planning, Ramboll, Sweden

<sup>3</sup>Project Management, Ramboll, Sweden

Quality of life in cities is closely connected to ecosystem services. In some parts of the world, the ability of ecosystems to regulate the local climate, reduce flooding and provide space for recreation is vital for creating city environments that are liveable. In this context, a liveable city supports a healthy population and protects air, water, parks and open space, as well as biodiversity. Many cities worldwide, however, find it difficult to prioritize space for urban blue and green infrastructure because urban demands for land development continue to increase. It is increasingly evident among urban planners that cities become vulnerable, losing social meeting places and biodiversity as parks and natural areas are converted to hard surface development. Preserving and strengthening urban blue and green infrastructure where ecosystem services are locally generated is a significant challenge for urban planners when developing new, modern environments.

This presentation describes a case study from the Swedish city of Norrtälje where an ecosystem services analysis was conducted in 2017 to examine a proposed residential development area called Lommarstranden. The analysis included mapping of existing ecosystem services to establish a base line condition and projection of the likely future condition associated with the changed land use. The work included mapping studies and workshops with officials from the municipality of Norrtälje and with reference groups from the city. The mapping was followed by a prioritization of ecosystem services and a non-monetary base line valuation on scale from 1 to 3, where 1 point represented “small amount of services”, 2 points “moderate amount of services” and 3 points “high amount of services”. The valuation was followed by an impact analysis on how the residential development would affect the value of the area’s ecosystem services. When visualized in a rose diagram the potential positive and negative consequence of the proposed development on ecosystem services were clearly evident and guidelines for preservation, strengthening and/or creating ecosystem services most important to the municipality were identified.

The valuation and impact analysis of ecosystem services created client value by making it possible to communicate the socio-ecological values of the area to stakeholders, developers and politicians. The guidelines on how to preserve, strengthen and/or create ecosystem services in Lommarstranden are now being implemented and handled within a zoning plan and sustainability program for the municipality. The municipality of Norrtälje has, by initiating an ecosystem service analysis early in the development process, created a platform for future sustainability work. The analysis has also helped to communicate how the strong ecological and recreational values of Lommarstranden will be preserved and strengthened to maintain and develop the character of the area for existing and future residents of Norrtälje.

## REGIONAL ADVANCE MITIGATION PLANNING IN THE SAN FRANCISCO BAY AREA: IMPLEMENTING RAMP IN THE BAY AREA FOR ECOSYSTEM SERVICES AND INFRASTRUCTURE BENEFITS

**Liz O'Donoghue**

Director of Infrastructure and Land Use, The Nature Conservancy – California Chapter

Transportation agencies in the San Francisco Bay Area plan to implement over 680 transportation projects over the next 20 years – roads, bridges, transit, and rail lines to serve the growing population and thriving economy. As a global biodiversity hot spot, the Bay Area hosts an extraordinarily rich array of valuable natural communities and ecosystems that provide habitat for rare plants and wildlife, and support residents' health and quality of life by providing clean drinking water, clean air, opportunities for outdoor recreation, protection from disasters like flooding, landslides, local food and adaptation to climate change. As the Bay Area grows, it is important that it happens in a manner that protects and enhances the region's natural resources, farms and ranches. Transportation and natural resource agencies are working together to develop an innovative way to advance needed infrastructure projects more efficiently and provide more effective conservation of our natural resources and working lands through *Regional Advance Mitigation Planning (RAMP)*. Plan Bay Area 2040 articulates this vision, with its balanced approach toward regional growth patterns and conservation of the region's parks, open spaces, farms, and ranches. The Metropolitan Transportation Commission and the State Coastal Conservancy are sponsoring the RAMP effort as it incorporates a regional and coordinated approach to infrastructure development and natural resources and working lands conservation, delivering benefits to both sectors.

Many of those transportation projects will have impacts that may result in increased fragmentation, and degradation of existing habitats and species. Most transportation projects require environmental mitigation as prescribed in each project's environmental document to reduce the potential impact as well as compensate for any impacts that do occur. In the Bay Area, mitigation activities often occur on a per-project basis, with each project individually satisfying its own mitigation requirements. This approach is often expensive, not integrated with a regional conservation vision, and done late in the project delivery cycle, thereby losing valuable conservation opportunities to conversion to other land uses and resulting in project delivery delays. RAMP aims to integrate conservation into infrastructure agencies' plans and project development well in advance and on a regional scale to reduce potential impacts of transportation projects, drive mitigation dollars to protect important ecological functions that are at threat of loss and protect working lands and accelerate project delivery.

The initiative has identified potential transportation impacts, developed a regional conservation assessment and drafted a document identifying potential mitigation opportunities that satisfy predicted mitigation needs. The locations of the mitigation opportunities will be run through the [Bay Area Greenprint](#), a new tool that reveals ecosystem services contained in the San Francisco Bay Area. The Greenprint is organized around nine nature's benefits and services: water (water yield, water quality and water hazard risk reduction), biodiversity (habitat connectivity, prioritized habitats, species that require mitigation), agriculture (food production), carbon (above ground and soil carbon) and recreation (regional trails). The greenprint also provides information on urban greening potential (air pollution, urban heat island, park need, urban forest need and stormwater retention). By integrating the RAMP program with the Bay Area Greenprint, planners and stakeholders can understand the co-benefits of potential mitigation opportunities, thereby protecting ecosystem services through mitigation.

## **BUILDING ECOSYSTEM SERVICES CONCEPTUAL MODELS FOR FEDERAL DECISION-MAKING**

*Lydia Olander, Sara Mason, and Katie Warnell*

Nicholas Institute for Environmental Policy Solutions, Duke University, Durham, NC, USA

The desire to use an ecosystem services approach to integrate considerations of both people and the environment in decisions continues to grow; however, simple methods that can help managers understand and integrate ecosystem services are lagging behind. One method that can help support widespread incorporation of ecosystem services into decision-making is the use of ecosystem services conceptual models (ESCMs). These conceptual models link changes in biophysical systems caused by an intervention to socio-economic and human well-being outcomes. They can help get stakeholders and experts on the same page, provide an intuitive entry point for those new to ecosystem services, identify a set of common socio-economic indicators for monitoring outcomes, create a foundation for evidence-based qualitative assessment or quantitative models, and provide consistency across applications within an agency or across agencies in a region.

Despite the potential usefulness of these models, there are few examples of their use in federal or state applications to build from and little published detail on how to implement them. In this project, we worked in partnership with two federal agencies, The National Oceanographic and Atmospheric Administration (NOAA) and the U.S. Bureau of Land Management (BLM), to develop ecosystem services conceptual models and evidence libraries for salt marsh restoration and solar energy development. For NOAA we demonstrated how a general model can be used to develop site specific models. This work provides proof of concept examples and builds a community of practice familiar with these ESCMs within federal agencies. From the experience gained during this project we developed the first version of a guidance document on how to develop and use ESCMs that has been released as part of the National Ecosystem Services Partnership Federal Resource Management and Ecosystem Services (FRMES) guidebook. The ESCM methods are now being applied in the Gulf of Mexico to develop consistent Gulf-wide conceptual models and socio-economic indicators for common restoration strategies, and on Department of Defense bases to lay the foundation for the development of predictive models.

## **LINKING RESTORATION IMPACTS TO ECONOMIC, HEALTH, AND WELLBEING BENEFITS FOR PEOPLE IN THE GULF OF MEXICO**

*Lydia Olander<sup>1</sup>, David Yoskowitz<sup>2</sup>, Chris Shepard<sup>3</sup>, Heather Tallis<sup>3</sup>, Katya Wojk<sup>2</sup>, Sara Mason<sup>1</sup>, Lauren Hutchinson<sup>2</sup>, and Katie Warnell<sup>1</sup>*

<sup>1</sup>Nicholas Institute for Environmental Policy Solutions, Duke University, Durham, NC, USA

<sup>2</sup>Harte Research Institute for Gulf of Mexico Studies, Texas A&M University Corpus Christi, TX USA

<sup>3</sup>The Nature Conservancy

Billions of dollars will be devoted to restoration of Gulf of Mexico ecosystems over the coming decades. However, no common framework for assessing and reporting on restoration effectiveness and progress toward shared overarching environmental, social, and economic goals currently exists. At this point, everyone in the Gulf uses different frameworks and indicators to assess potential restoration projects, and monitor and track progress over time, making it hard to assess the credibility of any given approach and to compare outcomes. This also makes it impossible to assess the overall benefits achieved by restoration spending across the Gulf. While other efforts are focused on understanding and tracking the biophysical restoration in the region, little has been done to assess the broader ecosystem services outcomes - the social, health, and economic benefits that are targeted by Gulf funding programs and meaningful to Gulf stakeholders. A common conceptual framework, an ecosystem services conceptual model (ESCM), can be a foundation on which to build consistency and credibility in application and monitoring inclusive of the socio-economic outcomes. An ESCM can be developed for any given site and context-specific intervention or created as general reference model for a type of intervention. Given a constrained set of ways in which managers manipulate the natural environment and a fixed number of effects such management can have on the environment and people, it seems possible to establish a reference set of evidence-based conceptual models that become a go-to resource that can provide desired efficiency and consistency in application (Olander et al. 2016). These models can also be the foundation for selecting a common set of core indicators that can be tracked and monitored across projects and sites to allow comparison, and roll-up of regional outcomes for evaluating and reporting on the social, health and economic benefits achieved by restoration spending.

Our project focuses on advancing standardized Gulf-wide ESCMs and socio-economic indicators of restoration success through a collaborative approach with practitioners, community members, technical experts, and decision-makers. Our first round of state-level estuary-scale working groups developed ESCMs for a number of different water quality management projects - those focused on both green and gray infrastructure options - aimed at restoration goals for the Gulf. Despite working in five different states and across numerous varied project types in each state, there are sufficient similarities to develop a representative reference ESCM and core set of common indicators that capture critical outcomes related to everything from fisheries and tourism to employment, community health, and recreation. Our next steps are to work with experts and decision makers across the region to align the reference ESCM and common indicators with the needs of funders and decision makers at the regional level, and insure that local needs can still be met. In year 2, we will complete the same process for additional restoration approaches, most likely coastal wetland and oyster reef restoration.

## **ENVIRONMENTAL INFRASTRUCTURE AS A FRAMEWORK FOR CITY-BUILDING**

***Sean O'Malley***

Managing Principal, SWA Group, Laguna Beach, CA, USA

Integrating ecological processes with a site's natural systems – from the waterfront to rural open space – has significant benefits for urban design and planning. This design process results in a natural formal expression of a site's character; seamless relationships between settlement patterns and ecological systems; increased interconnectivity between urban and open spaces; reduced environmental impacts; less need for hard infrastructures; and wildlife habitat preservation.

In this session, we investigate contrasting conditions in the US and China, from urban waterfronts to suburban communities. How do we protect citizens against rising floods, improve water quality, and provide access to nature? How do we integrate wetlands, gathering places, eating places- plants, animals, and people- together? How do we transition from city to nature; what are the appropriate patterns in the rural ring?

## **INTEGRATING GREEN INFRASTRUCTURE INTO WATER RESOURCES AND DISASTER RISK MANAGEMENT: INSIGHTS FROM DEVELOPMENT BANKS AND OTHER INVESTORS**

**Suzanne Ozment**<sup>1</sup>, **Marianne Fay**<sup>2</sup>, **Beth Bafford**<sup>3</sup>, **Denis Jordy**<sup>2</sup>, **Raul Munoz Castillo**<sup>4</sup>

<sup>1</sup>World Resources Institute, Washington DC, USA

<sup>2</sup>World Bank, Washington DC, USA

<sup>3</sup>Calvert Investment Capital, Washington DC, USA

<sup>4</sup>Inter-American Development Bank

A new generation of water infrastructure and disaster risk management projects is necessary to achieve water security and development goals, as well as to make progress on poverty alleviation, climate change, and sustainability objectives. Today, the investment need is largely outpacing investment flows, and this trend is only expected to continue as the impact of climate change sets in. Solutions that are cost-effective, enhance service provision, show resilience in a changing climate, and contribute to social welfare goals must be developed and deployed worldwide.

Integrating green infrastructure with gray infrastructure can help fill this need. Natural systems can be used in combination with conventional gray infrastructure to potentially provide lower cost and more resilient water-related services such as water supply, flood and drought management, hydropower, and irrigation. Although green infrastructure may not be appropriate for every project or location, opportunities to utilize green infrastructure in project designs are still frequently overlooked.

The World Bank and World Resources Institute are publishing a new report that encourages developing country service providers to routinely consider and integrate green infrastructure in their water and disaster risk management infrastructure projects. It provides general approaches and examples on how to evaluate green infrastructure on par with gray infrastructure on a project-by-project basis.

This panel will explore next steps to build the knowledge base and enable more high-quality, well-planned green infrastructure to be integrated into mainstream projects. Speakers from investment firms and development banks will share perspectives on what is needed to scale up investments in green infrastructure, pointing to successful examples as well as practical challenges. Several case studies will be discussed.

## **NATURE'S RETURN ON INVESTMENT IN SÃO PAULO'S WATER SUPPLY SYSTEM**

**Suzanne Ozment,<sup>1</sup> Rafael Feltran-Barbieri,<sup>1</sup> Perrine Hamel,<sup>3</sup> Erin Gray<sup>1</sup>**

<sup>1</sup>World Resources Institute, Washington, DC, USA

<sup>2</sup>The Natural Capital Project, Stanford, CA, USA

Restoring native forest is a natural infrastructure strategy that could be used for water management in the Cantareira System, São Paulo's primary water supply system. Using WRI's Green-Gray Assessment, we assessed natural infrastructure investment opportunities on two water management objectives: reduce sediment management costs and secure water flows in the Cantareira System. We found that targeted restoration of 4,000 hectares (ha) of native forest in the Cantareira System would cost about US\$38 million, depending on strategies employed. This investment would reduce soil erosion by roughly one-third, which avoids costs associated with dredging, water treatment, and equipment depreciation for a 21 percent return on investment. We faced significant gaps regarding natural infrastructure's impact on water availability but found that targeted restoration of forests is likely to have a very small, potentially positive, impact on water availability.

Local natural infrastructure programs operating in the Cantareira need additional funding to become fully operational. Our findings can guide their strategy to improve project performance and generate interest from potential financiers, including the local water company and water management agencies.

This study is part of a series of Green-Gray Assessments that WRI is conducting in Latin America. After application at several sites, the Green-Gray Assessment is ready for streamlined application at other sites. Its increased use will catalyze investor engagement in natural infrastructure programs, and contribute to the growing evidence base regarding the role of natural infrastructure in water management.

## **AN ARGUMENT FOR LONGLEAF PINE- COMPARING ECONOMICS OF YELLOW PINES ACROSS SOUTHERN UNITED STATES**

*Karuna Paudel, Stephen Matthew Kinane, David Dickens, Puneet Dwivedi*

Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, USA

The Southern United States supports about 20% of the pulpwood production worldwide and is rightly known as the “pulpwood capital” of the world. Almost 80% of the planted forest in the region is either loblolly or slash pine. The story was different during the early 1900s where longleaf pine covered nearly 30 million hectares relative to the current range of only 1.2 million hectares. While there remains a spatial difference in the yield of each three species, no study has so far compared economics of these species in an integrated platform. An understanding about geographical variability in the economics of yellow pines can help policy makers better target resources and increase the total area under longleaf pine. Hence, 45 scenarios were simulated using Timber Mart South (TMS) prices and SIMS (Simulator for Managed Stands) to estimate LEVs (Land Expected Value) of planted loblolly, slash, and longleaf pine across the Piedmont, the Upper Coastal plain (UCP) and the Lower Coastal Plain (LCP). Our results show better economic returns for longleaf pine in the Piedmont with LEV of \$1397 than loblolly pine with \$1340 at site index 60. In the UCP, at site index 60 LEV was same for slash and longleaf. While, in the LCP, loblolly is highly profitable than slash and longleaf. We also found that landowners could harvest longleaf as early as 22 years due to historically low sawtimber prices and higher pulpwood prices. This is compounded by the fact that the majority of longleaf stands are currently on the old agricultural fields with high fertilizer, aiding in earlier rotation. Hence, targeting landowners in the Piedmont and UCP while ensuring incentives that cover the difference in economic returns of planting loblolly in the LCP can be the optimal way of restoring longleaf acreage across the Southern United States.

## **IMPACT OF LAND USE AND LAND COVER CHANGE IN THE SPATIAL ASSESSMENT OF ECOSYSTEM SERVICES IN PHEWA WATERSHED, NEPAL**

*Kiran Paudyal, Himlal Baral, Santosh Prasad Bhandari, Rodney John Keenan*

The University of Melbourne, Melbourne, Australia

Community-managed forested landscapes are complex social-ecological systems that supply a variety of ecosystem services (ES) to society. The flow of these services depends on land use and land cover (LULC) patterns, composition and vegetation types and spatiotemporal changes. ES assessment helps to deal with the complexity of interrelationship between LULC, ES supply and societal benefits. Using a case of Phewa watershed, Nepal, this paper carries out a quantitative and qualitative appraisal of priority ES to understand how the supply of ES and their societal benefits have changed over the past 40 years. The LULC change was analysed using satellite images, ES were assessed using biophysical data and expressed spatially using ArcGIS. Results indicate that significant changes in LULC had a positive impact on ES due to the conversion of agricultural/grasslands and degraded forests to dense forests. Maps show that ES varied significantly across the watershed. Dense forests provided relatively higher volumes of sediment retention, carbon stocks, biodiversity maintenance, and raw materials but reduced the water discharge over the last four decades. Increased aesthetic value from the restored landscape provides higher opportunities for recreation and ecotourism. Analysis of benefits using relevant indicators reveals that the wider societal benefits of most of ES were significantly lower compared to the supply of respective ES in the watershed.

## **ECOSYSTEM SERVICES IN SHORELINE PLANNING AND DESIGN: CASE STUDIES FROM THE NORDICS**

*Derek M. Pelletier and Richard J. Wenning*

Balancing nature conservation and human development in cities and coastal communities has become an important societal consideration. This is especially true in Nordic countries, where there are many examples of protection or enhancement of natural habitats incorporated into the design and construction of man-made structures. Ecological engineering has emerged as a discipline dedicated to achieving development goals while mitigating the impacts of river and coastal shoreline structures. “Working with nature” and “nature by design” are important concepts in this discipline, reflecting the practice of eco-shoreline planning, design, and construction in the Nordics.

Eco-shoreline projects provide beneficial functions to the local ecosystem through a range of active or passive solutions that are integrated with commercial and residential development goals in urban waterways and coastal ports and harbors. In the Nordics, this is fundamental to achieving sustainable and environmentally friendly construction. Eco-shoreline projects are designed to support a range of ecosystem services such as providing aesthetic benefits through public open spaces; flood and cloudburst protection during extreme weather; and ecological benefits through construction of wetlands and related aquatic habitats. This is accomplished by merging conventional “hard” engineering approaches for shoreline structures with “soft” engineering approaches that preserve or enhance ecology and biodiversity.

Economic practicality, engineering safety, sustainability and social value remain key considerations for planning and design in eco-shoreline projects. This presentation will describe several examples of eco-shoreline projects in Denmark, Finland, Norway and Sweden that aim to mitigate the impacts of habitat loss or degradation caused by urban residential, transport and infrastructure development, or integrate conservation and enhancement aquatic environment into a resilient and livable cities framework.

## **ECOSYSTEM-BASED BUSINESS DEVELOPMENT FOR LOW-RESOURCE COASTAL COMMUNITIES**

*Anna Phelan and Damian C. Hine*

Business School, the University of Queensland, Brisbane, Australia

The marine ecosystems in the Selayar Regency of South Sulawesi Province in central Indonesia are experiencing the pervasive socio-economic challenges of overfishing and destructive fishing practices as well as the impacts of climate change. For coastal communities in this region, local economic development must include a delicate balance between protecting marine biodiversity and maintaining a sustainable and direct access to ecosystem services. Aimed towards strengthening coastal ecosystem management this study is part of the CCRES (Capturing Coral Reef and Related Ecosystem Services) project. This study examines how micro, small and community-based enterprises in coastal communities can support marine ecosystem services. Using semi-structured interviews, focus groups and direct observation we develop three complementary pathways of sustainable small-scale fisheries, responsible tourism and value-added products. We examine how these complementary pathways can enhance primary income and support local livelihoods through value capture and market access. The outcomes from this study offer guidance for ecosystem-based business development initiatives in coastal communities that address both the impacts of human activities and the need to sustain or restore the goods and services that are generated by healthy ecosystems.

## ESTIMATING SOCIETAL BENEFITS OF CARBON DIOXIDE SEQUESTRATION THROUGH PEATLAND RESTORATION

*Emily Pindilli<sup>1</sup>, Rachel Sleeter<sup>2</sup>, and Dianna Hogan<sup>2</sup>*

<sup>1</sup>US Geological Survey, Science and Decisions Center, Energy and Minerals Mission Area, Reston, VA, USA

<sup>2</sup>US Geological Survey, Eastern Geographic Science Center, Reston, VA, USA

The Great Dismal Swamp National Wildlife Refuge (GDS) is a forested peatland that provides a number of ecosystem services including carbon (C) sequestration. We modeled and analyzed the potential capacity of the GDS to sequester C under four management scenarios: no management, no management with catastrophic fire, current management, and increased management. The analysis uses the Land Use and Carbon Scenario Simulator developed for the GDS to estimate net ecosystem C balance. The model simulates net C gains and losses on an annual time-step from 2013 through 2062 which is converted to carbon dioxide equivalent (CO<sub>2</sub>-eq) and monetized using the Interagency Working Group's Social Cost of Carbon. Our analysis incorporates compounded uncertainty including variation in ecological processes, temporal and spatial heterogeneity, and uncertainty in the discount rate. The no management scenario results in 2.4 million tons of CO<sub>2</sub> emissions with a Net Present Value (NPV) under a 3% discount rate of -\$67 million. No management with catastrophic fires emits 6.5 million tons of CO<sub>2</sub> with an NPV of -\$232 million. Current management avoids 9.9 million tons of emissions (via sequestration) with an NPV of \$326 million. Increased management avoids 16.5 million tons of emissions with an NPV of \$524 million. Our research suggests the significant contribution of forested peatland management as a C mitigation strategy.

## RECONCILING LOCAL DEMANDS AND CONSERVATION TARGETS IN AMAZONIA

**Daniel Pinillos**<sup>1,2</sup>, **René Pocard**<sup>2</sup>, **Marc Corbeels**<sup>2</sup>, **Felix Bianchi**<sup>1</sup>, **Mário de Oliveira**<sup>3</sup>, **Rogier Schulte**<sup>1</sup>

<sup>1</sup>Farming Systems Ecology, Wageningen University and Research, The Netherlands

<sup>2</sup>Centre de Cooperation Internationale en Recherche Agronomique pour le Développement, CIRAD, UPR AIDA, Montpellier, France. SupAgro, Univ Montpellier, Montpellier, France.

<sup>3</sup>Núcleo de Apoio a Pesquisa e Transferência de Tecnologias, NAPT Belém/Brasília, Embrapa Amazônia Oriental

Deforestation rates in Brazil have undergone an unprecedented decline of more than 70% since 2005. Changes in policies, institutions and social movements provided a platform for this radical slowdown. Moreover, in 2012 a revised version of the Brazilian Forest Code determined that all rural properties in the Amazons should maintain between 50-80% of their area as native forest, known as Legal Reserves (LR), and 100% of the riparian forest. To achieve these targets, deforested properties should subscribe to an Environmental Regularization Plan (PRA).

Nevertheless, recent research indicates that biodiversity and carbon storage are still decreasing in areas of eastern Amazonia due to forest fragmentation and degradation. The current government policies and mechanisms are not efficient at incentivizing PRA compliance, nor at connecting forest patches to create a structural network of connected habitats and optimize carbon storage. The Paragominas municipality is one of the oldest frontier towns in this region heading towards agricultural intensification and environmental conservation. We explore land use change scenarios in this area to decrease forest fragmentation while taking into account local economic demands.

First, we applied the Functional Land Management framework to assess the spatial variability of three ecosystem services (ES): commodity production, carbon storage and habitat for biodiversity. This assessment was linked to a farm typology based on a survey of 40 farms, to farmers' perceptions on LR and ES using the Q methodology, and to jurisdictional agricultural and environmental policies. Land use changes were modelled in ArcGIS by simulating forest restoration in deforested areas with poor soils, and agricultural intensification on soils suitable for agriculture currently covered by degraded forest. Using FRAGSTAT 3.3 for spatial pattern analysis, we explored landscape scenarios where forest fragmentation decreases as compared to the current status.

The goal of these scenarios was to optimize the allocation of agricultural land and forested areas according to soil characteristics, farm type and ES supply. Our interviews suggest that landowners show interest in building efficient landscapes based on these scenarios, as an alternative to the Forest Code requirements, which they perceive as an imposition that weakens local production. Thus, our models intend to reconcile federal conservation goals with local demands by taking a jurisdictional approach to harmonize local development, commodity chains and ES.

This study combines technical aspects of ES with local demands for ES by actors in the area, and thus contributes to the ongoing discussion of an integrated zoning for the agricultural sector in eastern Amazonia. This is nevertheless a complex process that involves a multidimensional assessment and ample negotiations among an array of stakeholders across scales.

## **ASSESSING ECOSYSTEM SERVICE SUSTAINABILITY IN LIVESTOCK PRODUCTION**

**Sarah J. Pogue<sup>1</sup>, Tim A. McAllister<sup>1</sup>, Roland Kröbel<sup>1</sup>, H. Henry Janzen<sup>1</sup>, Karen A. Beauchemin<sup>1</sup>, Carrie Selin<sup>2</sup>, Majid Iravani<sup>2</sup>, Aklilu W. Alemu<sup>1</sup>, Shannan M. Little<sup>1</sup>, Getahun Legesse<sup>3</sup>, Danielle Maia de Souza<sup>4</sup> and James Byrne<sup>5</sup>**

<sup>1</sup> Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada

<sup>2</sup> Alberta Biodiversity Monitoring Institute, Edmonton, Alberta, Canada

<sup>3</sup> Manitoba Agriculture, Brandon, Manitoba, Canada

<sup>4</sup> Département de stratégie, responsabilité sociale et environnementale, Université du Québec à Montréal, Montréal, Québec, Canada

<sup>5</sup> Department of Geography, University of Lethbridge, Lethbridge, Alberta, Canada

Producing food to meet rising global demand requires a more thorough understanding of how farming systems can ensure food security without compromising economic, environmental and social sustainability. Our research outlines a regionalised, farm-level, social-ecological systems approach to the assessment of ecosystem service provision from beef production systems in the Canadian Prairies. Canada is the 11<sup>th</sup> largest producer and 5<sup>th</sup> largest exporter of beef globally, and the prairie provinces collectively support just over 80% of the national beef herd. As global demand for meat continues to grow, there is a need to weigh the contribution of this industry to the Canadian economy against the full range of positive and negative ecological and social impacts of beef production. Furthermore, the development of ecosystem service markets in agricultural systems requires in-depth knowledge of management impacts on ecosystem service dynamics. Our research focuses on nine ecosystem services: livestock, water supply, water, air and soil quality regulation, climate regulation, disease regulation (zoonotic diseases), cultural heritage, and recreation and tourism.

A regionalised approach facilitates ecosystem service assessment within different prairie ecoregions, acknowledging that governance and management, social-ecological capital and processes and human user groups vary amongst them. Within each region, we apply the assessment framework to example whole farms from “cradle-to-gate”, incorporating the dominant management practices adopted throughout grazing on pasture, confined feeding operations and forage/feed production. For each of these example farms, we identify and describe the different system components and the relationships between them: (1) governance and management strategies; (2) social-ecological capital and processes that underlie ecosystem service provision; (3) ecosystem services provided by the system and resulting benefit flows; and (4) dimensions of human well-being influenced by changes in the supply of ecosystem service bundles, user groups whose well-being is affected, and feedbacks between well-being and system governance and management. We also propose a set of indicators to evaluate changes in service provision and human well-being.

This work represents an interdisciplinary, social-ecological systems approach to ecosystem service assessment for beef production in the Canadian prairies. Such an approach is necessary to identify practices which, alone or in combination, enhance multiple regulating and cultural services while also increasing yield and production efficiency.

## **GUIDANCE ON MEASURING THE VALUES OF ECOSYSTEM SERVICES: MONETARY AND NON-MONETARY APPROACHES**

***Stephen Polasky***

Department of Applied Economics, University of Minnesota, St. Paul, MN, USA

Typical policy or management decisions involve choosing among alternatives that have different impacts on ecosystems, and hence, on the ecosystem services they provide. Choice among alternative decisions often involves evaluating tradeoffs. One policy or management alternative may be better in providing more of some ecosystem services, but alternatives may do better in providing more of other ecosystem services. For example, a decision about whether or not to ban a certain pesticide may involve tradeoffs between greater crop yield and farmer profits versus the potential negative impacts on water quality and non-target species. While a purely biophysical analysis of ecosystem services can help to inform policy and management decisions by showing how decisions will likely affect the provision of ecosystem services, such information is typically not sufficient for decision-making. Value judgements are also often necessary. For example, are the benefits from greater crop yields and associated farmer profits of greater or lesser value than the costs associated with negative impacts on water quality and non-target species? Comparisons among different objectives are greatly facilitated by measuring all objectives in terms of the same metric of value. Economists typically convert all positive and negative impacts (benefits and costs) into monetary values. Economists have developed many methods to measure aspects of environmental quality and natural resources in monetary terms, including air and water quality and the existence value of a species for which there is no market value or other readily apparent monetary value.

While a common metric facilitates comparison of policy and management alternatives, it can be difficult, and some analysts claim it is impossible or undesirable, to attempt to measure all objectives in terms of a common monetary metric. In particular, many aspects of nature are not easily captured in ecosystem services that can be readily measured in monetary terms. For example, trying to measure the monetary value of the continued existence of species, the affinity that people have with a place and the flora and fauna of that place, the cultural significance of certain aspects of nature, or the spiritual or religious values associated with particular species or places, can be problematic. Critics of economic valuation claim that trying to measure values in monetary terms can distort values and results in inaccurate or misleading results. Other critics contend that non-monetary values are routinely ignored in efforts to report monetary values of ecosystem services and therefore give biased views of what is important. In some cases, important information about ecosystem services relevant for decision-making can be reported in biophysical terms without attempting to convert all measures into monetary value.

This talk presents examples of the use of monetary and non-monetary methods for providing evidence on the value of ecosystem services and discusses the pros and cons of using alternative methods along with recommendations of when the use of monetary methods are warranted and when they are best avoided.

## **ECOSYSTEM SERVICE VALUATION AND CULTURE CHANGE IN THE PRIVATE SECTOR**

***Thomas Polzin***

Dow Chemical, Bristol, PA, USA

Dow's ambitious Valuing Nature Goal, which seeks to identify \$1 billion in long term value from nature driven projects, is in its third year and gaining momentum. The Valuing Nature goal requires the Company to look differently at the services nature is providing, and to attribute value appropriately to those services. The discussion will focus on how Dow can share the lessons learned and tools developed with other private or public stakeholders who are interested in integrating the value of ecosystem services into their work. The panel will reflect on the challenges and unexpected co benefits that private companies face in integrating ecosystem services into project methodology. Dow and TNC will also debut a new tool that measures ecosystem service impact in economic terms that is used in project methodology as well as detailing the journey.

Deploying and refining methodology for the Valuing Nature goal has been a challenge, namely identifying project opportunities that utilize ecosystem services within a chemical manufacturing environment. How can a company whose core business is turning feedstocks into chemicals derive financial value from ecosystem services? How can a company use ecosystem services to augment and enhance project economics? As the portfolio of projects and project types expands, the team has confronted new opportunities and new challenges, challenges that have required new approaches, new processes and ultimately a new vision for culture change.

## APPLICATIONS AND OPPORTUNITIES OF NATURAL CAPITAL ACCOUNTING FOR DECISION MAKING

**Stephen M. Posner**<sup>1,2</sup>

<sup>1</sup>COMPASS, Silver Spring, MD, USA

<sup>2</sup>Gund Institute for Environment, the University of Vermont, Burlington, VT, USA

Natural capital accounting (NCA), which calculates the total stocks and flows of natural resources and ecosystems services in a given ecosystem or region, has the potential to advance from academic concept to established practice within both Federal government and the private sector. Over the last several years, a USGS-led, interagency working group focused on NCA has made significant progress developing robust economic accounts for natural capital in the U.S. At the same time, economists at NOAA have used similar approaches to study the many ways that people benefit from the ocean and estimate the value of the blue economy, a key priority of the current Administration. Accounting for a nation's natural capital assets is critical to harness vast marine and land-based resources and also to safeguard them for current and future generations.

However, while the important technical work of creating economic information about NCA is necessary, it does not ensure that decision makers will use such information. Scientists and Federal agency leaders must survey the potential uses of NCA information in decision making, understand the decision contexts in which NCA information can lead to better outcomes, and engage with key stakeholders. This presentation will describe who within the Federal government might use information about the critical role of nature's inputs to the economy, and how. Ongoing, iterative communication and engagement with the people who can use NCA information will effectively integrate ecosystem services into Federal decision making in a timely fashion. Without a firm understanding of the relevant demand and uses for NCA information, along with a strategy for engaging with specific audiences, scientists risk producing data and reports that become relegated to online archives rather than institutionalized through the design of sustainable policy solutions.

## QUANTIFICATION OF FLOOD ATTENUATION DUE NATURAL FLOODPLAIN MORPHOLOGY AND WETLANDS

*Karen L. Prestegard and Carolyn A. Plank*

Department of Geology, University of Maryland, College Park, MD, USA

Floods are conveyed downstream by stream channels and their adjacent floodplains. Natural stream channels have rough beds, complex morphology, and other features that affect the transmission of in-channel floods. During large floods, both channel and floodplain characteristics, such as vegetation density, gradient, and floodplain width, affect the downstream transmission of flood peaks. Due to geological, geomorphic, and climatic reasons, natural channel and floodplain attenuation rates vary significantly among basins. In this research, we examined attenuation of flood peaks due to channel and floodplain characteristics for Atlantic Slope Basins from Vermont to Georgia. The purpose of the study is to provide metrics of the amount of natural attenuation of flood peaks in these basins, the variation among the basins, and the amount of attenuation provided by floodplain versus channel characteristics. We used USGS gaging station data to develop flood frequency relationships for individual gaging station location, we then combined these flood frequency data to determine flood scaling relationships for different recurrence interval events within each basin. These scaling relationships express the relationship of discharge ( $Q$ ) to drainage basin area ( $DA$ ) as a power law:  $Q = \alpha(DA)^\theta$ . The coefficient,  $\alpha$ , in these scaling relationships is closely related to precipitation and flood magnitude; its value increases with flood recurrence interval. The exponent in these scaling relationship decreases with increasing flood R.I., but the amount of this decrease varies among basins as a function of floodplain characteristics. We developed the ratio of  $Q_{100}/Q_{1.5}$  to quantify the amount of flood attenuation provided by the floodplain and compared it among the Atlantic Slope study basins. Comparison across basins provides information on hydro-climatic and geomorphic influences on flood scaling.

These attenuation metrics can be used to provide valuation for the flood mitigation potential provided by intact natural channel or floodplain characteristics. They can also be used to set restoration guidelines, including setting limits on the amount of floodplain disturbance to be allowed during the installation of channel restoration projects. In some cases, the floodplain attenuation potential lost due to construction on floodplains may be significantly greater than the restoration value added by the stream restoration project.

## BETTER DECISION MAKING THROUGH OUTCOME-BASED CONSERVATION

### *David Primozich*

The Freshwater Trust, Portland, OR, USA

Recovering resilient ecosystems will require coordinated land and water management initiatives that cross jurisdictional boundaries. Rapidly improving data quality and analytical techniques are being used to link benefits and impacts of field-level management choices to basin-scale objectives. New approaches are being used to design conservation strategies that meet traditional environmental permitting requirements—catalyzing millions of dollars of strategic investment in ecosystem restoration and promoting cross-jurisdictional coordination.

**Oregon:** The City of Medford faced a regulatory requirement to reduce the impact of clean, but warm, wastewater released into the Rogue River. Traditional treatment options involved expensive on-site controls that would deliver small environmental benefit. Application of new analytical approaches enabled the City and regulators to compare watershed restoration options to traditional approaches. Coarse-scale watershed assessments were used to confirm a large number riparian revegetation sites that, if replanted, would provide shade to reduce the thermal load on water temperature and have greater ecological benefits. The key to making this restoration solution possible was converting the site-level environmental output into a unit the regulated entity could buy. The tools and processes used created confidence in the restoration solution and enabled the City to secure its permit and implement a \$6.5 million riparian restoration program instead of a \$20 million grey infrastructure solution.

**Idaho:** Elevated stream temperature affects salmon in the Pacific Northwest. In the mid-Snake River basin, the Idaho Power Company faced a regulatory requirement to minimize the impact of its hydroelectric dam operations during certain months when native fish are spawning. Traditional technology controls such as pumping cold water from the lower elevations of the reservoir would have negative impact on water chemistry. Using advancements started through the Medford project, The Freshwater Trust applied better data and more sophisticated analytical techniques that gave the Company and regulators confidence that a combination of streamside revegetation and floodplain enhancement projects would meet the regulatory requirements and create needed improvements for other water quality and habitat issues impacting the basin. Application of these tools is driving a compliance program that will result in more than \$300 million in direct restoration efforts.

**California:** The environmental challenges in California are currently focused on the quality and quantity of groundwater and surface water—which are heavily influenced by agricultural production. Watershed assessment tools that were originally used for thermal benefits in the Pacific Northwest are being expanded to deliver multiparameter insight that link field-scale management choices to basin-scale environmental objectives. Because California farmers are facing multiple regulatory pressures that cross political and administrative boundaries, the goal is to create watershed-based approaches that drive needed environmental improvement, meet multiple regulatory requirements, and remain economically viable for working lands.

The insight provided by these new data analytics and data management structures have allowed public and private entities to compare conservation strategies, make investments, and track progress against quantified environmental outcomes. These decision-making tools can be applied to other basins where ecosystem recovery and resilience are needed.

## **UTILITY DECISION MAKING AND MARKET-BASED APPROACHES TO REGULATORY COMPLIANCE**

***David Primozich***

The Freshwater Trust, Portland, OR USA

In many ecosystem service markets designed for regulatory compliance, the regulatory liability is transferred from the buyer of the credit to the credit developer. In the water quality trading market, this is not the case. Credit buyers are ultimately responsible for the performance of nonpoint source pollution reduction. This can be a tough sell for utilities and municipalities who take a conservative approach to meeting their permit obligations, which leads many to prefer the use of onsite technology to reduce their pollutant loads, even when purchasing nonpoint source credits may be more cost-effective.<sup>1</sup>

With growing momentum of the One Water movement and heightened interest in whole-watershed approaches to clean water, this attitude may be shifting. Through interviews with utilities and municipalities from across the United States, the National Network on Water Quality Trading has found that many potential buyers of water quality credits are interested not just in cost-effective regulatory compliance, but also in the multiple ecosystem service benefits that nonpoint source best management practices can provide to a watershed, and in the opportunity that trading programs provide to highlight the utility's role in protecting their community's natural resources.

This talk will cover the key roles involved in a water utility's decision making process, and what information utilities need to accept the use of water quality trading as a preferred compliance option. It will highlight the role that utility governance and culture play in the acceptance or resistance to trading and other ecosystem service investment programs. These concepts highlight the key points from a recent report from the National Network on Water Quality Trading, which investigated organizational charts from utilities and municipalities of all sizes and how they make decisions. This information can be used to create tailored messages to win the support of key decision makers at utilities and municipalities for water quality trading.

## **A STUDY OF SUCCESSFUL COMMUNITY-BASED PAYMENT FOR ECOSYSTEM SERVICES PROGRAMS**

**Richard G. Pritzlaff**<sup>1,2</sup>

<sup>1</sup>Managing Partner, Borderlands Restoration L3c, Boulder, CO, USA

<sup>2</sup>President, Biophilia Foundation

Ecosystem services (ES), payments for ecosystem services (PES), and the development of markets for PES are transformational concepts and practices that emerged from environmental and ecological economics. Although the establishment of regulatory markets tends to be “top down,” there is evidence that more locally acceptable and successful markets tend to come from the community, from the “bottom up.” This presentation is based on 20 recent articles that examined approximately 454 PES cases from around the world, most organized from the bottom up.

Cross-case analysis reveals possible best practices. Involving communities in design, decision-making, governance, and operation of local PES programs is found in many cases to contribute to improvements in both ecosystems and community livelihoods. Devolving project administration and ES provision monitoring to the local level is found to lower costs, increase project legitimacy, community equity, and leaves efficiency and fairness tradeoff decision-making in the hands of local communities. This in turn adds to feelings of competence, autonomy, and control.

The experience of cooperative learning, skill acquisition, and enhanced individual and community capacities that results from participation in PES program design is found to positively influence social, cultural, economic, and multilevel political dynamics, allowing local sustainable resource use and management to emerge. In several cases, there are indications that this leads to a changed local and regional political economy due to successful value capture of enhanced ES resulting from restored ecosystems, as well as indications of other transformative changes in communities. These findings are used to provide recommendations to a watershed restoration initiative in the borderlands of Southern Arizona.

## **USING ECOSYSTEM SERVICES TO SUPPORT FOREST LANDSCAPE RESTORATION (FLR) POLICIES IN CENTRAL AMERICA, EXAMPLES FROM EL SALVADOR AND HONDURAS**

*Leander Raes<sup>1,2</sup>, Oscar Chacón<sup>3</sup>, Kelly Meza Prado<sup>4</sup> and Craig Beatty<sup>5</sup>*

<sup>1</sup>International Union for Conservation of Nature, San José, Costa Rica

<sup>2</sup>Department of Agricultural Economics, Ghent University, Belgium

<sup>3</sup>National University for Distance Education, Costa Rica

<sup>4</sup>University of Minnesota, Institute on the Environment/Natural Capital Project

<sup>5</sup>International Union for Conservation of Nature, Washington DC

The Regional Office for Mexico, Central America and the Caribbean of the International Union for Conservation of Nature (IUCN-ORMACC) has been supporting governments in the implementation of functional and forest landscape restoration (FLR) actions as part of national and regional pledges within the framework of the Bonn Challenge.

The aim of this presentation is firstly to show the results of the ecosystem service analyses carried out in El Salvador and Honduras as part of the implementation of the Restoration Opportunities Assessment Methodology (ROAM) in these countries, and how these were then used to inform policy making. Impacts on ecosystem services (erosion and sediment retention, nutrient retention) were measured with Natural Capital Project's InVEST tool.

Secondly, the presentation will show how the InVEST results were then used in a spatial multi-criteria model to define priority areas and actions for restoration. The priority maps were a key input for the development of El Salvador's national action plan for restoration, and Honduras' program for the recuperation of ecosystem goods and services. The inclusion of beneficiaries of ecosystem services in the multi-criteria analysis was key to prioritize FLR actions and areas and provide input to the policy-making process.

## **INTEGRATING ECOSYSTEM SERVICES INTO LANDSCAPE PLANNING FOR URBAN REGION IN INDONESIA**

***Widyastri A. Rahmy***

Department of Landscape Architecture, University of Florida, Gainesville, FL, USA

Maintaining balance between human and ecosystem is becoming more important in the challenge of rapid development, especially in a complex setting of urban region where nature intertwined with high population density. Ecosystem provides vast services for human use, such as clean air and water, food and timber production, as well as recreational resources, to help sustain development. On another side, development activities should be carried with consideration towards maintaining ability of ecosystem to continuously provide its services. It becomes critical to consider intergrating the ecosystem services concept into development related sector, including landscape design and planning.

This poster aims to present potentials of integrating the concept of ecosystem services into landscape planning for urban region in Indonesia, divided into three parts. The first part provides an overview on literature about ecosystem services and their spatial production measures, and how these measures fit in urban and regional scale units. The second part provides an overview on Indonesia's currently applied spatial planning policy for urban region, focusing on parts those reflect consideration towards maintaining ecosystem services provision. This will be followed by possible scenarios of applying the concept of ecosystem services into the policy, providing previous study that has addressed such possibility. The third part discusses possible ways to generate a framework that incorporates the concept of ecosystem services as decision making tool for practical implementation in landscape design and planning practices. This part also discusses the emerging opportunities and challenges given a diverse setting of urban region in Indonesia, and concluded by recommendation for future spatial planning policy development.

## SCALING SOIL HEALTH THROUGH ECOSYSTEM SERVICE MARKETS

**Debbie Reed**

DRD Associates LLC, Washington, DC, USA

The purpose of the Noble Research Institute (NRI) Ecosystem Service Market (ESM) Program is to scale soil health nationally to include diverse agricultural production systems across diverse geographies. With the support of ecosystem markets, agriculture can mitigate 89 percent of its GHG emissions by incentivizing farmers and ranchers to retain and increase beneficial soil carbon storage. The activities that improve soil health and soil carbon can also improve water quality, reduce nutrient run-off, conserve water and therefore reduce water use, and generate additional ecosystem service benefits for society. The outcomes-based NRI ESM program will launch with a newly developed ESM protocol that will be piloted beginning in January 2019 (check dates) with farmers and ranchers in NRI's Land Stewardship Program in the US Southern Plains states of Texas and Oklahoma. The Program initially will quantify and monetize three soil health ecosystem service attributes: soil carbon, water quality and water quantity. The protocol will support credit generation to monetize a portfolio of blended or stacked ecosystem service credits or attributes for sale or trade in the ESM and in voluntary carbon offset markets and will document contributions to meeting the United Nations (UN) Sustainable Development Goals (SDG) 2030. The author will describe how a 2-decade career in carbon offset markets and agricultural GHG mitigation approaches, and documentation of the successes and challenges in those markets, led to development of a new approach to developing market-based protocols that work first and foremost with the agricultural sector and that are cost-effective, scalable science-based, and transparent. Working through the NRI ESM Program, protocol development will follow an iterative process that scales via a pipeline of pilot projects that target expanding US geographies and agricultural production systems and additional ecosystem service attributes in a systematic and progressive manner, resulting in adapted modular protocols that encompass diverse agricultural systems, geographies, climates, soil types, etc. To scale agricultural producer participation and to monitor, report and verify the resulting beneficial ecosystem services for society, protocol development and program development will adhere to a science-based, transparent, standards-based process that incorporate lessons learned in ecosystem service markets to date. Policies and partnerships that enable and support program development will be highlighted, and progress and results shared.

## **INTEGRATED ASSESSMENT, VALUATION AND MAPPING OF ECOSYSTEM SERVICES FOR SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES, A CASE OF LAKE TANA BASIN, ETHIOPIA**

**Bedilu A. Reta<sup>1</sup>, Teshome Soromessa<sup>1</sup>, Maciej Zalewski<sup>2</sup>**

<sup>1</sup>Center for Environmental Science, Addis Ababa University, Ethiopia

<sup>2</sup>Department of Applied Ecology, University of Lodz, Poland

Lake Tana Sub Basin is the source of the Blue Nile River located within Abaya Basin of Ethiopia. The Lake Tana basin has potential natural resources provide various Provisioning, Regulating, and Cultural ecosystem services (ESS) that benefits the community. Although, the basin has this potential of ecosystem services, the prevailing environmental such as deforestation, land degradation, erratic rainfall, less nutrient availability, slope steepens, rapid urbanization, point and nonpoint source pollution, the lack of comprehensive assessment of ecosystem services, low level of knowledge on the use and importance of ecosystem services contributed direct or indirect impact on the annual potential ecosystem services of Lake Tana Basin and this problems indicated that the Lake Tana basin both terrestrial and aquatic resources are threatened that substantiate the importance of integrated assessment of Ecosystem services, value and mapping to embed the outputs in the decision making process for future Basin management plan and activities.

The purpose of this proposed research is to assess, analyze, value, and map the Lake Tana and its Basin ecosystem services, examine the impacts of pollutions and recommend appropriate Ecohydrological solutions and suggest appropriate intervention on ecosystem services assessment that will promote the conservation and sustainable utilization of the Lake Tana and its basin ecosystem services.

The research will use the various methods including primary and secondary data collection; field observation on selected sites; identification of ESS indicators; use of expert judgment matrix on ecosystem service; stakeholder consultation; use of ecohydrological approach; and ESS mapping using ArcGIS v10.1 software. During consultation, stakeholders selected ten land use land cover classes and thirteen prioritized provisioning, regulating, and cultural ecosystem services found in the study area. The outcome of this research is to conduct a comprehensive ESS assessment at Lake Tana basin scale, providing major emphasis for Lake Tana and nearby terrestrial ecosystem service. At the end of this research, awareness will be created among stakeholders on the concept of ecosystem services; and mapping tools will be available as an alternative option for decision makers, experts, and community members about the use and importance of ecosystem services and to be included in the future Lake Tana basin watershed management and development activities. In addition, potential point sources pollution to the existing Ecosystem services will be identified and best ecohydrological solutions will be recommended. Results of the study will reveal the spatial and temporal variation of potential ecosystem services identified within the Late Tana Basin based on the relevant ESS capacity of each LULC. The outcomes of the study demonstrated with diagram and maps to show the spatial patterns of ESS. Based on the consultations with stakeholders, three scenarios will be developed. Considering factors stated under urbanization scenario, stakeholders forwarded their expectation about the extent of change in land use land cover for the next 30 years LULC maps together with its ESS potential will be developed In addition, the study will identified the potential impacts of point and non-point source pollution on the existing annual potential ecosystem services of Lake Tana Basin and recommend best management practices to offset and/or minimize these impacts. The study will bring an alternative development options and basic information that will be used as a tool to communicate decision makers and other development partners for the future Lake Tana basin development plan to ensure sustainable management of natural resources in study area, Lake Tana Basin, Ethiopia.

## **ECOSYSTEM SERVICES IN ENVIRONMENTAL ASSESSMENTS – NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) VS. INTERNATIONAL STANDARDS**

**Greg Reub<sup>1</sup>, Alicia De la Cruz Novey<sup>2</sup> and Collin Ray<sup>3</sup>**

<sup>1</sup>EcoAnalysts Inc, Olympia, WA, USA

<sup>2</sup>EcoAnalysts Inc, Washington D.C., USA

<sup>3</sup>EcoAnalysts Inc, Port Gamble, WA, USA

The purpose of this presentation is to explore how the integration of Ecosystem Services (ES) into environmental assessment has advanced the process from a United States (US) and an international perspective. There is growing recognition of the importance of ecosystem services in providing for sustainable development. The consequences from loss of biodiversity and degradation of natural ecosystems are being recognized as having severe impacts on the services they provide people, including human well-being and economic development. Consideration of ecosystem services is becoming more common but integration and results into basic environmental assessments have been extremely slow and variable since the United Nations published the Millennium Assessment (2005).

Many public officials, private companies and institutions in the US understand the importance of protecting ES for the future of the US. It appears obvious that ES analyses is within the legal scope of NEPA and more importantly is a great tool in meeting NEPA's goals and requirements. The NEPA process is the foundation of the US decision making for determining alternatives, impacts and appropriate mitigation for development and it would seem reasonable to advance this important concept given the urgent nature of the issue. Rather than integrate physical, chemical, biological, social and economic values, we continue to examine each discipline in silos and treat each independently.

The incorporation of ES into the development of international Environmental and Social Impact Assessments (ESIAs) for development projects has been increasing since the Millennium Ecosystem Assessment. This is driven by the multilateral banks and private lenders who have adopted the Equator Principles. The International Finance Corporation (IFC) has developed eight Environmental and Social Performance Standards (PS) to guide the assessments, which are the leading benchmarks for sustainable development on a global scale. Of these eight PS, six PS require identification of risks, impacts and mitigation specifically related to ES. PS 6 (Biodiversity Conservation and Sustainable Management of Living Resources) requires a systematic review of the ES a project will impact. Priority ES impacts are identified, and mitigation is required. This results in a thorough analysis where "valued environmental and social components" (VECs) are identified through stakeholder consultation. The ES, with the VECs are incorporated into most other components of the environmental assessment.

The systematic incorporation of ES into the NEPA process would satisfy regulatory requirements and would make it more legally defensible. Current issues with most NEPA documents is that it does not integrate interdisciplinary science issues, allows for small or non-issues to drive the process and does not build the baseline and impacts assessment to construct efficient and cost-effective mitigation and management. The integration of ES would integrate physical, chemical, biological and human use and non-use effects and benefits. It would promote detailed, science-based and a transparent process that incorporates values from the affected stakeholders.

## IMPROVING CORPORATE PERFORMANCE WITH FINAL ECOSYSTEM SERVICES<sup>1</sup>

*Charles Rhodes,<sup>1</sup> John Finisdore,<sup>2</sup> Anthony Dvarkas,<sup>3</sup> Joel Houdet,<sup>4</sup> Joel Corona,<sup>5</sup> Simone Maynard<sup>6</sup>*

<sup>1</sup>Washington, DC, USA

<sup>2</sup>Founding Partner, Sustainable Flows, Washington, DC, USA

<sup>3</sup>Stony Brook University, Stony Brook, NY, USA

<sup>4</sup>Senior Research Fellow, Albert Luthuli Centre for Responsible Leadership, University of Pretoria, Johannesburg, South Africa

<sup>5</sup>Senior Economist, Office of Water, U.S. Environmental Protection Agency, Washington, DC, USA

<sup>6</sup>Simone Maynard Consulting, Brisbane, QLD, Australia

Ecosystem services (ES) are a growing part of corporate risk management and sustainability programs from environmental impact assessments to life-cycle assessments to mega-trend analysis. Practitioners have been working to better define, measure, and integrate ecosystem services into corporate decision making. However, insufficient use of ecosystem services classification systems (ES-CS) prevents companies from benefitting fully from them.

The final ecosystem services (FES) perspective, embodied by the National Ecosystem Services Classification System (NESCS), addresses key bottlenecks to mainstreaming ecosystem services in corporate decision-making and accounting. Compared to other ES groupings and classification systems, NESCS is easy to use with regards to defining ES in their value context for specific ES users, improves materiality analysis, and aids stakeholder engagement. In addition to offering a unique capacity to focus analysis on key relevant metrics, NESCS has the potential to improve the accuracy of valuation, making it preferable for natural capital accounting.

Desk studies were conducted utilizing NESCS in several business applications and to determine the impacts of commercial palm oil plantation. They show that NESCS would bring greater accuracy to mega trends analysis, corporate disclosures, and impact assessments among other applications. With regards to the palm oil plantation, NESCS would reduce double counting—resulting in a lower value for the commercial plantation than the alternative classification—while improving the identification of ES beneficiaries and metrics. Finally, FES-based classification systems, such as NESCS, offer improved stakeholder engagement tools and avoid duplication of metrics used within most corporate compliance systems.

Companies that adopt a final ecosystem services (FES) perspective are likely to gain immediate benefits and first-mover advantage, as this FES perspective is poised to become standard practice.

---

<sup>1</sup> Rhodes, C., Finisdore, J., Dvarkas, A., Houdet J., and Landers, D. (2017). Improving corporate performance with final ecosystem services; In Lee, K., Schaltegger, S. (Eds.). *Accounting for Sustainability: Asia Pacific Perspectives*. Springer. [https://link.springer.com/chapter/10.1007/978-3-319-70899-7\\_7](https://link.springer.com/chapter/10.1007/978-3-319-70899-7_7)

## **CRACKING THE AGGREGATION NUT: A COOPERATIVE APPROACH TO FOREST CARBON CREDITING**

***Jane Rice***

Conservation Finance Manager, WRA, Inc., Boulder, CO, USA

More than half of the forestland in the United States is privately owned and much of that land is at risk of being developed. Many privately owned forests are relatively small non-industrial properties that face greater risk of conversion amid development pressures, absent any revenue generated by the land. As these forests are sold off for other uses, we lose critical carbon stores, habitat, and other valuable ecosystem services. The carbon market provides one opportunity to incentivize landowners to keep their forests intact; however, relatively small landowners are typically excluded from the market because of the financial burden of forest carbon projects. The Santa Cruz Mountains Carbon Cooperative (Co-op) is being developed to address this challenge through an innovative aggregation approach and cooperative structure.

The Co-op aggregates multiple properties in the Santa Cruz Mountains into forest carbon projects to achieve the appropriate scale for financial viability. The approach reduces transaction and project management costs, while maintaining the sampling and monitoring rigor for credit issuance. The Co-op is also designed to provide educational resources, a community network, and discounted contractor services and equipment to further incentivize participation. This cooperative approach is based on conversations with landowners and their expressed motivations for participation. Additionally, the Co-op will evaluate and report the environmental and social co-benefits of the program because co-benefits are proven to motivate voluntary private sector buyers, which is the target audience of Co-op carbon credits. The program has already received considerable buyer interest from Silicon Valley companies and credit brokers.

Development of the Co-op is a collaborative project between the land trust, Sempervirens Fund, WRA Inc., and Spatial Informatics Group, with funding from the Moore Foundation and the California Coastal Conservancy. An initial feasibility study was conducted in 2015, followed by the methodology design and pilot exploration in 2017/2018. Our team has conducted forestry inventories in the Santa Cruz Mountains of California, performed credit yield analyses, conducted several workshops and meetings with landowners, and we have completed a draft aggregation methodology with the American Carbon Registry and a business plan for the implementation of the program. Our methodology is currently under review by the Registry, and we anticipate signing contracts with our landowners and credit buyers in late 2018. Ultimately the Co-op will bring together nonprofits, private sector credit buyers, foundations and potentially conservation investors as well.

The Co-op model is highly replicable. In fact, other conservation organizations are exploring the potential to use our aggregation approach in different locations across the country. Furthermore, the cooperative approach and lessons learned in engaging landowners, credit buyers, and investors are transferable to environmental entrepreneurship endeavors across environmental markets.

## **BEYOND BENEFITS: RECREATIONAL ECOSYSTEM SERVICES AS A MANAGEMENT FRAMEWORK**

**William L. Rice<sup>1</sup>, Peter Newman<sup>1</sup>, B. Derrick Taff<sup>1</sup>, Zachary D. Miller<sup>1</sup>, and Kathrine Y. Zipp<sup>2</sup>**

<sup>1</sup>Department of Recreation, Park, and Tourism Management, Pennsylvania State University, University Park, Pennsylvania, USA

<sup>2</sup>Department of Agricultural Economics, Sociology, and Education, Pennsylvania State University, University Park, Pennsylvania, USA

The act establishing the world's first federal protected area, Yellowstone National Park, imparts that the area be "set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people". The challenge of managing protected areas to purvey benefits through satisfying visitor experiences has since been a major subject of research within the fields of recreation and leisure. Driver and others have advocated for the Benefits Approach to Leisure (BAL) on the grounds that it can serve as an efficient means of maximizing the benefits visitors receive from protected areas. However the BAL largely ignores the tradeoffs managers must make with concern to ecological and visitor wellbeing. In the economic literature, use-values inherent with recreation are often referred to as cultural ecosystem services (CES). These services are those nonmaterial outcomes humans obtain from the natural world including: spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. In this way, benefits are the positive outcomes of ecologically-derived experiences. Yet, an effective framework must account for costs in addition to benefits. These costs likely present themselves as both internally induced negative outcomes (i.e. tripping on a rock, a lack of stamina, etc.) and outcomes provoked by negative externalities (i.e. crowding, conflict, etc.).

Though a union between the management concepts of CES and BAL has long been advocated for in the recreation literature, no study has explored a means of linking their theory or methods. This presentation focuses on research concerning both benefits achieved and services provided and puts forth a means of coalescing them in future research and management, the Recreational Ecosystem Services Framework (RESF). This is achieved through an exploration of the foundations of both concepts and highlighting the common elements inherent within both models.

## **NON-MARKET VALUATION AND NATURAL AREAS: ADVANTAGES AND LIMITATIONS**

*Melissa M. Kreye, and Renata Rimsaite*

Department of Ecosystem Science and Management, Pennsylvania State University, University Park, PA, USA

Natural areas and conserved lands give rise to many important ecosystem services that enhance the health and wellbeing of local communities. Non-market valuation methodologies offer conservation advocates and practitioners the opportunity to understand the economic value of their conservation efforts. Estimated values can be used to help advocate for continued financial support and inform planning by demonstrating the impact of associated conservation activities on human welfare.

While non-market valuation has been recognized as an important decision-making tool, a lack of understanding about how valuation methodologies are applied, associated assumptions, and inherent technical limitations are a likely barrier to people's use of non-market valuation approaches. This session seeks to highlight what conservation advocates need to consider when pursuing non-market values to advance their conservation activities.

In this section, we will present (1) key terms and economic concepts associated with non-market valuation, (2) straightforward descriptions of stated and revealed preference and benefit transfer methods, (3) discussion about the inherent advantages and limitations of each approach, and (4) examples of how estimated values have been linked with ecosystem services to help inform decision-making. Our goal is to make valuation concepts more accessible to practitioners and advance the use of the Ecosystem Services framework and non-market valuation in the protection of natural areas.

## METRICS TO REPRESENT NON-USE VALUES OF STREAMS AND LAKES

**Paul L. Ringold<sup>1</sup>, David V. Peck<sup>1</sup>, Ted Angradi<sup>2</sup>, Michael Papenfus<sup>1</sup>, Steve Paulsen<sup>1</sup>, Tom Kincaid<sup>1</sup>, Dennis Guignet<sup>3</sup>**

<sup>1</sup>US EPA, Office of Research and Development, Western Ecology Division, Corvallis, OR, USA

<sup>2</sup>US EPA, Office of Research and Development, Mid Continent Ecology Division, Duluth, MN, USA

<sup>3</sup>US EPA, National Center for Environmental Economics, Washington, DC, USA

While there is a substantial literature on the importance of non-use values, the specification of ecosystem metrics best associated with those values is not well developed. Specification of such metrics is important for communicating the quality of a resource, and in evaluating how a resource change impacts human welfare. Such linked analyses are the foundations for benefit-cost analysis and thus a key element in the formulation of policy.

Two opposing constraints make it difficult to comprehensively represent ecosystem quality for non-use values. First, aquatic ecosystems are heterogeneous, making it difficult to fully quantify ecosystem quality with a single or limited set of metrics. Second, respondents to stated preference surveys designed to elicit nonuse values have a cognitive limit to the complexity and number of metrics they can comprehend.

Ongoing collaborations between natural and social scientists suggest that metrics of biotic integrity (i. e. metrics representing the degree of departure from conditions expected in the absence of human activity) are appropriate representation of aquatic ecosystems for non-use values. Over the last several decades, aquatic ecosystem ecologists have developed metrics of biotic integrity for differing assemblages and ecosystems consistent with the goals of the Clean Water Act. For example, in surveys that represent large regions of the United States metrics of biotic integrity have been developed for vertebrates and macroinvertebrates for streams and for macroinvertebrates, phyto and zooplankton for lakes. Methods used to develop these metrics include both multimetric indices and metrics estimating the loss of taxa. In quantifying these metrics, biophysical scientists make choices about the spatial units of the representations. Should the data be represented in terms of numbers of lakes or stream length or in terms of stream and lake area? For purposes of economic valuation, this question must focus on how people perceive the resource. Finally, there are also questions about whether the metrics for aquatic resources within a region should be pooled or addressed separately, e.g. one representation for lakes and another for streams. If the status of the ecosystems or their projected responses to changes in stressors is not equivalent among these choices then the choice of metric and its spatial dimension could well make a difference in the formulation of policies.

To examine these questions about the appropriate metric and spatial units we calculate aquatic ecosystem status using different methods for a dozen regions in the United States. We evaluate whether the ranks of the regions change with the differing assumptions. We also identify the the magnitude of aquatic ecosystems responses to changes in selected stressors also as a function of varying assumptions. Our analysis is based on data from EPA's National Aquatic Resources Surveys. Our conclusion is that the differences among assumptions are not equivalent. As a result, we recommend that biophysical and social scientists continue to collaborate and ensure a system of metrics feasible from a biophysical perspective and sensible from the perspective of communicating and estimating non-use values.

## PERCEIVED SERVICES AND DISSERVICES OF GREEN INFRASTRUCTURE

**Megan A. Rippy**

Department of Civil and Environmental Engineering, Virginia Tech, VA, USA

Most urban communities in the U.S. have centralized water grids that are expensive, unsustainable, and negatively impact human and ecosystem health. A water revolution (coined water 4.0 by David Sedlak at UCB) is needed to “break free of the water grid”. Water 4.0 requires fit-for-purpose water use, water conservation, hybrid water grids with centralized and decentralized elements, and public acceptability of decentralized infrastructure. Decentralized infrastructure includes heavily engineered grey as well as green infrastructure elements, which are often viewed through a regulatory lens - e.g., urban stormwater systems are assessed relative to water quality and volume related metrics. However, many forms of stormwater infrastructure are also ecosystems (e.g., rain gardens), that provide an array of services to people and the environment. Key services include habitat provisioning, protection of downstream ecosystems from pollutants and unnatural flow regimes, flood control, recreational, educational, and aesthetic benefits, and nutrient cycling and carbon storage. At present, many green infrastructure services are poorly understood (and thus undervalued), and the relationships between putative drivers (social, ecological or hydrological) and realized co-benefit suites remain un-elucidated.

Here I present preliminary results from a public-perceptions survey designed to identify the ecosystem services and disservices that people believe green infrastructure provide (focusing on a subset of cultural, provisioning, and regulating services) and possible drivers of those beliefs (education, environmental ethics, etc.). The survey targets university students because they are the next generation of urban greenspace designers and perceivers, and utilizes photographs of green infrastructure, lawns, native greenspace, and ornamental gardens on college campuses to contextualize services provided by green infrastructure relative to other greenspace forms. The results of our student survey suggest that 34% of the variability in perceived services/disservices across greenspace types is explained by one principal component mode that distinguishes systems perceived to provide many services well (native greenspace, ornamental gardens) from those that provide a restricted subset of services (lawns, green infrastructure). Secondary modes (27% variance explained) link individual greenspace types to specific service/disservice suites, with green stormwater infrastructure being associated with reduced flooding, water quality and water conservation. Lawns were primarily associated with aesthetics and recreation, native greenspace was associated with biodiversity and public health-related services, and ornamental gardens were variously perceived, suggesting limited social norming for the services they provide. Variability in perceived services was observed for all greenspace types. Significant drivers of this variability include knowledge (about biodiversity, urban runoff, native ecosystems, and green infrastructure itself), environmental ethics (particularly anthropocentrism and the belief that humans are exempt from nature’s control), education (e.g., discipline of study), and demographics (particularly country of origin). Our results demonstrate that multiple factors come together to influence our perceptions of green infrastructure and other landscape types, which in turn are expected to inform what future urban landscape looks like and the services it provides.

## USING ECOSYSTEM SERVICES TO PRIORITIZE RIPARIAN AREA CONSERVATION

*Karen Gaffney<sup>1</sup>, Alex Roa<sup>1</sup>, Allison Schichtel<sup>1</sup>, and Barbara Wyse<sup>2</sup>*

<sup>1</sup>Sonoma County Agricultural Preservation and Open Space District, Santa Rosa, California

<sup>2</sup>Highland Economics, Portland, Oregon

The Sonoma County Agricultural Preservation and Open Space District (Ag + Open Space) was formed to permanently protect the diverse agricultural, natural resource, and scenic open space lands of Sonoma County for future generations. As part of its voter approved expenditure plan, Ag + Open Space is tasked with protecting natural lands including riparian corridors through such tools as conservation easements. This multi-year study aims to identify the most important riparian corridors to prioritize for protection or restoration, and to document the multiple benefits and values of conserving functional riparian ecosystems in Sonoma County.

Ag + Open Space developed screening level maps to approximate the extent of channel and floodplains in Sonoma County. The riparian maps were developed using very high resolution topographic data derived from countywide high-density LiDAR data, field work, object-based image analysis using Trimble Ecognition, manual photointerpretation, and historic flood information. Comparisons between the screening level riparian maps and existing hydraulic models show that the model performs very well in topographically constrained systems but is less effective in very flat valley settings and in areas heavily modified by humans.

Based on the mapping results, Highland Economics evaluated the economic value of conserving Sonoma County's existing riparian areas (18,100 acres), and of restoring Sonoma County's riparian areas to a fully functional level (38,450 acres). Based on existing studies combined with data specific to the area, we estimated four types of economic value: water quality benefits, reduced flood damage costs, biodiversity benefits (including associated recreational, commercial fishing, cultural, and species preservation values), and avoided costs associated with climate change due to carbon sequestration. The findings illustrate the value and importance of riparian conservation in preserving the quality of life, economy, and culture of Sonoma County.

While the analysis drew from numerous ecological studies focused on riparian areas, with the exception of wetland riparian areas, there are relatively few economic studies of the values provided by riparian areas. This study helps to fill this gap to support decision making in Sonoma County. Economic findings indicate that prioritizing riparian area conservation and restoration based on biodiversity and habitat services (which will increase aesthetic, recreation, species existence, cultural, and commercial fishing values) will likely provide the greatest return on investment.

## **WATER QUALITY TRADING: A CATALYST FOR LANDSCAPE CONSERVATION IN URBAN AND AGRICULTURAL COMMUNITIES**

***Bruce Roll***

Department of Watershed Management, Clean Water Services, Hillsboro, OR, USA

Throughout the United States, communities struggle to address the challenges of extreme weather events and rapid urban growth at the scale needed to create healthy and resilient watersheds. We have come a long way towards identifying the actions needed to address these challenges, but are only beginning to understand how to move from pilot projects to programmatic scale. In 2004, Clean Water Services ([www.cleanwaterservices.org](http://www.cleanwaterservices.org)), a public water resources utility in northwestern Oregon, initiated the development of a riparian restoration program to meet regulatory requirements under the Clean Water Act (CWA). As this program evolved over a dozen years it grew into one of the USA's most effective landscape conservation programs ([www.jointreeforall.org](http://www.jointreeforall.org)). Working across both urban and rural communities this program is able to access the social and financial capital needed to work at the landscape scale. To date, this program has restored over 140 river miles across more than 25,000 acres in the agricultural and urban communities of the Tualatin River Watershed. Moving from pilot projects to a landscape scale conservation program restoring more than 10 river miles annually was a twelve year journey for Clean Water Services and the partners of the Tualatin River Watershed. Shifting from the planting of a few thousands native plants to more than 2 million annually across broad riparian and upland landscapes was enabled by the development of innovative restoration tools, transformational partnerships, and innovative long-term funding strategies. In addition, community social networks play a key role in the planning, implementation and long term stewardship of this program. This presentation will chronicle a decade of lessons learned and highlight the innovative tools and social networks created to sustain a landscape conservation program. As we consider large-scale water quality and climate change issues throughout the United States (e.g. Gulf hypoxia, Great Lakes and the Chesapeake Bay) similar landscape restoration programs will be needed to bring to scale the actions required to address these complex issues.

## **ECOSYSTEM SERVICES IN THE COURTS**

*J.B. Ruhl*

This presentation will review a recent study by a team of researchers examining the corpus of case law from the US, UK, and other common law nations to identify instances where courts use the professional language of the ecosystem services framework (e.g., natural capital, ecosystem services, nature's services). The study finds very little uptake of the terminology thus far and offers explanations for why this may be and how it hinders development of the ecosystem services framework in law generally. It also makes recommendations for how to increase judicial attention to the theme.

## **SOLUTIONS FOR ECOLOGICAL RESILIENCY IN COASTAL CITY DESIGN**

*Lucy Rummler, Andrew Cole, and Lisa Iulo*

Pennsylvania State University, University Park, USA

Resilient coastal ecosystems can reduce the impact of natural disasters and reoccurring environmental and human-caused stresses on coastal cities. The winning proposals of the Rebuild by Design Hurricane Sandy Design Competition, compiled by teams of design firms and consultant groups, address social, infrastructural, economic, and ecological resiliency of a given city or region impacted by Hurricane Sandy. The proposals offer design solutions that would allow coastal cities to withstand and recover from future natural disasters and stresses, framing ecological resiliency as an ecosystem service.

However, further investigation is needed to render these ideas transferable to future coastal resiliency projects. The proposals assign design solutions to specific places within their project region, but the coastal city project regions may be dissected into broad categories of landscapes, such as tidal marsh or heavily developed river edge. The intent of this research is to classify coastal landscape types found in each proposal and identify the solutions that can be implemented in each context in order to facilitate application of design solutions in other coastal cities.

Each of the seven Rebuild by Design proposals were studied to identify design changes that were intended to increase ecological resiliency in ways that benefit city residents. Information was collected about each location in which design solutions were proposed. These locations were then classified into landscape typologies based on landscape characteristics. For each landscape typology, information was gathered to define the basic definition of the landscape, its risks, and its ecosystem services. Graphic representations of the typologies and design solutions were made to help designers recognize similarities and differences between landscapes and to help them know what problems and solutions may be present.

From the seven Rebuild by Design proposals, ten landscape typologies and 40 design solutions were classified. Project proposals contained between two and six landscape typologies. For each typology, between two and 15 design solutions were proposed by various project teams. The Rebuild by Design proposals contain many overlapping design solutions. Pairing design solutions to the ecosystem service they facilitate, as well as to the suitable landscape typologies they may be employed within proved valuable in the consolidation of these solutions for future dissemination to other designers, planners, and politicians.

## INTRODUCTION TO NATURAL CAPITAL ACCOUNTING

*M. Russell<sup>1</sup>, C. Rhodes<sup>2</sup>, and F. Soulard<sup>3</sup>*

<sup>1</sup>US EPA's Office of Research and Development, Gulf Ecology Division, Gulf Breeze, Florida, USA

<sup>2</sup>ORISE post-doctoral research fellow, participating at USEPA

<sup>3</sup>Stats Canada

The nation's economic accounts provide objective, regular, and standardized information routinely relied upon by public and private decision makers. But they are incomplete. The U.S. and many other nations currently do not account for the natural capital — such as the forests, grasslands, wildlife, soils, and water bodies— upon which all other economic activity rests. National capital accounts (NCA's) would standardize, regularly repeat, and aggregate diverse natural resource and environmental data, allowing those data to be linked to economic activity already captured by GDP, job reports, and other data that track national performance. NCAs would help guide and potentially save billions of investment dollars every year by helping businesses and governments understand the past, peer into the future, innovate, and plan for shocks. Here we present an introduction to natural capital accounting using examples from successful implementation in Canada where they quantified changes in land cover (particularly conversion of forests to shrublands and agricultural land to urban land uses), the use and value of fisheries, and ecosystem service indicators for wetlands.

The United Nations System of Environmental-Economic Accounting (SEEA) includes a Central Framework for Environmental Accounts. The Central Framework looks at “individual environmental assets”, such as water resources, energy resources, etc. and how those assets “move” between the environment and the economy. The SEEA Experimental Ecosystem Accounting (SEEA-EEA) complements the SEEA Central Framework by taking the perspective of ecosystems and considers how individual environmental assets interact as part of natural processes within a given spatial area. These ecosystem assets provide ecosystem services, which are the beneficial contributions of ecosystems to economic and other human activity. The SEEA-EEA has a system of accounts that present a coherent and comprehensive view of ecosystems including ecosystem extent, condition, ecosystem services supply and use, and monetary value as well as standalone thematic accounts for land, carbon, biodiversity etc. that are important to track but may not be included in the other accounts.

Ecosystem accounts following the SEEA-EEA have been compiled at both national and subnational scales to track linked environmental-economic trends in developing and developed-world contexts including Canada, Australia, the Netherlands, Peru, the Philippines and Rwanda. In addition to our efforts to develop accounts for the US, substantial efforts are currently underway to construct ecosystem accounts for member nations of the European Union and for Brazil, China, India, Mexico, and South Africa through the U.N. Statistics Division.

## **LAW & POLICY OF PAYMENTS FOR ECOSYSTEM SERVICES PROGRAMS**

***Jim Salzman***

University of California, Santa Barbara, CA, USA

This presentation will discuss a recent study providing the most comprehensive examination to date of the global status and trends of payments for ecosystem services (PES) programs. The over 550 programs, with annual transactions above \$36 billion, operate at local, regional, and national levels. The study assesses the trends and current status of PES institutions and mechanisms and their various dimensions of growth, as well as assessing which factors have contributed to or hindered growth. Four features stand out for scaling up PES—motivated buyers, motivated sellers, metrics, and low transaction cost institutions. Legal instruments and institutions can facilitate these conditions.

## **FROM RESTORATION TO RECREATION: INTEGRATING COMMUNITY VOICES TO DEVELOP A LANDSCAPE-SCALE VISION AND ECONOMY FOUNDED ON ECOSYSTEM SERVICES**

*Cynthia Sandeno<sup>1</sup> and Doug Arbogast<sup>2</sup>*

<sup>1</sup> Monongahela National Forest, Marlinton, WV, USA

<sup>2</sup> West Virginia University, Morgantown, WV, USA

The Monongahela National Forest (MNF), in the northcentral highlands of West Virginia, comprises roughly a million acres of National Forest System lands. The numerous rural communities that are surrounded by the MNF have long had their livelihoods tied to the coal and timber industries. Over the last few decades, these industries have waned and these communities are struggling to find a new path forward.

Building on recent restoration economy planning efforts, MNF staff have been convening discussions around community enhancement through sustainable recreation on public lands. What uniquely characterizes these discussions is the collaboration of specialists in varying fields and the integration of community members who are given equal power and voice in the process. Following the principals of the Eastern Region Sustainable Recreation Strategy, the MNF ultimately seeks to cultivate relations across lands and forest gateway communities (i.e., Mon Towns) that will enhance the economy and quality of life for residents and visitors, while simultaneously sustaining the quality of the environment.

The recreation economy has been recognized by the United States Department of Agriculture as an emerging or priority area of national need. Annually, the outdoor recreation economy generates \$887 billion in spending, directly supports 7.6 million American jobs, and generates \$125 billion in federal, state, and local tax revenues. Outdoor recreation is a growing and diverse economic super-sector that is a vital cornerstone of successful communities which cannot be ignored, yet, many rural communities lack the capacity and resources needed to successfully support and fully capitalize on the recreation economy. An approximate 1.3 million visitors come to the MNF each year, providing a strong base to grow local economies.

To move this effort forward, the MNF has partnered with the West Virginia University Extension Service to develop a strategic framework for the project that will be implemented across the larger forest landscape. Together, we are working collaboratively to develop a shared vision with our forest communities that identifies ways to grow conservation and nature-based recreation that will result in environmental and economic gains over the long-term. By building upon an existing strong foundation of ecosystem services, we can contribute to a forest in which nature, people, and local communities and their economies thrive.

The process of developing “Mon Towns” will be presented, including a description of recent progress in developing a co-designed brand that has allowed residents an opportunity to be part of the forest story.

## EFFECT OF LONG TERM MANAGEMENT PRACTICES ON SOIL MICROBIAL PROCESSES IN GRAZING LANDS

*S.S Sandhu, K.S. Inglett, and S. Gerber*

Soil and Water Sciences Department, University of Florida, Gainesville, FL, USA

The carbon (C) and nutrient cycling in ecosystems are regulated by the soil microbial processes. The C quality and quantity, and nutrient availability are affected by management practices in grazing lands, hence altering soil microbial processes and carbon storage. Understanding the impacts of management practices such as grazing duration, vegetation type and nitrogen fertilization on soil organic matter (SOC) storage in grazing lands is crucial to provide the most effective soil C management options. However, it is still uncertain how the soil microbial processes respond to long-term management practices in grazing lands. The objectives of this study were to i) analyze the effects of long-term (>24 years) management practices on soil microbial processes and C storage ii) To determine the carbon storage potential of the sub-surface spodic horizon. The experimental site consisted of two management systems including improved pasture and native rangeland. The native rangeland consisted of woody and non-woody perennial plant species, whereas improved pastures consisted of only non-woody perennial grass species with continues grazing throughout the year. The native rangeland was never fertilized, however, improved pastures received  $67 \text{ kg N ha}^{-1} \text{ yr}^{-1}$ . The soil samples were collected in September 2017 from A1, A2, E and Bh horizons from both management systems. The data from this study indicated that improved pastures significantly ( $P < 0.05$ ) promoted the activity of extracellular enzymes involved in C and N mineralization except for N-acetyl-  $\beta$ -D-glucosaminidase enzyme compared to native rangeland system probably due to increased substrate availability. However, there were no significant differences in microbial biomass carbon in both management systems. This indicates that the specific microbial activity was higher in improved pastures due to the availability of more labile as indicated by hot water extractable C. Moreover, improved management practices resulted in increased SOC stocks from  $32.8 \text{ Mg ha}^{-1}$  in native rangeland to  $59.1 \text{ Mg ha}^{-1}$  in improved pastures with the majority ( $14.3 \text{ Mg ha}^{-1}$  in native rangeland and  $19.6 \text{ Mg ha}^{-1}$  in improved pastures) of C being stored in the spodic horizon. Our results indicated that long-term management practices can be helpful in storing more C in soil along with supporting cattle industry in grazing lands.

## **A ROSE BY ANY OTHER NAME: HOW WATER UTILITIES INVEST IN ECOSYSTEM SERVICES**

***Carrie Sanneman***

Willamette Partnership, Portland, Oregon, USA

Water utilities for stormwater, drinking water, and waste water are charged with protecting clean water resources, and they have dedicated long-term funding toward that end. Water funds, forest resilience bonds, and PES programs are some of the ways that the ecosystem services community and water utility sector work together, but there is opportunity to do so much more, to move beyond working with only the most innovative utilities and partners. But first we need to communicate. The ecosystem services community can do more to speak in a language that water utilities understand and invest in.

The presentation is intended to start a conversation about how to leverage language to get more money into conservation and restoration. It will cover trends in the water utility sector related to enhancing ecosystem services: the drivers pushing utilities toward utilizing conservation, restoration, and natural treatment; leading examples; and the framing that resonates with utility boards. The presentation will also highlight how different types of utilities (stormwater, drinking water, waste water) talk differently about what we call ecosystem services, and some of the sector-wide trends that are well positioned to take advantage of ecosystem service science.

## PROMOTING SUSTAINABLE LAND MANAGEMENT THROUGH A ROBUST SCIENCE/POLICY DIALOGUE

*Mark Schauer, Hannes Etter*

Economics of Land Degradation (ELD) Initiative, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Germany

The Economics of Land Degradation (ELD) Initiative is an initiative on the economic benefits of land and land based ecosystems. The initiative highlights the value of sustainable land management and provides a global approach for analysis of the economics of land degradation. It aims to make economics of land degradation an integral part of policy strategies and decision making by increasing the political and public awareness of the costs and benefits of land and land-based ecosystems. The partner institutions' vision of the Economics of Land Degradation (ELD) Initiative is to transform global understanding of the value of land and create awareness for the holistic economic case for sustainable land management that prevents loss of natural capital, secures livelihoods, preserves ecosystem services, combats climate change, and addresses food, energy, and water security, and to create capacity for the utilization of economic information for sustainable land management. ELD's methodology introduces a step-wise approach to the valuation of ecosystem services and the inclusion of this information in decision-making processes (called the "Action"-step). This methodological approach is implemented in national contexts in a number of partner countries with a focus on Africa and the example from Kenya gives a good impression, how economic information on the value of land-based ecosystem services can facilitate decision making for a more sustainable land use approach.

Kenya's soils are currently suffering from degradation in the form of nutrient depletion, acidification and erosion, all of which affect the ability of the land to support agricultural production. The Government of Kenya, in its Kenya Vision 2030, recognizes the need to increase productivity in the agricultural sector if food security is to be maintained and enhanced, and if food demands from a rapidly increasing population are to be met. However, on-going agricultural yield declines put the achievement of this vision at risk, and for more than a decade the country has experienced a downward production trend. Land degradation and soil fertility losses are considered to be a key factor in the Kenya Government's failure to achieve its food production goals. Kenya plans for its Land Degradation Neutrality (SDG 15.3) target to be achieved by 2030, as compared to 2015, with an **additional 9% of the national territory to be improved** (net gain), while simultaneously achieving the following goals, to which the economic information provided by ELD will contribute:

- Increase forest cover through **afforestation/agroforestry** in existing forests; areas of shrubs/grassland; wetlands; croplands (by 5.1 million ha) ;
- Increase by 16% net **land productivity** in forest, shrubland/grassland and cropland showing declining productivity; achieved through SLM practices ;
- Increase **soil organic carbon** by 319,626 total tonnes in cropland land use achieved through sustainable land management practices ;
- **Halt the conversion of forests** to other land cover classes by 2030 ;

## **EXPANDING FINANCE FOR CONSERVATION OF NATURAL ASSETS**

*Rowan Schmidt, David Batker, Johnny Mojica, Jordan Wildish, Matt Chadsey*

Earth Economics, Tacoma, WA, USA

Natural assets like forested watersheds, parks, street trees, and floodplains provide a broad range of benefits for urban communities such as water filtration, flood risk reduction, clean air, and opportunities for recreation. These benefits build community climate resilience and support health and equity. More broadly, conservation and restoration is a critical to building resilience and adapting to other pressures like population growth and escalating inequity. However, to be effective, we must move beyond piecemeal solutions – a green roof here and a few street trees there – to investment on the scale of millions and billions of dollars. Change at this level requires local, state, and federal policies that fully integrate green infrastructure into the core tools of decision making – accounting, benefit-cost analysis (BCA), and financing mechanisms.

This presentation will highlight several areas that Earth Economics is pursuing to expand finance for natural assets, including advancing natural accounting rules to support new finance options for green and distributed infrastructure investments, and taking advantage of new federal policies that encourage the use of pre- and post-disaster funding streams for conservation.

## GAP ANALYSIS OF ECOSYSTEM SERVICES AT THE DEPARTMENT OF THE INTERIOR

*Rudy Schuster<sup>1</sup>, James Meldrum<sup>1</sup>, Chris Huber<sup>1</sup>, Benjamin Simon<sup>2</sup>, Adam Stern<sup>2</sup>, and Christian Crowley<sup>2</sup>*

<sup>1</sup>U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, USA

<sup>2</sup>Department of the Interior, Office of Policy Analysis, Washington, D.C., USA

To date, there have been many studies focused on understanding the process of coordinating collaborative management efforts for large ecosystems and eco-regions. However, few have focused on ways to identify and address gaps and barriers to coordinating research efforts, setting priorities, and resource allocation and understand how these efforts come to be (Heikkila and Gerlak 2005). The importance-performance analysis (IPA) framework has been used to provide research and decision support in many topical areas (Oh 2001). IPA can provide systematic information and statistical analysis to facilitate resource allocation decisions. The IPA framework provides a highly transparent and replicable method to identify agency strengths, weaknesses, and areas for resource prioritization and appropriation (Lemieux et al. 2013).

This project employed the IPA framework to understand areas of strength and gaps in data, methods, and decision-making tools associated with ecosystems services in the Department of the Interior. Our online IPA questionnaire asked a series of 5-point Likert-type scales on: 1) the importance of 24 ecosystems services to their individual decision-making context; 2) the status (performance) of available data; 3) development and quality (performance) of research methods; and 4) the development and quality (performance) of tools. The series of questions on data, methods, and tools were repeated for ecological production functions, economic valuation, and non-monetary valuation topics. In total, the online survey was sent to 141 DOI employees who use ecosystem services in their daily work activities. A modified Dillman (2014) Tailored Design Method for internet surveys was used to achieve a response rate of 72% (n=102). Importance and performance scores were plotted on a two-dimensional grid with the intercept representing lowest possible scores. This grid was then segmented into a four-quadrant matrix used to categorize responses into one of four groups: 1) Gap, 2) Good Work, 3) Reassess, or 4) Sufficient. Results will be presented using the two-dimensional matrices and descriptive statistics.

We find that tools were rated low on the performance axis relative to data and methods in almost every instance. Non-monetary valuation consistently rated lowest on the performance axis for data, methods, and tools when compared to the ecological production function and economic valuation sections. While the ecological production function section had the best overall performance scores, there was still a great degree of underperformance in most data, methods, and tools categories. Cultural and spiritual resources, fish, and fauna were in the Gap quadrant in data, methods, and tools. Recreation was the only category consistently in the Good Work quadrant for data, methods, and tools. Fungi, depredators and predators, fiber, pollinators, viewscapes, sound and scents, weather, and the presence of environment were always in the Reassess quadrant, indicating perceived overall low performance and low importance of these categories in the typical respondent's daily work activities.

## **VARIABLES ASSOCIATED WITH (ENVIRONMENTALLY) SUCCESSFUL PAYMENT FOR ECOSYSTEM SERVICES PROGRAMS.**

*Sierra Gibbons, Daniel Scognamillo, and Gary Kronrad*

Arthur Temple College of Forestry and Agriculture. Stephen F. Austin State University, Nacogdoches, Texas, USA.

Considering the large implications of Payment for Ecosystem Services (PES) programs for conservation of natural resources and economic development, and the lack of standards for their development and evaluation, we conducted a meta-analysis to identify common program characteristics associated with their success and to assess their relative effect on that outcome. Chi-square tests provided evidence of the association of success to specific moderator variables and odd ratios and their 95% confidence interval estimated the probability of success conditional on the presence of a moderator variable. We also estimated the magnitude of effect of each moderator variable on the probability of the program's success using nominal multiple logistic regression models. Our results indicate that how administrators measure landowner's compliance with program regulations (direct measurement of ecosystem services or measurement of land management changes), the form of payment (monetary or in-kind payment), type of administration (public or private), program origin (brand new program or program that evolved from previous one), existence of carbon payments, implementation of training component, and active communication with landowners had the largest positive statistically significant influence on the success of the program. We also examined how each analyzed PES program defined success and determined if a common definition was used or could be used across programs. While social goals, especially poverty alleviation, are being proposed in the literature as possible outcomes of payment for ecosystem services programs, a word cloud analysis of the words in the definitions of successful programs revealed that authors focused primarily on the environmental impacts of PES programs, and that social goals are not being incorporated into the evaluation of overall program success.

## **NUTRIENT TRACKING TOOL: QUANTIFYING ENVIRONMENTAL AND ECOSYSTEM SERVICE IMPACTS OF AGRICULTURAL PRACTICES**

*Ali Saleh<sup>1</sup> and Mindy Selman<sup>2</sup>*

<sup>1</sup>Texas Institute of Applied Environmental Research, Tarleton State University, Stephenville, TX, USA

<sup>2</sup>Office of Environmental Markets, USDA, Washington, DC, USA

Nutrient and sediment losses from agriculture can have far reaching impacts on the environment and ecosystem services. Notably, these losses can lead to declines in local water quality and contribute to coastal eutrophication and dead zones such as in the Chesapeake Bay and Gulf of Mexico. The types of cultural and structural conservation practices that can help mitigate nutrient and sediment pollution are well known, however the relative benefits of these practices on the farm scale can be hard to quantify. Suitability and cost-effectiveness of various conservation practices will depend both physical characteristics of the site (slope, precipitation, soil type, etc.) as well as current and planned management practices (crop rotation, fertilizer inputs, tillage etc.).

In 2018 the Texas Institute of Applied Environmental Research released a national version of the Nutrient Tracking Tool (NTT) that can estimate nutrient and sediment losses from agricultural operations. NTT estimates nutrient and sediment losses based on the crop rotation, tillage, fertilizer applications, grazing and irrigation practices. Users can also specify several structural and conservation practices such as cover crops, rotational grazing, filter strips, riparian buffers, contour buffers, water and sediment control basins, wetlands, tile drains, etc. NTT, which uses the Agricultural Policy Environmental eXtender model (APEX), simulates one or more management scenarios and compares results. Thus the user can estimate changes in nutrient and sediment losses for one or more management scenarios on any given field. In addition, NTT estimates yield impacts so that producers may also assess the relative costs and benefits to their bottom line of implementing various conservation practices.

Tools like NTT can have several applications, including environmental markets, supply chain sustainability, education and outreach, tracking progress towards TMDL or other water quality goals, etc. NTT is currently being evaluated by several states for use in their water quality trading programs.

## **WATER QUALITY TRADING MARKETS IN THE CHESAPEAKE BAY: WHO PAYS, WHO BENEFITS AND WHY IT MATTERS**

***Mindy Selman***

Office of Environmental Markets, USDA, Washington, DC, USA

The Chesapeake Bay is facing an aggressive multi-state TMDL for nutrients and sediments in the Bay. In order to meet targets for reducing these pollutants, states like Maryland, Pennsylvania and Virginia have begun regulating nutrient losses from wastewater treatment plants, MS4s and development. In conjunction with these measures, the states have also implemented water quality markets. These markets allow for regulated entities flexibility in how to meet their allocations by purchasing nutrient reductions from other sources that can reduce these nutrients more cheaply. In addition, water quality trading allows flexibility in the nutrient caps by allowing new or expanding sources to purchase additional allocations from other sources/sectors.

The water quality trading programs in Maryland, Pennsylvania and Virginia have evolved differently and vary in the sources that are included in the trading program, the rules of the trading program, and the level of activity within the program. This presentation will provide an overview of the water quality trading programs within the Chesapeake Bay, future sources of demand, and what's next.

## MAPPING AGGREGATE FLOWS OF ECOSYSTEM SERVICES FROM MULTIPLE MIGRATORY SPECIES

*Darius J. Semmens<sup>1</sup>, Laura López-Hoffman<sup>2</sup>, Ruscena Wiederholt<sup>3</sup>, Wayne Thogmartin<sup>4</sup>, Brice Semmens<sup>5</sup>, Christine Sample<sup>6</sup>, Amy Russell<sup>7</sup>, Leslie Ries<sup>8</sup>, Karen Oberhauser<sup>9</sup>, Rodrigo Medellín<sup>10</sup>, Gary McCracken<sup>11</sup>, Brady Mattsson<sup>12</sup>, John Loomis<sup>13</sup>, Joshua Goldstein<sup>14</sup>, Jim Dubovsky<sup>15</sup>, Paul Cryan<sup>16</sup>, Joanna Bieri<sup>17</sup>, Ken Bagstad<sup>1</sup>, and Jay Diffendorfer<sup>1</sup>*

<sup>1</sup>United States Geological Survey, Denver, CO, USA

<sup>2</sup>University of Arizona, Tucson, AZ, USA

<sup>3</sup>Everglades Foundation, Palmetto Bay, FL, USA

<sup>4</sup>United States Geological Survey, Lacrosse, WI, USA

<sup>5</sup>University of California, San Diego, CA, USA

<sup>6</sup>Emmanuel College, Boston, MA, USA

<sup>7</sup>Grand Valley State University, Allendale, MI, USA

<sup>8</sup>Georgetown University, Washington DC, USA

<sup>9</sup>University of Wisconsin Arboretum, Madison, WI, USA

<sup>10</sup>National Autonomous University of Mexico, Mexico City, Mexico

<sup>11</sup>University of Tennessee, Knoxville, TN, USA

<sup>12</sup>University of Natural Resources and Life Sciences, Vienna, Austria

<sup>13</sup>Colorado State University, Fort Collins, CO, USA

<sup>14</sup>The Nature Conservancy, Fort Collins, CO, USA

<sup>15</sup>United States Fish and Wildlife Service, Lakewood, CO, USA

<sup>16</sup>United States Geological Survey, Fort Collins, CO, USA

<sup>17</sup>University of Redlands, Redlands, CA, USA

Migratory species provide many different types of ecosystem services throughout their migratory range, often with substantial monetary value. Although the animals themselves provide these benefits, their ability to do so hinges on the availability of the habitat upon which the animals depend for survival and reproduction. By cataloguing the goods and services provided by a migratory species, and modeling the species proportional dependence on habitat throughout the full migratory range, it is possible to quantify net benefit flows from habitat to people. Regions providing more benefits than they receive are net exporters of services that effectively subsidize beneficiaries elsewhere. By quantifying these subsidies across jurisdictional and political boundaries we can inform the management and conservation of migratory species, many of which are threatened worldwide due to anthropogenic change.

We demonstrate this approach using three North American case studies that provide a range of different services: northern pintail ducks (recreational hunting and viewing, subsistence hunting); Mexican free-tailed bats (agricultural pest control, recreational viewing); and monarch butterflies (aesthetic enjoyment, recreational viewing). Ecosystem service values provided by these species range from \$20-130 million, totaling \$250 million annually, with substantial subsidies between regions in each example. We further combine the benefit flows for these three species to generate an aggregate flows map across North America. Aggregating flows in this fashion provides an opportunity for opposing flows between regions to cancel each other out, leaving only the net imbalance (flow) between regions. As international efforts to manage and conserve migratory species increase in number, quantitative information on net flows between countries can both inform negotiations over financial responsibilities and provide a critical means of communicating the value of conservation to the public.

## SOCIAL CONTEXT AND VALUE-TRANSFER PERFORMANCE FOR SPATIAL CULTURAL ECOSYSTEM SERVICE MODELS

*Darius J. Semmens<sup>1</sup>, Benson C. Sherrouse<sup>2</sup>, and Zachary H. Ancona<sup>1</sup>*

<sup>1</sup>United States Geological Survey, Denver, CO, USA

<sup>2</sup>United States Geological Survey, Baltimore, MD, USA

Recreational and aesthetic enjoyment of public lands is growing across a wide range of activities, highlighting the need to identify where people receive these cultural ecosystem services and adapt management to accommodate their growing use. Despite substantial progress assessing and valuing biophysically derived ecosystem services, the capacity to account for non-market social values associated with cultural ecosystem services remains limited. The Social Values for Ecosystem Services (SolVES) tool was designed to help meet this need by providing the ability to generate maps of value intensity for various cultural ecosystem services. SolVES works by relating the spatial responses (locations associated with each particular value type) from public value and preference surveys to various user-provided environmental data layers. The results provide models of the spatial distribution of social value as a function of landscape features. Although SolVES has expedited the development of spatial information on social values, it still requires users to conduct expensive and time-consuming surveys of a target population to collect the necessary input data. This survey requirement has limited applications of SolVES around the world to well-funded studies in high-value locations.

Spatial value transfer, if it could be justified for social-value models, would further expedite the development of social-value information and promote its more regular inclusion in ecosystem service assessments. We used social-survey data from six national forests in Colorado and Wyoming to explore the potential for transferring cultural ecosystem service models between forests and specifically to test the hypothesis that transfer performance will increase with social-context similarity between transferring and receiving areas. Results show a statistically significant, positive relationship between social-context similarity, as measured by four widely available demographic parameters, and transfer performance, but fall just short of being able to predict with certainty when transferred models will meet the minimum performance criterion needed for defensible use by managers. Education level was the most influential predictor of transfer performance, followed by age, gender, and income, respectively. Social values are highly variable and can be difficult to predict, but our results suggest that with the right combination of indicators spatial value transfer can become a defensible means of generating social-value information when primary data collection is not feasible. An obvious next step is to incorporate similar, quantitative indicators of biophysical-context similarity to develop a more robust set of predictors for transfer performance.

## **VALUING LIVELIHOOD AND ECOSYSTEM BENEFITS OF RAINFOREST REFORESTATION FOR CLIMATE CHANGE MITIGATION: A SUCCESS STORY OF HINIDUMA BIO-LINK IN SRI LANKA**

***D.K. Lakmini Senadheera<sup>1</sup>, W.M.P.S.B. Wahala<sup>2</sup>, Shermila Weragoda<sup>3</sup>***

<sup>1</sup>Conservation Carbon Company, Colombo-05, Sri Lanka,

<sup>2</sup>Department of Tourism Management, Sabaragamuwa University of Sri Lanka

<sup>3</sup>Carbon Consulting Company, Colombo 05, Sri Lanka

There is growing acceptance that the environmental and livelihood-improvement benefits of forests extend beyond the mitigation of climate change. Forest reforestation programs that are typically motivated only by carbon benefits also has the potential to improve livelihoods, reduce gender disparities, and provide non-carbon ecosystem benefits with appropriate targeting of land selection and involvement of local communities in governance. The Hiniduma Bio-link Project owned and maintained by Conservation Carbon Company in Sri Lanka. Apart from the direct benefit of forest protection on decreasing carbon emissions and increasing carbon sequestration, forest projects yield indirect benefits, called co-benefits which can be linked to the national agenda of the SDGs and beyond-carbon impacts of forest carbon projects are often of equal or greater importance to buyers of emissions reductions.

Our project, the Hiniduma Bio-link offers value-added carbon credits for socially and environmentally conscious organisations and individuals. It is a reforestation project to establish a biodiversity corridor between two large protected remnant Sri Lankan rainforest patches – Singharaja and Kanneliya. In addition to mitigating the broader issue of climate change, the project helps to (1) conserve limited rainforest groves by providing buffers and a safe corridor between the two protected forest patches to help reduce threats to local biodiversity and wildlife from adjacent human communities and (2) improve livelihoods of local farmers and landholders by providing training and income generating opportunities

The Bio-link Project accomplishes this through the reforestation of traditional farmers' home-gardens in the lowland wet zone region through analog forestry. Along with the baseline biomass estimation of the selected pilot project, the carbon savings from the newly planted trees were calculated and registered for carbon credits. The expected sequestration potential per hectare is 152.14 tCo<sub>2</sub>/ha after a 20% deduction for unexpected losses.

The Hiniduma Bio- Link Project is also the first project in Asia to complete a Plan Vivo. Plan Vivo is a standard for designing and certifying community based payments for ecosystem services (PES) programmes. One of the noteworthy successes of the project has been the sale of carbon credits from the Hiniduma Bio-link Project to Marks & Spencer, UK.

Beyond-carbon impacts of creating just employment or saving habitat for an endangered species are actually the main motivation of the project, and the verified emissions reductions that result are themselves a "co"-benefit – and a means of leveraging carbon finance to implement project activities.

## LAND AND WATER ACCOUNTS: SETTING THE STAGE FOR ECOSYSTEM SERVICE TREND ANALYSIS

*Ken Bagstad<sup>1</sup>, Carl Shapiro<sup>2</sup>, Zach Ancona<sup>1</sup>, Pierre Glynn<sup>3</sup>, Julie L. Hass<sup>4</sup>, Scott Wentland<sup>5</sup>*

<sup>1</sup>USGS Geoscience and Environmental Change Science Center, Denver, CO, USA

<sup>2</sup>USGS Science and Decisions Center, Reston, VA, USA

<sup>3</sup>USGS Water Mission Area Reston, VA, USA

<sup>4</sup>Independent consultant, Boulder, CO, USA

<sup>5</sup>Office of the Chief Economist, Bureau of Economic Analysis, Washington, DC, USA

In the context of natural capital accounting, ecosystem service assessments typically use the System of Environmental-Economic Accounts' Experimental Ecosystem Accounting (SEEA-EEA) framework. However, the related SEEA Central Framework provides the methods and framework for understanding how other resources – including land, water, minerals, fisheries, and forestry – ecosystem goods that contribute to national and subnational economies and human well-being. In addition to ecosystem accounts, our U.S. natural capital accounting working group has developed land and water accounts for the continental U.S., at the national and state levels.

The land accounts bring together data on land cover, land use, and residential land value changes over an initial 10-year time span (2001-2011). Key changes observed include expansion of urban lands (particularly in the Southeast, Texas, Arizona, and California), agricultural lands (primarily in eastern states), and forest loss (Southeast and West). The greatest overall observed changes in land cover occurred in the Southeast. Spatial data on land use allowed us to summarize the economic activities and different land cover types that provide land value (e.g., distinguishing between forests used for recreation vs. forestry). In turn, land value data enable more precise quantification of changes in residential growth over time.

Water accounts summarize water supply and use, quality, and productivity over roughly the same time period (2000-2015 for water use and productivity, 2002-2012 for water quality). We also conducted an expert elicitation to conceptually model linkages between water quality and water users within the U.S. economy. Continuing a trend since 1980, total U.S. water use has declined, leading to concurrent decreases in per capita water use and rising water productivity. However, parts of the U.S. have seen increases in water use, notably Oklahoma and Mississippi. National-scale surface water quality trends included declines in key water quality constituents, especially in the Southeast, Plains, and Northwest, and improvements in the Midwest, Northeast, and Southwest. Key recent changes to the U.S. economy, including agricultural intensification, shale gas extraction through hydraulic fracturing, and computer and electronics manufacturing, have important implications for water use, productivity, and quality. Water accounts provide a more complete view of the role of water in the U.S. economy, and we describe data gaps and next steps to improve future water accounts.

Together, land and water accounts can provide a more complete view of how, why, and where changes in water resources result from changes in land use and cover. They can also provide insight on how changes in environmental and resource conditions may lead to changes in ecosystem service production and use, providing a better understanding of trends in natural capital and its role in the U.S. economy.

## SHIFTING CONTEXTS: HOW CHANGES IN GOVERNANCE FRAMEWORKS, STAKEHOLDER ENGAGEMENT, AND RESEARCH APPLICATION INFLUENCE PROJECT OUTCOMES

**Leah Sharpe<sup>1</sup>, Kathleen Williams<sup>2</sup>, and Matthew C. Harwell<sup>1</sup>**

<sup>1</sup>Gulf Ecology Division, Office of Research and Development, United States Environmental Protection Agency, Gulf Breeze, FL, USA

<sup>2</sup>Mid-Continent Ecology Division, Office of Research and Development, United States Environmental Protection Agency, Duluth, MN, USA

The EPA Office of Research and Development's (ORD) Sustainable and Healthy Communities (SHC) research in community-based decision support (CBDS) includes advancing the science in developing tools, models, and approaches that can be transferred among communities. Recent research on CBDS has focused on advancing the introduction of ecosystem goods and services (EGS), in particular, the EGS that are directly experienced by people (*final EGS*), into community decision processes. To examine the effectiveness of this research in CBDS, there is a need to not only understand the EGS science, but also how decisions unfold in practice, including how research was applied, the role stakeholders played, and the structure of the overarching governance framework.

We conducted a governance-stakeholders-outcomes analysis assessment across five case study locations, each with different ecosystems and EGS types, decision contexts, and governance structures. Specifically, the analysis focused on exploring four aspects of the case studies in order to better understand how these individual elements related to project outcomes:

- The context for the decision – the program, policy, and the research questions;
- The geography, history, research, and use of tools;
- Stakeholder identification, engagement, and participation; and
- The project outcomes.

Ultimately, this study will provide a better understanding of how shifts in the decision context, the differing ways in which stakeholder roles are defined and applied, and the differing ways in which research is integrated can influence project outcomes and perceptions of success.

## A ROLE FOR SOCIAL-VALUES MAPPING IN INCREASING PUBLIC ACCESS TO THE CHESAPEAKE BAY WATERSHED

**Benson C. Sherrouse<sup>1</sup>, Darius J. Semmens<sup>2</sup> and Zachary H. Ancona<sup>2</sup>**

<sup>1</sup>United States Geological Survey, Baltimore, MD, USA

<sup>2</sup>United States Geological Survey, Denver, CO, USA

The Chesapeake Bay watershed, covering approximately 64-thousand square miles over six states and the District of Columbia, is currently home to over 18-million people. The well-being of its residents depends, in part, on the food, water-quality regulation, wildlife habitat, and recreational experiences it provides. These services, however, have been degraded by the impacts of ongoing land-use change including urbanization and agriculture. To protect and restore the Bay and its related ecosystem services, Executive Order (EO) 13508 was issued in 2009. As a response to this EO, the *Strategy for Protecting and Restoring the Chesapeake Bay Watershed* was developed. The strategy includes a goal to meet public demand by increasing the number of publicly accessible recreation sites to the Bay by 300 in 2025. This increased access is anticipated to foster increased connection to and concern for the condition of the watershed. As a result of this strategy, the National Park Service (NPS) was instructed to develop a public access plan, and they collected over 400 locations from the general public that indicate suggested sites for additional access to the Bay. By the end of 2017, 153 access sites had been added to the Bay. Although site additions are currently on pace to meet the 2025 goal, several factors, including land ownership, funding, and user conflicts will continue to influence future progress. Additionally, other planning and policy considerations such as providing public access to underserved areas will also impact the selection of new access sites.

Using the publicly identified recreation (boating, swimming, fishing, and nature-viewing) locations collected by the NPS, in conjunction with relevant environmental data layers describing the watershed (distance to existing access, relative urbanization, and relative water clarity) we applied the GIS tool, Social Values for Ecosystem Services (SolVES; <http://solves.cr.usgs.gov>) to define additional criteria for selecting access sites. SolVES generated a recreation value map rendered as a 10-point value-index (VI) scale indicating the most highly valued locations for new recreation access to the watershed. This value map was then compared to the spatial distribution of underserved communities (as defined by relatively under-age and higher-poverty areas) to identify sites that both scored high on the VI scale and that were closer to underserved areas.

Our preliminary results demonstrate that SolVES can be used to provide spatially explicit social-values information that takes into account direct, public input within the context of broader planning and policy considerations. This information, in turn, can be used to help prioritize recreation access sites for future development. Additional work should include refinements to the environmental variables that can help to better explain the locations of publicly selected access sites as well as the identification of variables that further expand SolVES analysis to more explicitly consider existing opportunities and concerns related to future site development such as the loss of older, working waterfronts and inadequate railroad crossings.

## **HARNESSING TECHNOLOGY TO CONSERVE A WILD ICON OF THE WEST: GREATER SAGE-GROUSE, THE WEB, AND PROACTIVE DECISION SUPPORT TOOLS**

*Carolyn A. Sime, T. Hartman, G. Neale, and J. McFadden*

Montana Sage Grouse Habitat Conservation Program, Helena MT, USA

The Greater Sage-grouse (*Centrocercus urophasianus* or sage grouse) inhabits sagebrush grassland habitats exclusively. Approximately 270 other species are also associated with sagebrush habitats. Sage grouse are only found in 11 western states, with remnant populations in Alberta and Saskatchewan. This iconic bird depends on sagebrush shrubs for nearly all its life history. It evolved with nothing taller than a bison or louder than a stampede. Sage grouse do not fare well in the face of anthropogenic change. Populations west wide have declined significantly over recent decades because of habitat loss and fragmentation. Causes include conversion of sagebrush rangelands to cultivated agriculture, energy development, subdivision, ex-urban development, wildfire, and invasive species. Sage grouse are not opportunistic pioneers of new habitat and typically do not adopt new areas if translocated. Site fidelity to breeding areas is particularly high, and some in Montana have been used for more than 70 years. Site fidelity is so strong, and the tolerance of and adaptation to disturbance is so low that localized extirpations result if disturbance exceeds a threshold, regardless of the cause/s. Petitioners have sought federal Endangered Species Act protections eight times. Montana is a sage grouse stronghold and has long emphasized habitat conservation. More recently, Montana formally adopted a conservation strategy that blends voluntary incentives with regulatory oversight through the permitting process. Other western states enacted their own conservation strategies. In 2015, the U.S. Fish and Wildlife Service concluded that listing was not warranted due to states' efforts and those by the federal land management agencies. States and their diverse stakeholders share the goal to avoid a federal listing in the future. Successful conservation depends on proactive stewardship of the remaining intact sagebrush landscape to carefully manage the type, duration, location, nature, and degree of human development in sage grouse habitats. In Montana, web-based tools enable developers to consider potential impacts proactively before approaching regulators to initiate the permitting process. Online tools perform both a qualitative and a quantitative assessment of potential impacts to breeding areas for comparison against thresholds of disturbance identified in the scientific literature (i.e. an impact calculator). Geospatially referenced analyses provide instantaneous information that developers can use to anticipate resource concerns that will catch regulators' attention and then proactively adjust siting or other facets of the project. Key advantages include the calculator's transparency and repeatability for developers, a user-friendly web interface, and the underlying geospatial SQL database that the state and the U.S. Fish and Wildlife Service will use to evaluate the efficacy of Montana's efforts. Through consultation, the Montana Sage Grouse Habitat Conservation Program can guide development in sage grouse habitats to avoid and minimize impacts to habitat and sage grouse populations. Where impacts are documented, mitigation is required. In this way, developers can proactively plan projects to keep mitigation obligations as low as possible. In turn, developers are incentivized to take the steps necessary to ensure Montana's conservation strategy is successful.

## PUTTING HEALTH ON THE MAP

**Cary Simmons**

The Trust for Public Land, Seattle, WA, USA

*Presented By: Lara Miller*

The Central Puget Sound Open Space Assessment Tool (OSAT) is an online data library and mapping portal, built to integrate and elevate the many activities underway to conserve and enhance the ecological, economic, recreational, and aesthetic vitality of the Central Puget Sound region. OSAT visualizes data to highlight key regional challenges and their intersection with open space planning: Climate Change, Biodiversity, Human Health, Social Equity and Economic Development. The intention is to aggregate the region's most strategic data available to date to understand opportunities and tradeoffs in regional decision-making across these challenges, communities and the landscape.

The tool integrates multiple data sources highlighting the key benefits provided by the region's open space system, with the goal of aiding planners and policy makers in identifying the highest priority places for investments. Current users of the tool include parks departments, regional planning organizations, environmental organizations, and academic institutions.

In Spring 2018, a group of more than two dozen representatives from social justice organizations, county health departments, and healthcare providers began a process to better incorporate health data into OSAT. A growing body of research proves that better access to high quality parks, in conjunction with improved access to clean air and water, living wage employment, stable housing, healthy food, and education can support residents living in vulnerable communities through increased physical activity and health-building resources. Parks and open space provides multiple benefits and can be an important tool to address public health needs and disparities that exist in our communities.

This presentation will focus on: 1. the challenges of merging public health data with built environment data, 2. how to engage health partners in planning for parks and recreation amenities, and 3. how to leverage data to increase funding for multi-benefit open space projects.

## **MODELING, MAPPING, AND VALUING AIR TEMPERATURE EFFECTS OF URBAN VEGETATION ON HUMAN HEALTH.**

*Paramita Sinha*<sup>1</sup>, *Jennifer Richkus*<sup>2</sup>, *Brian Lim*<sup>3</sup>, *David J. Nowak*<sup>4</sup>, *Theodore Endreny*<sup>5</sup> and *Robert Coville*<sup>6</sup>

<sup>1,2,3</sup>RTI International, Washington, DC and Durham, NC, USA

<sup>4</sup>USDA Forest Service, Syracuse, NY, USA

<sup>5</sup>SUNY College of Environmental Science and Forestry, Syracuse, NY, USA

<sup>6</sup>The Davey Tree Expert Company, Syracuse, NY, USA

Urban tree cover provides a myriad of ecosystem services at local, regional, national, and global scales. Tools that quantify and value these ecosystem services are critical to decision-makers who are typically faced with limited resources and competing needs. The i-Tree suite of urban forest modeling tools currently quantifies and values many of the ecosystem services provided by forests, including reductions in building energy use and associated power plant emissions, stormwater runoff mitigation, carbon sequestration, and improvements in public health due to air pollution reduction.<sup>1</sup> Reduced temperatures are also a critical ecosystem service provided by trees and quantifying and valuing these services is important in understanding urban forestry benefits. In this study, we develop a framework and methods to model air temperature regulation by trees, the impacts of temperature on human health and comfort, and the value of those impacts for incorporation into the i-Tree tool suite. The results of the study will allow users to assess a more comprehensive suite of benefits and thus support sound urban environmental planning and management.

Temperature reductions can reduce heat-related health effects such as respiratory illnesses, cardiovascular illnesses, heat stroke, and mortality.<sup>2</sup> We developed a four-step approach to quantify and value tree impacts on air temperature and its subsequent impacts on human health. The first step quantifies urban tree cover and impervious surface cover. The second step estimates hourly air temperature effects of trees using local meteorological data and local land cover data based on canyon air temperature methods.<sup>3</sup> The third step involves applying estimated relationships (from epidemiological literature) between temperature and different health effects to the exposed population. The fourth step applies value estimates (from non-market valuation literature) to the change in health effects to obtain the total monetized benefits of the avoided health effects. We present preliminary findings from applying the method through a case study analysis for the city of Baltimore, MD and discuss next steps for incorporation into i-Tree.

## **BEYOND THE SERVICE-SHED: TRANSLATING ECOSYSTEM SERVICES INTO HUMAN WELL-BEING**

*Elizabeth C. Smith<sup>1</sup>, Rebecca Shirer<sup>2</sup>, Shannon Tho<sup>2</sup>, Dave Richardson<sup>2</sup>, Stephen Lloyd<sup>1</sup> and Karen Leu<sup>1</sup>.*

<sup>1</sup>The Nature Conservancy, East Hampton, NY USA

<sup>2</sup>The Nature Conservancy, Albany, NY USA

Ecosystem services are not new to conservation, as government and management have attempted to include ecosystem services into decision-making for years, implicitly connecting ecological health and function to human well-being. Yet as the field of conservation continues to evolve what still lags behind is how to systematically include beneficiaries and equity considerations into conservation management and planning. The hypothesis we explore in this project is - if we include beneficiaries and equity on an equal playing field with ecosystem function, will it change where and how we do our conservation work? To answer this question, we have developed a geospatial tool to prioritize our land protection in NY which focused on a selected set of ecosystem services tied to the lands' functional attributes, including flood control, recreation and scenic value, water supply and heat mitigation. In addition to multiple ecosystem services, we include beneficiaries and vulnerability to allow trade-offs to be evaluated on multiple dimensions. This Strategy Assessment Tool (SAT) connects information about the population back to the land providing the service, to prioritize places based on who they serve, acknowledging that we are interested in both the types of beneficiaries (tied to services) and in who benefits. Loss of ecosystem services stands to impact some populations more than others, if they lack the economic or social means to avoid, minimize, or recover from those losses; therefore, we include a 7-metric social-vulnerability index to capture differences across beneficiary populations. Our approach allows for robust discussion across disciplines and creates a more equal playing field between the traditional conservation view of maximizing biodiversity and ecosystem function and a more current approach that connects ecosystem services to their beneficiaries, ultimately allowing us to use a single platform to analyze the many dimensions of conservation management. The results indicate that if we optimize a decision based on only ecosystem function our geographic priorities would (in most cases) be quite different than a decision that also include beneficiaries and equity considerations systematically. We believe others can use this work as a model for how to incorporate beneficiaries and equity into conservation planning.

## ECOSYSTEM SERVICE VALUATION OF KEY WATERSHEDS IN KENYA

*David Langat<sup>1</sup>, Nikola Smith<sup>2</sup>, and Alphonso Guzha<sup>3</sup>*

<sup>1</sup>Kenya Forestry Research Institute, Nairobi, Kenya

<sup>2</sup>USDA Forest Service, Portland, OR, USA

<sup>3</sup>Center for International Forestry Research, Nairobi, Kenya

The U.S. Forest Service is collaborating with Kenyan institutions to assess the critical importance of forest cover to support Kenya's sustainable development goals. Kenya's National Forest Programmed (2017) articulates a need to "enhance forest-based economic, social and environmental benefits". This objective recognizes ecosystem services provided by forests as key to the success of other productive sectors including agriculture, tourism, industry and energy.

This study focuses on three priority watersheds - Mt. Elgon, Cherangani Hills and Mau Complex. The assessment couples ecosystem service valuation (ESV) with climate change adaptation planning to define, promote and conserve the watershed ecosystems. The Total Economic Valuation (TEV) approach used here addresses a diversity of use and non-use values and includes a literature review, compilation of secondary data, and primary data collection. Benefits assessed include provisioning services (fuel wood, timber, construction materials, food, water, and hydropower generation) which contribute directly to the livelihoods of local communities as well as diverse economic sectors (agriculture, forest industries, and municipal water). Regulating services (climate regulation, water flow and quality regulation) are significant to local, regional, national and global beneficiaries. Supporting services (soil conservation, nutrient cycling and pollination) indirectly influence productive sectors including agriculture, upon which approximately 75% of the local population depends for their livelihood. Cultural services (spiritual, aesthetic and bequest values) are captured through primary data collection and willingness to pay studies.

The Total Economic Value of the three watersheds assessed is approximately 355 billion Kenyan Shillings (US \$3.5 billion). In all of the three watersheds, regulating services contributed significantly to TEV (ranging from 66%-93% of value provided by each watershed), underscoring the importance of indirect use values provided by forest ecosystems. The results of this study are now being applied to an implementation strategy to support integration of ecosystem services in national budgeting and county-level land use planning. Findings are also being used to leverage innovative forest financing, including private sector investments and payments for ecosystem services.

## **U.S. FOREST SERVICE: INNOVATIVE FINANCING FOR WATERSHED CONSERVATION**

*Nikola Smith<sup>1</sup>, Tommie Herbert<sup>2</sup>, and Jacqueline Emanuel<sup>2</sup>*

<sup>1</sup>USDA Forest Service, Pacific Northwest Regional Office, Portland, OR, USA

<sup>2</sup>USDA Forest Service, National Partnership Office, Washington, DC, USA

Forests are a critical component of the network of built and natural infrastructure that supports clean and abundant water supplies, sustainable recreation, flood protection, forest products and other important benefits for communities, governments and the private sector. The U.S. Forest Service (USFS) is developing innovative financing mechanisms to share investments in forests that generate social, economic and ecological outcomes at a lower cost for the agency, our partners, and the American public.

Public and philanthropic capital alone cannot meet cross-boundary restoration needs. The USFS and partners sustain ecosystem services provided by healthy watersheds through collaboration with local stakeholders and coordinated implementation across the urban to rural gradient. Key partners in this effort include state agencies, private forest owners, cities, public utilities, and investment firms.

Existing USFS financing innovations include municipal bond measures, water funds and corporate partnerships. Examples of these efforts will be shared, with a focus on approaches in the Pacific Northwest. These include a voluntary incentive program in Eugene, Oregon to steward the city's headwaters and conserve privately owned riparian forests; urban and community forestry investments in green infrastructure; and federal partnerships to support restoration and environmental justice in Seattle, Washington. We will also share emerging opportunities to work with municipalities in the greater Puget Sound area to address forest restoration needs across ownerships.

## VIRTUAL WATERSHED: A SPATIAL DECISION SUPPORT SYSTEM FOR AN AGRICULTURAL WATERSHED

**Seth Soman<sup>1</sup>, Girmay Misgana<sup>2</sup>, and Steven Kraft<sup>3</sup>**

<sup>1</sup>Department of Agriculture, Northwest Missouri State University, Maryville, MO, USA

<sup>2</sup>GIS Lab, University of Pennsylvania, Philadelphia, PA, USA

<sup>3</sup>Department of Environmental Policy, SIUC, Carbondale, IL, USA

Multi-functional working agricultural landscapes have the potential to produce ecosystem services such as nutrient cycling, water purification, biodiversity, and carbon sequestration to a far greater extent than is now occurring. A spatial decision support system called “Virtual Watershed” that uses the carbon model CENTURY and the watershed model SWAT embedded in an evolutionary algorithm to identify the optimal production suites of economic commodities and ecosystem services that are possible from a watershed. Using agent-based modeling and historical validation from satellite imagery, Virtual Watershed evaluates the land uses that rural landowners are most likely to choose in any given decision environment (e.g., crop prices, agricultural and environmental policies, prior uses of fields) and determines the economic and ecosystem service outputs from the resulting landscape patterns. The program Virtual Watershed is a visually attractive and user-friendly tool that can be used as an educational tool and as a laboratory for policy makers to test the outcomes of public policy alternatives under variable economic conditions.

Various studies have shown that, the relationships among market forces, public policies, land use decisions, and economic and ecological outcomes are not well understood. The spatial decision support system (SDSS) “Virtual Watershed” captures these dynamic interactions and is used to investigate, through evolutionary algorithms, the optimal or near-optimal suites of economic commodities and ecosystem services – the production possibilities frontier (PPF)-- possible at a watershed scale. After the identification of the ecologic-economic PPF, the study investigates, using an agent-based model (ABM) the effects of various decision-environments consisting of crop prices, forms of agricultural subsidization, ecosystem services payments, and historic land uses on the ecological and economic performance of agricultural watersheds. The resulting land uses from agent-based model, based on various policy scenarios, can be evaluated against the PPF, and there by evaluate the improvement space achievable in regards to economic and ecosystem service production.

Results of “Virtual Watershed” look at how agricultural/environmental policy such as farm bill will affect agricultural land use and water resources under various policies and incentive structures will facilitate early adaptation and make a timely contribution to the successful integration of agricultural, environmental, and trade policy. Results of this modeling framework indicates that current landuse practices at the watershed can be significantly improved, both in terms of economic as well as ecosystem service outputs. Results, especially in the form of maps that show where cropping patterns and associated agricultural revenues, carbon sequestration, water quantity and water quality are most likely to change, will be disseminated to the broad scientific community and relevant policy-makers in USDA and Congress, both directly and through website that can be accessed at <http://vws.erp.siu.edu:90/vws/>

## RECREATION AND CONSERVATION VALUES OF FLORIDA COSTAL SYSTEMS: AN APPLICATION OF MULTI-PROFILE BEST WORST CHOICE

*José R. Soto<sup>1</sup>, Elizabeth F. Pienaar<sup>2</sup>, John Lai<sup>3</sup>, and Damian C. Adam<sup>3</sup>*

<sup>1</sup>School of Natural Resources and the Environment, The University of Arizona, Tucson, AZ, USA

<sup>2</sup>Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, USA

<sup>3</sup>School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

Self-imposed green/ecological taxes can provide substantial resources for the provision of important local ecosystem services that benefit both the ecology and surrounding communities. In the 1990s, residents of Palm Beach County, Florida, USA, voted in favor of two bonds to finance the acquisition and restoration of lands of environmental concern. In total, 31,445 acres of native habitat were conserved. These lands protect both biodiversity and ecosystem services (ES), including open space, outdoor recreation, and flood protection in urban and peri-urban areas. In 2015, county staff determined that a dedicated source of funding would be required to continue running the Natural Areas Program. In lieu of such funding deficit, the local government commissioned us to determine what value residents place on the program and ecosystem services it provides.

To assess the willingness-to-pay (WTP) for various native habitat (e.g., forests, wetlands) and recreational infrastructures (e.g., kayak ramps, paved or dirt trails), we combined a recent innovation in survey methods, called multi-profile best-worst scaling (MBWS), with the traditional discrete choice experimentation (DCE) format. To our knowledge, this research is the first to combine such methods. We call our hybrid choice experiment 'multi-profile best-worst choice' (MBWC). Survey respondents were presented with three profiles of hypothetical programs that provide ES (these varying in terms of habitat type, recreational infrastructure, reductions in flood risk, and cost) and were asked to perform the following two tasks: 1) choose one profile that is 'best' and one that is 'worst;' and 2) choose to participate in one program or neither. The payment vehicle was framed as an annual tax that the respondent would be expected to pay to finance a county Natural Areas Program.

Preliminary results indicate that the value that survey respondents place on the hypothetical Natural Areas Program exceeds the amount per household that would be required to finance the program. Respondents were heterogeneous in terms of the value they placed on habitat conservation and ecosystem services.

Our results also suggest that Palm Beach County should hold a referendum on financing the Natural Areas Program. Furthermore, our findings indicate that combining MBWS and DCE into a single choice experiment format (i.e., MBWC), with two tasks, results in the measurement of two types of utility: conditional demand estimates from DCE (e.g., WTP) and unconditional demand estimates from MBWS. The two tasks appeared to be cognitively manageable to our survey respondents. Measuring preferences from multiple dimensions of utility enables an analysis of ES trade-offs that is much more nuanced, while offering interpretations of results that can affect the analysis of policy relevant questions.

## ANALYSIS OF ECOSYSTEM SERVICES IN WATER SUPPLY INFRASTRUCTURE IN SOUTHEASTERN BRAZIL

*Mariana Abreu<sup>1</sup>, Wilson Sousa Junior<sup>1</sup>, Demerval Gonçalves<sup>2</sup>, Angélica Giarolla<sup>2</sup>*

<sup>1</sup>Department of Water Resources, Aeronautics Institute of Technology, Brazil

<sup>2</sup>Department of Earth Sciences, National Institute for Space Researches, Brazil

Faced with the increasing demand for water resources brought about by population growth and, in the midst of a climate change scenario, where extreme events such as drought are increasingly frequent, it is opportune to think of strategies to increase the potential of our ecosystems to provide and ensure the regularity of this service. Water bodies are under great pressure from human presence and from their economic activities. Therefore, they are protected by legal devices, such as the Brazilian Forest Code. The areas of Permanent Preservation (APP) were created with the function of mitigating the anthropic pressure on these environments. At first, its structure was based on the preservation (or recovery) of the original native forest, without human presence. The most recent changes in Brazilian legislation allow the management of APPs with agroforestry systems, including in the reforestation stage. The objective of this study is to understand if this new possibility of land use and land cover in these preservation areas will fulfill the original ecosystem functions of the APPs and also if it is compatible with the water supply infrastructure thought in terms of Nature based Solutions (NbS). In order to do so, this study analyzed the APPs of the Jaguari watershed - located in the Paraíba Valley in southeastern Brazil - which is part of a network of reservoirs that guarantee the water supply of one of the most populated and industrialized regions of Latin America: the metropolitan region of São Paulo. In order to carry out the mapping and quantification of the water supply services, the InVEST - Integrated Valuation of Ecosystem Services and Trade-offs - Seasonal Water Yield model was used. The preliminary results have shown significant differences between the three types of riparian areas coverage. The next steps include the assessment and definition of the best balance between use and conservation strategies for these areas.

## PAYMENTS FOR ECOSYSTEM SERVICES: WATER RESOURCES PROVIDED BY PROTECTED AREAS IN BRAZIL

*B.F. Pavani<sup>1</sup>, T.C.L. Ribeiro<sup>1</sup>, W.C. Sousa Júnior<sup>1</sup>, R.C.G. Martins<sup>2</sup>, L.C.A. Lemos Filho<sup>2</sup>, D. Letson<sup>3</sup>, M.L. Estevanez<sup>3</sup>*

<sup>1</sup>Department of Water Resources and Environmental Sanitation, Aeronautics Institute of Technology, S.J. Campos, SP, Brazil

<sup>2</sup>Center of Exact and Natural Sciences Federal, Rural University of the Semi-arid Region, Mossoró, RN, Brazil

<sup>3</sup>Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, USA

In this work, the Payments for Ecosystem Services (PES) are established by the ecosystem functions of protected areas linked to the erosion control and reduction of the amount of sediments suspended in water. The benefits of nature's water resources are calculated to eight protected areas in Brazil. The data collection and the information of each area contribute inputs to calculate the Natural Potential for Erosion (NPE), from Universal Soil Loss Equation (USLE) applied to the InVEST model (Natural Capital Project). In order to estimate the effectiveness of the protection of water resources and amount of soil loss avoided, the current scenario, with the protected area, was compared to a hypothetical scenario in which there would be no protection area. The protected area is changed to the common land cover and use in the surrounding. The increase of the water treatment cost is linked with high levels of suspended sediments.

Applying the empirical model, the values of turbidity treatment costs were established and, subsequently, the avoided costs between the scenarios (current to hypothetical), in USD/year:

- Paraíba do Sul River Basin Environmental Protection Area: 21.656.443
- Castanhão Ecological Station: 3.047.105
- Araripe-Apodi National Forest: 281.482
- Brasilia National Park: 12.410.727
- Chapada dos Guimaraes National Park: 8.864.612
- Chapada dos Veadeiros National Park: 32.223
- Matinguari National Park: 8.224.272
- Tijuca National Park: 1.859.945

The values relating to expenses with the chemicals (aluminum sulphate, polymer and hydrated lime) were used to find an equation that relates the cost of water treatment and turbidity reduction of the water. The sludge disposal and dredging costs calculated as potential expenses granted by water supply and hydropower dams companies. The value of PES is also intrinsically linked to the size of the drainage basin and the percentage of this area that is protected. A PES mechanism involving the avoided costs by the protected areas would help in their efficient management, contributing to the budget for conservation of nature in the country.

## **ECOSYSTEM SERVICE VALUATION AND THE BENEFITS OF EVERGLADES RESTORATION**

**G. Andrew Stainback<sup>1</sup>, John H. Lai<sup>2</sup>, Elizabeth Pienaar<sup>2</sup>, Chloe' Vorseth<sup>3</sup>, Damian Adams<sup>4</sup> and Mahadev Bhat<sup>3</sup>**

<sup>1</sup>The Everglades Foundation, Palmetto Bay, FL, USA

<sup>2</sup>Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, USA

<sup>3</sup>Department of Earth and Environment, Florida International University, Miami, FL, USA

<sup>4</sup>School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

The Everglades is one of the world's largest wetland ecosystems in the world covering almost 18,000 square miles from central Florida southward to Florida Bay. Its location at the transition between the sub-tropical and tropical climatic zones make it one of the world's most unique natural areas. Over the 20<sup>th</sup> century efforts to drain the Everglades severely damaged the ecosystem so that today roughly 50% of the historic flow of water through the Everglades has been diverted elsewhere. In 2000 the U.S. Federal government and the state of Florida initiated the Comprehensive Everglades Restoration Plan (CERP). CERP is expected to cost over \$16 billion and take several decades to complete, making it one of the largest ecological restoration efforts in the world. We administered a survey using a discrete choice experiment to a sample of 2,100 Florida households to determine how much they are willing to pay for some of the benefits expected from restoration - increase in populations of wading birds, snail kites, American alligators and reduction of polluted discharges from Lake Okeechobee to the St Lucie and Caloosahatchee estuaries. Environmental concern, using the New Ecological Paradigm scale, of respondents was also measured. Analysis of respondents' willingness to pay with a mixed logit model indicate that Florida residents value all of the benefits of restoration included in the survey, with the greatest value placed on reducing polluted water discharges to the estuaries. The relationship between environmental concern and respondents' willingness to pay was also explored using a latent class model. Specific examples of how the results from this study can be used to inform restoration efforts will be discussed.

## **USING A MULTI-BENEFIT ECOSYSTEM SERVICES APPROACH TO PRIORITIZE OPEN SPACE PROTECTION IN CENTRAL PUGET SOUND**

***Tracy L. Stanton***

The Emerald Alliance and USFS, PNW Research Station and State and Private Forestry R6, Seattle, WA, USA

Over the next 25 years, 1.8 million new residents are expected to move to the central Puget Sound region. This incredible growth is a testament to the high livability factors rooted in treasured environmental amenities, economic vitality and thriving communities. However, current growth is already putting tremendous strain on both the natural and built infrastructure that supports present-day lifestyles. Top of mind for the region's leadership is safeguarding Puget Sound's rich and thriving uniqueness, especially those tenants that are directly under threat from growth--prized open spaces, natural landscapes and urban green infrastructure.

But how do decision makers plan for and prioritize the investment in open space protection in the face of other pressing regional challenges: climate change, environmental degradation, social equity concerns, and maintaining the economic vitality and health and well being of their communities and people? By way of answering these compelling questions, this presentation will introduce an innovative collaborative approach underway to address the challenge of accommodating growth while simultaneously protecting the natural landscape and the flow of ecosystem services it provides. The Emerald Alliance is a new regional collaborative that bridges sectors, disciplines and jurisdictional boundaries – a collaborative efforts driven by a shared vision with clear priorities and solutions where open space services can simultaneously play a critical role in addressing key policy challenges.

The approach embraces a cross-disciplinary, multi-pronged approach focused on:

1. A defined regional open space network and ecosystem service value;
2. Improving regional coordination and decision-making;
3. Building a regional advocacy community; and
4. Developing frameworks and tools to help advance the most important projects and actions.

Included in this presentations will be an overview of the key research findings from the Regional Open Space Strategy; findings that called for the creation of this new regional entity to support the protection of open space through an ecosystem services lens.

## **VALUE OF WETLANDS TO PROTECT BIODIVERSITY, REDUCE DISASTER IMPACTS, AND PROMOTE HUMAN HEALTH**

***Ariana E. Sutton-Grier<sup>1</sup> and Paul Sandifer<sup>2</sup>***

<sup>1</sup>Maryland/DC Chapter of the Nature Conservancy & University of Maryland, College Park, USA

<sup>2</sup>College of Charleston, SC USA

There is substantial, growing literature that details positive human health effects, psychological and physiological, of exposure to “nature,” including “green” and “blue space,” with evidence suggesting that diversity of species or environments may have specific positive human health benefits. These health benefits are important ecosystem services provided by healthy ecosystems. In this presentation, we discuss several critical ecosystem services provided by wetlands including disaster risk reduction, with an emphasis on benefits to human health and well-being. Impacts to human health via damage to ecosystem services from disasters have rarely been considered in disaster planning or mitigation, nor have the health benefits been part of the framework for planning urban greenspaces and land-use. Coastal wetlands can be part of “natural and nature-based” solutions, minimizing the impacts of disasters by buffering coastal communities from storms and erosion and absorbing flood waters. In addition, mental and physical health benefits of experiencing healthy wetlands could offset some stress and disease encounters related to disasters. Thus, coastal wetlands should be part of a strategy for reducing the risk posed by disasters and facilitating recovery. We conclude with recommendations for research priorities and specific inclusion of wetlands in coastal community planning for disaster response and recovery.

## A WEB MAPPING APPLICATION FOR ECOSYSTEM SERVICE VALUATION

**Paul C. Sutton<sup>1</sup>, Sharolyn Anderson<sup>2</sup>, Ida Kubiszewski<sup>3</sup>, Robert Costanza<sup>3</sup>**

<sup>1</sup>Department of Geography and the Environment, University of Denver, Denver, Colorado, USA

<sup>2</sup>School of Natural and Built Environments, University of South Australia

<sup>3</sup>Crawford School of Public Policy, The Australian National University

The value of land and its associated ecosystem services is increasingly being recognized. Land Grabbing is a growing concern in which land grabbing countries may be obtaining valuable ecosystem services for pennies on the dollar because ignorance of the actual value of ecosystem services and because of significant power and wealth differentials. Rapid initial assessments of ecosystem service values for specific regions of the world can prove useful for a variety of stakeholders. We developed a web site with a web mapping tool that will allow users to estimate the value of ecosystem services for a variety of spatial boundaries (e.g. nations, states, and watersheds). The application uses at least five distinct landcover maps representing current land cover and modelled landcover for several modeled datasets representing future scenarios of the Great Transition Initiative (Market Forces, Fortress World, Policy Reform, and Great Transition). The user is presented with a global map of landcover which they can pan, zoom, and query. They will also be able to display modeled land cover for the four scenarios which will represent changes in land cover that result from different policy pathways. The user will define their area of interest using additional layers of national boundaries, sub-national boundaries (e.g. 'states'), watersheds, and other desired layers. User will select an area of interest (AOI) which will be used to generate a table of the areal extent of landcover in their AOI. At this point the user will be presented with a default set of ecosystem service values for the land covers in their AOI. These defaults are derived from a paper titled '*Changes to the global value of ecosystem services*' (Costanza et al. 2014). At this point the user will be given the opportunity to edit the default values to any value they desire. If they don't choose to do this the default values will be used to calculate the total value of the ecosystem services of each land cover class in their AOI. The sum of these values will be an estimate of the total value of the ecosystem services in their AOI in accordance with the methods of the Costanza et al. publication. The user can print or download both a map and a table of these values for their area of interest. This paper will be a demonstration of this web based mapping and analysis tool.

## **MATCHING SUSTAINABLE INVESTMENT WITH CRITICAL ECOSYSTEM NEEDS**

*Omar Romero-Hernandez<sup>1, 2</sup>, Federico Castillo<sup>2</sup>, Martin Szczepanik<sup>2</sup>, Sauming Seto<sup>2</sup>*

<sup>1</sup>Hult International Business School, USA

<sup>2</sup>University of California at Berkeley, USA

Purpose & Scope: Climate change has contributed to an increase in intensity and frequency of extreme weather events such as wildfires and thunderstorms. The risks and civil impacts of these climate events could be mitigated with creative investments in the ecosystem. However, dedicated public funds have been historically inadequate in addressing the maintenance and protection of natural resources, thereby increasing the severity and risks related to extreme event occurrence and externality costs for many stakeholders. For example, recent increases in the frequency and severity of wildfires have forced the US Forest Service to shift its already scarce resources to fighting fires rather than fire prevention. This creates a cost burden to downstream consumers such as utilities, homeowners, and local businesses.

Hypothesis, Vehicle for Change, and Research Methods: Environmental challenges have traditionally been solved using expensive “grey” infrastructure techniques consisting of capital equipment use, construction, and complex engineering designed to solve a specific problem. However, companies and public institutions have found that “green” infrastructure can be a cost-effective and dynamic alternative that takes the form of ecosystem services. Public Private Partnerships (“P3s”) are collaborative agreements between government bodies and private institutions to achieve these common long-term goals such as forest health and can leverage private capital to perform public services that benefit a diverse set of stakeholders. In this project, we explored the use of partnerships and private capital in the forms of sustainable investments such as “Forest Resilience Bonds” and “Environmental Impact Bonds” that support ecosystem services may be better suited in solving environmental challenges than their “grey” infrastructure counterparts. We interviewed key members of an environmental services non-profit to discuss green infrastructure bonds and performed case studies on several prominent examples to guide our research.

Conclusion & Recommendation: The use of financial instruments and partnerships to preserve natural resources and the value of nature is still an area of research. We identified some circumstances and drivers that may increase the chances to execute successful conservation projects that are also financially sound. The availability of alternative financial vehicles is a key driver in leveraging ecosystem services to address pressing environmental challenges, with significant potential to compensate for increasingly scarce resources for public services.

## **A BABY BOOMER AND A MILLENNIAL EXPERIENCE ACES' FIRST DECADE - "ARE WE THERE YET?"**

***Ione L. Taylor<sup>1</sup> and Carl A. Taylor<sup>2</sup>***

<sup>1</sup>Queen's University, Kingston, ON, Canada

<sup>2</sup>Lowcountry Land Trust, Charleston, SC, USA

The decade-long lifespan of ACES has witnessed, and been a catalyst for, the emergence of the ecosystem services concept into public consciousness. Together, as the generational pair of a baby boomer mom and her millennial son, we have been participants riding the wave of this emergence. Since its inception in 2008, we have collectively presented a talk, poster, or in a panel session at every ACES Conference. We consider here how the timeline of our ACES experience has impacted our work and thinking. Through the lens of this ACES Conference and the community it has built, we have witnessed a progression through three distinct stages. From the baby boomer perspective, the initial motivation for the creation of ACES remains a compelling mandate to this day. That is, to get the message out about what ecosystem products and services are and their value. This first stage involved sorting out and ground-truthing the lexicon. Seminal components of this initial stage receiving much focus at the early ACES Conferences were the Millennium Ecosystem Assessment and the first published estimate of the monetary value of planet earth ecosystems. The second stage linked ecosystem services into high level frameworks related to environmental quality, economics, and policy, as evidenced by the proliferation of ACES papers showing this important integration led mainly by the boomer generation.

The millennial generation came of age during the emergence of the *Nature Deficit Disorder* and *No Child Left in the Woods* concepts. This served as a bridge between generations by bringing a returned public focus to the inherent value of earth's natural systems. The third stage built on the foundation laid by the boomers and has been powered by the techno- and map-savvy millennials – those "digital natives" growing up in the big data and internet age. Their skills have allowed the ACES community to expand the scale and scope of landscape application for the original concepts and designs of the baby boomers. Millennials are creating useful tools for local to regional analysis integrating ecosystem products and services to specific landscapes. This generation has capitalized on the use of Geographic Information Systems (GIS), georeferencing, and advances in modeling capability, and is bringing innovation in multiple areas to our ACES community. These areas include advanced visualization technology such as the use of drones. The baby boomer's early idea and design work has been adapted by the millennials into hands-on tools enabling an advance into taking the next important step of really understanding the complex dynamics of ecosystems. Thus the ACES community at the end of our first decade is opportunistically poised to actually begin this hard work of figuring out how to support the ability of our ecosystems to provide products and services essential to the planet, to us, and to the next generation joining us.

## **BREAKING DOWN BARRIERS: PRIORITY ACTIONS FOR ADVANCING WATER QUALITY TRADING**

***Kristiana Teige Witherill***

Willamette Partnership, Portland, OR, USA

This talk explores the key barriers to increasing demand for water quality trading identified through the National Network on Water Quality Trading's market demand assessment and highlights a suite of actions that could be taken by National Network participants and others to increase the successful implementation of water quality trading programs and other ecosystem service market-based approaches to clean water.

Many academic and industry studies have explored the lack of demand in water quality markets over the last decade. Researchers frequently point to a lack of numeric discharge limits<sup>2</sup>, high transaction costs<sup>3</sup>, compliance preferences of regulated dischargers<sup>4</sup>, and a lack of empirical analysis of existing programs<sup>5</sup> as some of the main barriers to successful implementation of water quality trading programs. In the summer of 2017 and spring of 2018, the National Network on Water Quality Trading conducted interviews with over 50 professionals experienced with water quality trading to better understand the current landscape of demand for water quality trading in the United States, as part of a broader water quality trading demand assessment.

We compared the interview responses to analyses of the decision-making roles and processes involved in, geographic scope of demand for, and lessons learned from other ecosystem service markets about water quality trading to hone in on the key barriers limiting the success of new water quality markets. Based on our understanding of those barriers, we propose a comprehensive and prioritized action agenda, specifying the products, processes, and campaigns that would support the full suite of National Network participants in their individual and collective actions to move forward with water quality trading.

---

<sup>2</sup> See Government Accountability Office, *Water Pollution: Some States Have Trading Programs to Help Address Nutrient Pollution, but Use Has Been Limited – Report to the Honorable Sheldon Whitehouse, U.S. Senate* (2017), *See also* Industrial Economics, *EPA Water Quality Trading Evaluation*, (2008)

<sup>3</sup> See Marzieh Motallebi, Dana L. Hoag, Ali Tasdighi, Mazdak Arabi, and Deanna L. Osmond, *An economic inquisition of water quality trading programs, with a case study of Jordan Lake, NC*, *Journal of Environmental Management* 193: 483-490, (2017)

<sup>4</sup> See Kurt Stephenson and Leonard Shabman, *Where did the agricultural nonpoint source trades go? Lessons from Virginia water quality trading program*, *Journal of the American Water Resources Association*, 53(5):1178-1194, (2017)

<sup>5</sup> See Karen Fisher-Vanden and Sheila Olmstead, *Moving Pollution Trading from Air to Water: Potential, Problems, and Prognosis*, *The Journal of Economic Perspectives* 27(1): 147-171, (2013)

## PROMOTING SUSTAINABLE LAND MANAGEMENT THROUGH A ROBUST SCIENCE/POLICY DIALOGUE

*Richard J. Thomas<sup>1</sup>, Mark Schauer<sup>2</sup>, Silke Schwedes<sup>2</sup>, Jan Libera<sup>2</sup>, Lara Beisiegel<sup>2</sup>*

<sup>1</sup>c/o International Center for Agricultural Research in the Dry Areas (ICARDA) Oakville, Ontario, Canada

<sup>2</sup>Sector program BoDeN (Soil protection, desertification, sustainable land management) Economics of Land Degradation (ELD) Initiative, Division G520 - Rural Development and Agriculture Sectoral and Global Initiatives, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Germany

With as much as 10 million ha of land degrading every year and the need to increase food production by at least 70% until 2050 to satisfy demands of a growing population, there is an urgency to focus efforts on reversing land degradation and improving land stewardship through sustainable land management (SLM) options. Despite the availability of hundreds of tried and tested SLM interventions, the adoption of these options by land users remains low. Given the fact that the mainly biophysical evidence of beneficial SLM options has not gained sufficient attention to reverse the degradation trends, the Economics of Land Degradation Initiative (ELD) was established to highlight the benefits of SLM practices in financial terms, using a total economic value approach. The initiative compares the costs of action to reverse or halt land degradation with the costs of inaction to develop sound cost/benefit analyses of SLM practices. These analyses also take into account ecosystem service values. In addition, the initiative proposes recommendations to countries that are policy relevant.

The initiative has developed reports and incentives for policy and decision makers, the private sector and land users. Here it elaborates on an improved science-policy dialogue that is needed to encourage investments in SLM options by governments and land users including the private sector. This includes capacity building within institutions through a multi-stakeholder two stage process. The first stage targets familiarization with the methods for total economic valuation (natural capital assessments) through workshops that include government and research institutions, NGOs and the private sector. The second stage continues the capacity building through case studies selected by participants.

With better knowledge of the economic and environmental benefits from SLM practices participants are in a much stronger position to negotiate for increased public and private investments. The paper will present the example from Kenya as illustrative of the process the ELD initiative is undertaking in several Sub-Saharan and Central Asian countries.

## **CELEBRATING ECOSYSTEM SERVICES GAINS FROM WETLAND RESTORATION USING PARTICIPATORY MAPPING AND HIGH-RESOLUTION ECOSYSTEM SERVICE MODELS**

***Stephanie A. Tomscha<sup>1</sup>, Julie R Deslippe<sup>1</sup>, Bethanna Jackson<sup>2</sup>, Mairead de Roiste<sup>2</sup>, Stephen Hartley<sup>1</sup>***

<sup>1</sup>School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand

<sup>2</sup>School of Geography, Victoria University of Wellington, Wellington, New Zealand

Wetland loss in New Zealand has led to problematic declines in ecosystem services, including sediment and nutrient retention, flood regulation, culturally important bird species, and traditional foods and fibres. Witnessing such declines has inspired restoration initiatives from farmers across the country. We blend participatory mapping and high-resolution ecosystem service models to track gains in ecosystem services from these restoration projects. We ask three main questions: 1) What ecosystem services have we gained through restoration? 2) Where have ecosystem service trade-offs been alleviated? Our work takes place in Ruamahanga Basin, which is situated in the southern part of New Zealand's North Island. The 3289 km<sup>2</sup> watershed is home to ~40,000 New Zealanders, including the Māori iwis Ngāti Kahungunu ki Wairarapa and Rangitane o Wairarapa. The Ruamahanga's primary land uses include dairy, beef cattle and sheep farming, viticulture, forestry, and conservation. The region was historically rich in wetlands with more than 26% of the watershed area thought to have been wetland habitat, reduced to approximately 0.5% in contemporary times. We conduct and interview and participatory mapping exercise with farmers and landholders using an online participatory mapping and survey tool called maptionnaire. Participants mapped their restoration project as well as specific restoration treatments including, fencing, predator control, and native species planting. We link these participatory maps to the Land Use Capability (LUCI) model, which allows us map ecosystem services including sediment and nutrient retention, carbon storage, flood regulation at spatial resolutions as fine as the sub-farm level. Highlighting farmer successes can build the social capital necessary to tackle the enormous challenges facing New Zealand regarding biodiversity loss and declines in water quality.

## **SOIL HEALTH RESEARCH: CONNECTING SCIENCE AND PRACTICE**

***Paul Tracy***

The Soil Health Institute, Morrisville, NC, USA

Research shows that improving soil health can enhance water quality, increase carbon sequestration, reduce greenhouse gas emissions, boost crop yield, increase nutrient availability, contribute to pollinator habitat, increase drought resilience, and build disease suppression. To achieve these benefits, the Soil Health Institute (SHI) was established in late 2015 to safeguard and enhance the vitality and productivity of soil through scientific research and adoption.

With input from its numerous stakeholders, the Soil Health Institute developed *Enriching Soil, Enhancing Life: An Action Plan for Soil Health* to strategically address gaps in research, measurements, economics, communications, education, and policy. The Action Plan is designed to move scientific knowledge and technology from research laboratory to farm field by bringing together traditional and non-traditional agricultural industry partners, farmers, ranchers, government agencies, scientists, and consumers to focus on common, clear goals that protect and enrich our soils.

The commitment includes basic, translational, and applied research to elucidate biological, chemical, and physical soil functions and how they link management practices to desired outcomes in agriculture and the environment. It ensures that knowledge and information generated from scientific research is available for prompt, widespread dissemination to all stakeholders. It seeks to provide farmers and ranchers evidence-based information to help them evaluate and adopt positive, economically sound soil health management systems, increase agricultural productivity, and conserve natural resources with confidence.

## GREENERY ALONG NEIGHBORHOOD ROADS IS LINKED TO BMI AND PHYSICAL ACTIVITY ACROSS FOUR DIVERSE COMMUNITIES

*Wei-Lun Tsai*<sup>1</sup>, *Leah Yngve*<sup>2</sup>, *Kirsten M. M. Beyer*<sup>3</sup>, *Kristen M. Malecki*<sup>4</sup>, *Laura E. Jackson*<sup>5</sup>

<sup>1</sup>Oak Ridge Institute for Science and Education Research Fellow, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

<sup>2</sup>Association of Schools and Programs of Public Health Environmental Fellow (former), Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

<sup>3</sup>Division of Epidemiology, Medical College of Wisconsin, Milwaukee, WI, USA

<sup>4</sup>Department of Population Health Sciences, University of Wisconsin, Madison, WI, USA

<sup>5</sup>Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

Urban greenery benefits human health through a range of ecosystem services from hazard mitigation through venue provision for healthy behaviors. Greenery metrics are designed variously in different studies. Variations include the definition and resolution of greenery, and the spatial extent of analysis units. Greenery data may be aggregated by administrative units, or specified for individual residences using Euclidean or road-based buffers. When comparing studies about the effects of greenery on health outcomes, disparate methods dilute the weight of evidence for plausible effect pathways. For example, total greenery in a radial buffer or across an administrative unit may indicate larger-scale services such as ambient air-pollutant filtration. Tree cover along residential roads is perhaps a more precise indicator of shade and aesthetics. This presentation will introduce two studies finding greenery effects by different vegetation types and spatial analysis units on (1) body mass index (BMI) and (2) moderate-to-vigorous physical activity for recreation (MVPA-R). Individual BMI across greater Phoenix, AZ, and Portland, OR, was calculated using height and weight data from the motor vehicle depts. of participating states. Individuals' MVPA-R reporting across greater Milwaukee and Green Bay, WI, was collected by the Survey of the Health of Wisconsin. Greenery metrics were designed by the U.S. EPA's EnviroAtlas project to quantify the pedestrian environment (road based) along a gradient of suitability for promoting physical exercise for 950 cities and towns within 24 U.S. Census urban areas. Additional non-overlapping and overall greenery metrics (Euclidean) were generated to compare with the road-based greenery for BMI and MVPA-R, respectively. Both studies showed positive effects of road-based greenery on indicators of physical fitness in logistic regressions, after controlling for covariates. Trees, but not herbaceous cover, were consistently associated with lower odds of being overweight or obese in both Portland and Phoenix, across all residential network buffers from 500 to 2000m. Both tree cover and total greenery in network buffers were associated with greater odds of participating in MVPA-R. Tree cover along streets was more influential in smaller buffers (500m), while total greenery was more important in larger buffers (1000m). Significant associations were not found for radial buffers. Physically accessible greenery may better represent ecosystem services that promote physical activity than does overall greenery. Trees may be more influential than herbaceous cover, across communities in three U.S. climate zones. Findings suggest that it is important to carefully define greenery measures, including type and extent, while examining the associations between greenery and different health outcomes.

## MEASURING THE INFLUENCE OF RESIDENTIAL EXPOSURE TO NATURAL ENVIRONMENTS ON MENTAL HEALTH AND WELL-BEING

*Raquel A. Silva<sup>1</sup>, Wei-Lun Tsai<sup>1</sup>, Ferdouz Cochran<sup>1</sup>, Steven E. Prince<sup>2</sup>, Daniel Rosenbaum<sup>2</sup>, Maliha Nash<sup>2</sup>, Aimee A. D'Aloisio<sup>3</sup>, Laura Jackson<sup>2</sup>, Megan Mehaffey<sup>2</sup>, Anne C. Neale<sup>2</sup>, Dale P. Sandler<sup>4</sup>, Timothy J. Buckley<sup>2</sup>*

<sup>1</sup>ORISE at Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

<sup>2</sup>Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

<sup>3</sup>Social & Scientific Systems, Research Triangle Park, NC, USA

<sup>4</sup>National Institute of Environmental Health Sciences (NIEHS), Research Triangle Park, NC, USA

There is compelling evidence that exposure to natural environments has a beneficial effect on human health and well-being, however there are few nationwide studies in the U.S. that have explored this issue. Much of the existing research comprises small, spatially-limited samples or is based on aggregate spatial scales, leading to imprecision in effects estimation and risk for erroneous conclusions. Also, many studies have access to only limited measures of exposure to the natural environment (e.g. percent greenery) and are unable to consider more robust metrics (e.g. distance to green or blue space, views of trees, views of water, etc.). In this study, we evaluate the influence of residential exposure to natural environments on individual well-being outcomes in the NIEHS Sister Study cohort. The cohort is comprised of 50,884 women, aged 35-74 years, living across the U. S. and Puerto Rico, who were enrolled from 2003 to 2009. The multifaceted measures collected by the Sister Study and the broad coverage of participants' geographic distribution, as well as the diverse demographics within the cohort, help us develop a more comprehensive understanding of linkages and potential mechanisms for how exposure to natural environments influences selected health outcomes. Specifically, we focus on participants who live in the conterminous US and did not change primary residential address during the follow-up period up to 2015. We assess both presence of and access (physical distance) to natural environments based on EPA's state-of-the-art geospatial ecosystem services tool, EnviroAtlas, using different sized spatial buffers (e.g. 250-m, 3000-m radii) around each individual residential address. We apply mixed effects logistic and linear regression to quantify the associations between several metrics of residential exposure (e.g. population near roadways with little or no tree buffer, access to outdoor recreational resources, percentage of natural land cover, percentage of forest) and outcomes of self-reported health, quality of life, perceived stress, and depressive symptoms. We control for a variety of covariates including individual-level demographic variables (e.g. age, income, education, race/ethnicity, marital status and employment status) and lifestyle factors (e.g. physical activity, dog ownership, perceived social support, smoking and alcohol consumption), an environmental stressor (air pollution), and level of urbanicity. Considering social, spatial, and temporal perspectives, we discuss the impact of using different metrics for assessment of exposure to natural environments. This research will yield a more complete assessment of environmental influences on human health and well-being in support of EPA's mission to protect public health and the environment.

## **NOMADIC HERDERS' TRADITIONAL KNOWLEDGE OF ECOSYSTEM SERVICES**

*Navchaa Tugjamba, Greg Walkerden*

Department of Geography and Planning, Macquarie University, Australia

The benefits that ecosystem services provide change as a result of both socio-economic and environmental dynamics. Most notably, climate change is altering these benefits. An ecosystem services approach is a commonly used to inform development thinking at global and national levels, but the helpfulness of an ecosystem services approach to support local planning is less clear, particularly when it is being used alongside traditional knowledge and when empirical data is scarce.

This paper explores how the benefits to nomadic pastoralists from land and water ecosystem services have been changing, and how these changes are reflected in their traditional culture and livelihoods through a case study of nomadic herders in Northeastern Mongolia. In Mongolia, nomadic culture and traditions have been dominant for more than 4000 years'. Nomadic pastoralists have their own experience and knowledge of nature and its services derived from their local use and management of pasture and water. However, there has not been sufficient study of the impacts of the changing environment on traditional culture and the livelihoods of nomadic herders.

Nomadic Mongolians move in search of the best pastures and campsites, and are highly dependent on natural resources for their livelihoods. There are dramatic increases in pressure on pastoral ecosystems arising from both (i) climate change and (ii) growth in the number of herd animals. Local knowledge and practices, though transferred from one generation to another, have been modified over time, responding to economic and environmental changes. Our findings are based on semi-structured interviews with a local herders in Northeastern Mongolia.

This study demonstrates how local herders accumulate and develop detailed information about their environment to manage and use pasture land. Research results show that traditional ecological knowledge plays a major role in shaping nomadic herders' understanding of changes in ecosystem services in Northeastern Mongolia. These changes are influencing their future management of pastureland and their adaptation to climate change at a local and regional level. The findings indicate that climate change has affected availability of water and pasture. This has changed the seasonal migration patterns of nomadic herders and their livelihoods. Nomadic herders' local knowledge should play a fundamental role in local authorities' decision making. This will strengthen local adaptation by nomadic herders. Conserving traditional knowledge is essential to long term sustainability.

## EVALUATING THE IMPACT OF CLIMATE CHANGE ON ECOSYSTEM SERVICES IN SOUTHERN CALIFORNIA

*Emma C. Underwood<sup>1</sup>, Allan D. Hollander<sup>1</sup>, and Hugh D. Safford<sup>2</sup>*

<sup>1</sup>Department of Environmental Science and Policy, University of California, Davis, CA, USA

<sup>2</sup>USDA Forest Service, Pacific Southwest Region, Vallejo, CA, USA

Climate change is projected to impact the functioning of ecosystems, however it is unclear how it will affect the provision of ecosystem services. We focus on southern California, where millions of people benefit from the services provided by natural landscapes including climate regulation, sediment erosion retention, and water provision. By evaluating the amount of services under current and end-of-century conditions using a range of global circulation models (GCMs) we can provide information for proactive decision making by resource managers.

Our study area stretches between Monterey and San Diego counties (~8.7 million acres) and encompasses four national forests – the Angeles, Cleveland, Los Padres, and San Bernardino. Over half of this area is covered by chaparral shrubland, which is historically under-appreciated and under-valued. We examined five ecosystem services: carbon storage, water runoff, groundwater recharge, sediment erosion retention, and biodiversity, and assessed their current quantity and change by end-of-century under five GCMs.

We used five GCMs from the Fifth Assessment IPCC report under a RCP8.5 scenario: a warmer wetter projection (CNRM-CM5), two hotter drier projections (MIROC-ESM and FGOALS-G2), a hotter, marginally drier projection (IPSL-CM5A-LR), and the projected climate closest to the ensemble mean (CCSM4). A variety of methods quantified the five services under current (1981-2010) and end-of-century (2070-2099) conditions. Data on current and future water provision were extracted from the Basin Characterization Model; sediment erosion used the InVEST software with future precipitation incorporated to generate end-of-century estimates; current and future carbon storage was from the MC2 dynamic global vegetation model; and a layer that represents current biodiversity was generated using Marxan and integrated data on end-of-century climatic water deficit.

Results showed the direction and degree of change between current and end-of-century ecosystem services varies substantially by GCM. Water runoff had the greatest change from current conditions to end-of-century, while changes in carbon storage ranged the least. The change in precipitation was found to be a key determinant affecting the provision of end-of-century ecosystem services.

Understanding the distribution of ecosystem services in southern California and the projected impacts of climate change on their provision can help develop strategies to ensure their sustainability. National forests in this region occupy 3.5 million acres (40% of the study area) which provides a framework within which areas of high service provision can be addressed to ensure the continued healthy functioning of shrub dominated ecosystems.

## IMPLICATIONS OF GENDER ROLES AND PERCEPTIONS ON DEVELOPMENT OF CO-INVESTMENT SCHEME IN SOUTHERN PHILIPPINES

*Joan U. Ureta<sup>1</sup>, K.P. Evangelista<sup>2</sup>, R.J. Evangelista<sup>3</sup>, and R. Lasco<sup>3</sup>*

<sup>1</sup>Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC

<sup>2</sup>College of Forestry and Natural Resources, University of the Philippines Los Baños, Laguna, Philippines

<sup>3</sup>World Agroforestry Centre Philippines, Laguna, Philippines

Development of sustainable financing mechanisms such as Payments for Ecosystem Services (PES) or Co-Investment Scheme (CIS) is seen as a way to improve environmental conservation and watershed management in the Philippines. These mechanisms aim to enhance the sustainability of ecosystem services and alleviate poverty. Upland farmers are usually considered as a marginalized sector in the country, but also recognized as major stakeholders which impact provision of ecosystem services; hence they are strongly encouraged to participate in conservation activities. While farming is considered a major economic activity in rural areas, it is also generally a product of household effort. However, the intrahousehold dynamics between women and men farmers are commonly not assessed. Hence, this paper seeks to assess the varied roles and perceptions of women and men farmers to recommend appropriate sustainable farming designs to be supported by a co-investment scheme in the uplands.

Implementation of a co-investment scheme, a PES-like mechanism that is largely dependent on altruism and mutual understanding between different stakeholders, was piloted in Manupali Watershed, Province of Bukidnon, Philippines. Although the province is situated in the uplands, large portions of its area have been converted to monoculture plantations of banana, sugarcane, and annual crops. With the increasing incidence of strong typhoons in the region, shifting to sustainable farming practices to rehabilitate landscapes and improve their hydrological condition are considered necessary. Prior to CIS implementation, gender-disaggregated participatory activities including focus group discussions, key informant interviews, and household survey were implemented to solicit information on the communities' perception on ecosystem services (e.g. biodiversity, water quality) and conservation activities.

Results showed that women and men farmers are both aware of the ecosystem services provided by forests and trees on farm. However, their perceptions differ on the condition and importance of these services. For instance, women farmers identified species with mostly medicinal values, while men's discussion focused more on species that could serve as food source. Furthermore, women argue that water from creeks are no longer potable with the increasing number of monocropped farms, while men perceived otherwise. However, both groups recognized the decline in water quality and quantity in recent years. Finally, while men used to be more involved in farming, environmental and economic shocks influenced them to shift to off-farm and non-farm livelihood sources. In these cases, wives take the responsibility of managing farms which further adds to their domestic tasks. The findings of this study provide a different lens which could be used in crafting gender-sensitive adaptation program for smallholder farmers in the area.

## **ASSESSMENT OF STAKEHOLDERS' PERCEPTION TOWARDS CONSERVATION: LAYING FUNDAMENTALS OF A PAYMENTS FOR ECOSYSTEM SERVICES IN SOUTH CAROLINA**

*Julie Carl Ureta<sup>1</sup>, M. Motallebi<sup>2</sup>, M. Alhassan<sup>3</sup>, and R. Baldwin<sup>1</sup>*

<sup>1</sup>Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC, USA

<sup>2</sup>Department of Forestry and Environmental Conservation, Clemson University, Georgetown, SC, USA

<sup>3</sup>US Geological Survey, Science & Decisions Center, Energy & Minerals Mission Area, USA

With increasing demand for goods and services in the economy brought by urbanization and continuously increasing population, extraction of natural resource around the globe has also rapidly increase to meet these economic needs. Hence, programs on natural resources conservation and sustainable usage were developed in different areas of the world. Among these programs include watershed scale sustainable management practices through Payments-for-Ecosystem Services (PES). In this program, a market will be created between watershed stakeholders wherein the act of enhancing and ensuring continuous provision of good quality ecosystem services is the tradable product. To do so, ES providers engage in conservation programs to enhance ecosystem services ensuring continuous provision of its benefits while ES beneficiaries, who depend on the products of ecosystem services support the ES providers in terms of compensating their efforts. In this manner, a market of enhancing and continuous provision of ecosystem services is created in the watershed. However, creation of markets involve foundational activities such as determining the willingness to participate of stakeholders by assessing their level of understanding of market elements. Hence, it is important to gather stakeholders' perception for designing an effective market initiative.

The state of South Carolina has been practicing different conservation programs to enhance environmental quality and promote sustainable use of natural resource. Furthermore, a potential PES program could further advance natural resource conservation in the state. Therefore, this study focuses on assessing the stakeholders' perception towards conservation as requisites in laying the fundamentals towards a creation of a viable sustainable financing mechanism in enhancing the conservation programs. The study adopted both quantitative and qualitative techniques in eliciting the stakeholders' perceptions. Qualitative assessment used stakeholders' participation in identifying potential issues, threats, and possible management practices for a sustainable use of the state's natural resource through an interactive participatory mapping workshop. Furthermore, a survey of 1500 respondents across the state was conducted to quantitatively assess their perception towards "conservation" and "conservation programs". The answers were subjected to econometric models to determine significant factors that affect the preference of these respondents. The results from these assessments are critical, not just on the formulation and design of a potential PES program, but also in understanding how South Carolina stakeholders perceive the use of their current natural resource. Furthermore, the results could be used in improving sustainable usage of natural resource in the state.

## **PES BEYOND ECONOMICS: AN ANALYSIS OF LESSONS LEARNED FROM ESTABLISHING PES MECHANISMS IN THE PHILIPPINES**

*Julie Carl P. Ureta,<sup>1</sup> Joan U. Ureta<sup>1</sup>, and Marzieh Motallebi<sup>2</sup>*

<sup>1</sup>Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC, USA

<sup>2</sup>Department of Forestry and Environmental Conservation, Clemson University, Georgetown, SC, USA

Payments for Ecosystem Services (PES) has been a popular research area in the Philippines for more than a decade now. With the increasing climate change impacts to the country, together with rampant natural resource extraction to meet the increasing competitive economic needs, PES is seen as a mechanism to improve the condition of natural resources in Philippine watersheds. However, despite the promising theoretical framework of PES in promoting sustainable management, difficulties and challenges beyond its computable aspect has to be considered in designing the scheme to actually implement the program. Furthermore, although there has been a substantial increase in the body of knowledge on this area, very few efforts had been translated to a functional and fully operational PES mechanism. Hence, this paper argue that PES establishment has multifaceted factors, thereby requiring a transdisciplinary approach.

Beginning 2012, four PES projects were pilot-tested in four major watersheds in the Philippines including Mt. Malindang in Misamis Occidental, Mt. Banahaw-San Cristobal in Quezon, Mt. Kalatungan and Mt. Kitanglad in Bukidnon. PES mechanisms were designed and tailored to each site depending on the results of socio-economic assessments and feasibility studies such as valuation of ecosystem services and business case development. Based on first-hand accounts and observations of the researchers in developing these PES schemes, the enabling factors, barriers and constraints were assessed in each stage of implementation— (1) conduct of scientific studies, (2) negotiations between buyers and sellers , (3) setting up institutional arrangements, and (4) actual implementation. While majority of the PES projects were successful in the first two stages, establishing the third step and transitioning from the fourth has been the most challenging and a major hindrance for the actual implementation. Among these four PES schemes, only the Mt. Kalatungan has been successful in all stages, while the Manupali Watershed is in early stage of the 4th step. A critical key take away from implementing the PES highlights the many stages and challenges encountered in setting up the scheme which traverses in different disciplines beyond the field of economics, such as institutional dynamics and cultural sensitivity. This paper summarizes the lessons learned from the challenges encountered in establishing the PES scheme emphasizing socio-economic aspect of the framework. This involve: role of property rights; willingness to pay; willingness to accept; role of biophysical research; institutional dynamics; cultural sensitivity and traditions; and the importance of holistic transdisciplinary perspective in managing the watershed. The summary of lessons learned could provide critical information to others in considering implementation of a PES scheme in different areas as well as for policy makers to support a holistic approach in addressing environmental conservation efforts.

## ECOSYSTEM SERVICES OF LIVESTOCK WASTE BASED ENERGY GENERATION

*Meltem Urgun-Demirtas and Lionel Mojekwu*

Argonne National Laboratory, Lemont, IL, USA

About 335 million dry tons of animal manure is produced annually from the livestock industry in the US. This renewable feedstock has an energy potential of  $4.8 \times 10^{15}$  Btu/year (1,250 TWh) that would displace the equivalent of  $3.9 \times 10^{10}$  gallons of gasoline ( $4.6 \times 10^{12}$  cft of natural gas) per year.

The resolution of multiple issues arising from farm practices is quite complex and needs to be considered in a “system approach”. The main objective of this paper is to enhance anaerobic digestion of manure to generate biogenic methane and to scale up the Integrated Waste Management System (IWMS) for the livestock industry. In this system approach, agriculture, energy and environmental sectors are considered as components of a single system and environmental liabilities are used as recoverable resources for production of renewable methane and fertilizer quality digestate.

The groundwork for development of an integrated platform was established for a low-cost approach to waste-to-energy conversion to produce renewable methane at farm digesters. A 500-gallon mesophilic anaerobic digestion pilot plant was designed and constructed in a farm facility located in northern Missouri. Pilot-scale study was conducted for four months at mesophilic temperatures (30-37 °C).

Addition of alkaline biochar to digesters resulted in selective removal of CO<sub>2</sub> (up to 80%) and reduction of H<sub>2</sub>S (up to 62%). The greenhouse experiments indicated that digestate from the IWMS increased switchgrass biomass relative to urea without harming feedstock quality, hence could be considered as a potential substitute for chemical fertilizer. The IWMS is a good example of an integrated close to zero waste system. Within one process, not only problems related with methane emissions from current manure management practices and disposal of excess animal manure are solved, but also nutrient recovery and energetic use of farm wastes are increased in this new process.

## POWER ASYMMETRIES IN ECOSYSTEM SERVICES GOVERNANCE: INSIGHTS FROM SOCIAL NETWORK ANALYSIS

*Améline Vallet<sup>1,2</sup>, Bruno Locatelli<sup>3,4</sup>, and Harold Levrel<sup>2</sup>*

<sup>1</sup>Ecologie Systématique Evolution, AgroParisTech, CNRS, Univ. Paris-Sud, Université Paris-Saclay, 91400, Orsay, France

<sup>2</sup>CIREAD, AgroParisTech, Cirad, CNRS, EHESS, Ecole des Ponts ParisTech, Université Paris-Saclay, 94130 Nogent-sur-Marne, France

<sup>3</sup>CIRAD, Research Unit on Forests and Societies, F-34398 Montpellier, France

<sup>4</sup>CIFOR, Av. La Molina 1895, La Molina, Lima, Peru

Understanding how power asymmetries arise and how they can affect policy outcomes are crucial questions for ecosystem services (ES) research. In political sciences and sociology, the distribution of power among individuals has been widely studied with social network analysis (SNA). SNA have also been used to understand natural resource governance, for example in the context of fisheries, REDD+ or urban green areas. In this paper, we propose to analyze the structure of social networks of influence and domination related with ES governance in the Mariño watershed (Peru). The objectives of this paper are (1) to propose a framework for analyzing power asymmetries in relation with ES governance and (2) to apply it to the study case to highlight power differentials between selected stakeholders from different sectors and scales. We conducted face-to-face semi-structured interviews with representatives of 52 stakeholders of the watershed to understand how they relate with each other. For the influence network, we specifically asked them to identify the stakeholders with whom they exchange information, collaborate for projects, have regular and unregular meetings, do business with. In contrast, for the network of domination, we asked them to identify the stakeholders they restrict, punish, advice, or supervise, as well as the stakeholders that have such control over them. We assessed degree, closeness and betweenness centralities of the two networks. Four categories of stakeholders were distinguished depending on stakeholder's levels of influence and domination. Stakeholders from local scale, business and civil society showed significantly lower levels of both influence and domination than other stakeholders. Power was significantly correlated with the benefits received and participation to ES management: ES managers showed higher levels of power, and were found in the core of the two networks. These power asymmetries raise issues of equity and might reduce the adaptive capacity of the social-ecological system.

## **ENVIROATLAS' NATIONAL ASSESSMENT OF CULTURAL ECOSYSTEM SERVICES: LEVERAGING SOCIAL MEDIA TO UNDERSTAND AMERICA'S MOST VALUED LANDSCAPES**

*Derek Van Berkel, Koen Tieskens, Payam Tabrizian, Anne Neale, & Megan Mehaffey*

While the United States is home to many special places that deliver numerous cultural ecosystem services (CES), there has yet to be a national assessment of these benefits. Identifying and characterizing locations that are appreciated for their beauty, opportunities for outdoor activities, and sense of place can help in conservation prioritization and the development of management objectives for preserving the unique qualities that make these locations attractive. In this presentation, we describe a new initiative by the EPA for assessing CES across the US using social media. Approximately 6 million photographs and their volunteered locations are analyzed to understand valued locations, dominant activities and the spatial characteristics associated with these places. We classify photographic content from Flickr and Panoramio using TensorFlow, a machine learning algorithm that allows for distinguishing relevant interaction with natural areas. Based on the calculated viewsheds of these filtered locations, we model the characteristics associated with highly photographed and visited areas. The high resolution national maps of CES will be made available through the EnviroAtlas. By providing these locations across the United States, our aim is to help local and national stakeholders weigh conservation priorities and evaluate developments and landscape qualities that enhance or conflict with these important benefits.

## **A TRADE-OFF ANALYSIS FOR PRIORITIZING LAND CONSERVATION IN THE CATAWBA-WATEREE BASIN**

*George Van Houtven, Michele Eddy, Katie van Werkhoven, Ben Lord, Jake Serago and Samuel Kovach*

RTI International, Research Triangle, NC, USA

Rapid population growth and land development in the Catawba-Wataree Basin, an area covering almost 5,000 square miles in North and South Carolina, is placing increasing stress on the ecosystem services provided by its waters and other natural resources. Targeted land conservation can play a key role in managing this growth and reducing ecosystem stresses.

In this study, we apply a spatially explicit hydrologic model (Watershed Flow and Allocation, WaterFALL™) to simulate (1) streamflow alterations in over 5,000 enhanced National Hydrograph Dataset (NHDPlus) catchments and (2) changes in sediment loads to 11 mainstem reservoirs. We simulate conditions in 2050 using land-use change projections from EPA's Integrated Climate and Land-Use Scenarios (ICLUS) model. With our modeling framework, we develop catchment-level metrics to compare land conservation benefits and costs, through evaluation of projected future conditions with and without conversion of natural lands. For each catchment, we develop measures of land conservation benefits, including changes to streamflow variability and extremes, recreation benefits, property value impacts, and avoided drinking water treatment costs due to reduced reservoir sediment loads, as well as carbon storage and air quality benefits from maintaining tree cover. Land conservation costs in each catchment are based on average per-acre tax assessed values for parcels with predominantly natural land cover.

Applying these metrics and focusing on catchments with the largest projected future land use-driven hydrologic and sediment changes, we demonstrate how the framework can help to assess tradeoffs and identify priority areas for land conservation.

## COMMODITY CONSISTENT META-ANALYSIS OF WETLAND ECOSYSTEM SERVICE VALUES

*Hermine N. Vedogbeton and Robert J. Johnston*

Clark University, Worcester, MA, USA

The demand for information on ecosystem service values combined with a lack of time and resources required to conduct primary valuation studies has led to a growing use of benefit transfer to quantify these values. Meta-analysis is increasingly used for this purpose. The dependent variable in these meta-regression models (MRMs) is a comparable measure of ecosystem service value drawn from multiple prior valuation studies. Independent variables in the MRM explain systematic variation in this value across different studies and contexts (e.g., sites, populations, types of changes). MRM results are used to predict values for unstudied sites. MRMs of wetland ecosystem service values are particularly common in the literature. However, these models have been criticized due to an almost universal lack of *commodity consistency*—they “compare apples and oranges.” Commodity consistency implies that values for similar goods or services are compared within the MRM. However, prior MRMs of wetland ecosystem service values pool values for fundamentally different types of services—for example those related to recreation, flood control, fisheries production, and carbon sequestration. Because there is no reason that the ecological production or economic value of these distinct services should be comparable in any systematic way, the resulting models violate commodity consistency and have questionable validity.

This paper pioneers a new type of commodity consistent MRM for wetland ecosystem service values, with an application to salt marshes. We report on the first ecosystem service value MRM restricted to a specific wetland type (coastal and salt marshes), location (the US and Canada), and type of ecosystem service (habitat and nursery services). The resulting model is the most commodity consistent MRM in the wetland ecosystem services literature. The MRM is also welfare (or value) consistent, in that it is restricted to comparable value estimates from one type of valuation approach (stated preference methods). Changes in habitat services are quantified and reconciled as percentage gains or losses in each service, compared to specified intrinsic or extrinsic baselines. The resulting metadata include 139 comparable observations of willingness to pay (WTP) per household from 23 different studies published from 1990-2016, with all values adjusted to 2017 USD. MRMs are estimated using cluster-robust OLS and random effects specifications. Results supersede those of prior wetland service MRMs in terms of statistical fit, conformance with expectations, and an ability to predict changes in a specific type of ecosystem service value. We find that WTP per household for marsh habitat services is strongly responsive to dimensions such as scope (the magnitude of service changes), spatial scale (the area over which the service changes), the location of households, the type of habitat change considered, surrounding household characteristics, and other factors suggested by theory and intuition. The resulting transferable benefit function allows habitat and nursery service values to be estimated for quantified service changes at any US coastal marsh. Discussion emphasizes the conceptual and practical advantages of commodity consistent MRMs of this type, and how they may be used to generate more valid and reliable value estimates.

## **INNOVATIVE MECHANISMS FOR FINANCING COASTAL RESTORATION**

*Tibor Vegh and Todd BenDor*

Department of City and Regional Planning, University of North Carolina, Chapel Hill, NC, USA

Sustainable growth in environment- and natural resource based economic sectors may become undermined if the natural capital that underpins this economic activity is degraded or destroyed. To return previously degraded ecosystems to their healthy functioning state, ecological restoration activities must be implemented. Ecological restoration can be thought of as a collective action problem where the financiers and beneficiaries of restoration are different groups and thus the costs and benefits are difficult to reconcile. In addition to this, the literature on restoration finance shows a several hundred billion dollar gap between the annual requirements of restoration projects and programs, and the amount provided by the public sector and the global community. Furthermore, it is widely accepted that private finance must be leveraged more effectively to close the aforementioned restoration finance gap, because public funding streams have proven to be limited in magnitude.

To better understand the conditions under which private finance can play a larger role in ecological restoration, this presentation reviews and summarizes key findings in the peer-reviewed and grey literatures on recent developments in ecological restoration finance. The scope of the review includes resilience bonds, catastrophe bonds, land value capture, and other ways to channel private investment into ecological restoration, and discusses the application of various financing mechanisms in the coastal context. The main challenges to overcome, and global opportunities for private finance for ecological restoration are identified from the perspective of ecosystem services quantification, monetization, and innovative contracting with beneficiaries of service flows.

## **COST BENEFIT ANALYSES OF ECOSYSTEM SERVICES: SOME FUNDAMENTAL ECONOMIC CONSIDERATIONS AND CONTRADICTIONS**

***Kristen A. Vitro***

Department of City and Regional Planning, University of North Carolina, Chapel Hill, NC, USA

Over the past few decades, the ecosystem services framework has been widely accepted as a method for assessing and estimating benefits that the environment can provide for society. Ecosystem services valuations have become increasingly important in decision making, including the allocation of money to ecological conservation or restoration projects.

Critics of the ecosystem services framework often note that economic valuations of environmental services can vary greatly due to the many assumptions that must be made when engaging in the economic valuation of non-market goods – independent research teams may reach very different conclusions about the approximate monetary value of a particular ecological system. Such variation may be amplified when the calculated value from one particular geographic area is applied to another. Reliance on previous calculations can also contribute to uncertainty in the economic valuation of ecosystem services.

In addition to the previously listed considerations, we must also take a step back to acknowledge the underlying economic assumptions used in the valuation process. Units of ecosystem services are not necessarily exchangeable on a geographic or temporal level, and do not function as market goods and services. Despite our best efforts to put a box around ecological systems and assess their component parts, we must also acknowledge that these are complex systems that may not have transferrable properties. Even as our collective understanding of the environment has improved, we still suffer from a lack of complete information – if we do not know that something is there, or we cannot measure or perceive it, it cannot be subjected to economic valuation. A major underlying assumption that we rely on is the concept of diminishing returns, which is represented by the application of a discount rate when conducting cost benefit analysis. While this certainly might make sense in the case of a large infrastructure project that deteriorates over time (and therefore must take into account the time-value of money), this is not an accurate representation of a functional ecosystem. At a minimum, ecological goods and services would not diminish in their returns over time. In fact, greater need for such goods and services, as well as potential for increasing scarcity in the future, might be better modeled by increasing returns (i.e. a negative discount rate). This is itself an economic paradox, as this would lead a rational decision maker to restrict development and promote conservation and restoration above all other decision factors.

This paper examines the above economic considerations in depth, and provides recommendations for addressing such concerns in the decision making process.

## **USING NOAA'S MARINE RECREATIONAL INFORMATION PROGRAM DATA FOR POLICY ANALYSIS: APPLICATIONS AND OPPORTUNITIES FOR MEASURING ECOSYSTEM SERVICES**

***Roger H. von Haefen***

North Carolina State University, Department of Agricultural and Resource Economics, Raleigh, NC, USA

For several decades, the National Oceanic and Atmospheric Administration (NOAA) has been collecting coastal recreational fishing data from Maine to Louisiana in two-month waves through the Marine Recreational Information Program (MRIP). Although the data is extraordinary in its coverage, scale and scope, its use for policy purposes has largely been limited to its primary purpose of measuring recreational catch from coastal waters. That limited focus has changed recently with a series of papers that use the data to answer a variety of policy relevant questions. In this presentation, I review three studies that use MRIP data to answer the following questions: 1) what are the benefits of Chesapeake Bay TMDL to coastal recreational anglers (Massey, Moore, Newbold and Ihde, 2016); 2) what are the impacts of climate change on coastal recreational fishing (Dundas and von Haefen, 2018); and 3) how does the value of coastal recreational fishing vary across time and space (Naumenko and von Haefen, in preparation). The presentation highlights the strengths and weaknesses of the MRIP data as well as directions for future research that could generate valuable policy insights for USDA and other government agencies.

## **VALUING ECOSYSTEM SERVICE CHANGES FROM CHESAPEAKE BAY RESTORATION**

***Lisa Wainger***

Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD, USA

The Chesapeake Bay watershed and estuary is a well-studied socio-ecological system that is currently undergoing restoration to improve a wide range of ecosystem services. Restoring water quality in tidal portions of the estuary is now legally mandated due to a Total Maximum Daily Load (TMDL), which is a cap that has been established on nutrient and sediment inputs to the bay. The cap was designed to restore estuarine aquatic habitat but actions to meet the cap have many co-benefits throughout the watershed and freshwater streams.

Multiple research groups have worked to value the benefits of planned restoration actions and have documented substantial public benefits of the effort and its expected outcomes. Benefits that have been monetized include property value to homeowners, recreational fishing, aesthetics, and nonuse or passive use values associated with improving the health of lakes, streams, and the estuary. Other benefits, such as improvements to human health and safety, have been quantified with performance indicators.

In this talk I will review results of valuation and the integrated ecological and economic modeling that enabled the valuation. Further, I will highlight where filling data gaps can enrich knowledge of the full suite of estuarine restoration benefits. This work helps to reveal the biophysical model elements that must be included to enable economic valuation. Further, it clarifies the work that remains to refine model and monitoring integration, which is needed to broaden the types of ecosystem services that can be evaluated, including those generated by enhancing system resilience to future change.

## LOCAL ECONOMIC IMPACTS OF FEDERAL PROTECTED LANDS

**Margaret Walls**

Resources for the Future, Washington, DC, USA

Public lands in the United States provide a wide range of ecosystem services, including protection of drinking water, wildlife habitat, carbon sequestration, and more. They also are the foundation of a growing outdoor recreation economy. National parks are seeing record numbers of visitors and many communities located near parks and other public lands are growing. Nonetheless, residents in some of these communities feel that protective status hurts more than it helps because of the prohibitions on resource extraction activities such as mining and oil and gas development. This has created a backlash against some designations, especially some recent national monuments in Western states. In this study, we use a unique micro-dataset of all business establishments in the eight Mountain West states over a 25-year period and a combination of statistical matching techniques, difference-in-differences regressions, and synthetic control methods to estimate a causal relationship between protected land designations and economic activity. We analyze the impacts on numbers of jobs and business sales revenues at a local level and by sector; we also assess trends in local economic activity over time and analyze business survival rates. We assess the distribution of industries and job types in communities near protected lands and how those have changed over time. This study sheds light on the contribution of federal protected lands to local economies in the Mountain West.

## **INCORPORATING ECOSYSTEM SERVICES INTO NATURAL CAPITAL ACCOUNTING: FRAMEWORK AND APPLICATIONS IN THE SOUTHEASTERN U.S.**

*K. Warnell<sup>1</sup>, L. Olander<sup>1</sup>, K. Bagstad<sup>2</sup>, M. Russell<sup>3</sup>, and C. Rhodes<sup>4</sup>*

<sup>1</sup>Nicholas Institute for Environmental Policy Solutions, Duke University, Durham, North Carolina

<sup>2</sup>Geosciences and Environmental Change Science Center, United States Geological Survey, Denver, Colorado

<sup>3</sup>U.S. Environmental Protection Agency

<sup>4</sup>ORISE post-doctoral research fellow, participating at U.S. Environmental Protection Agency, Washington, DC

Natural capital accounting is a method of assessing the contribution of ecosystems to the economy, making the links between natural and economic systems more clear. While the System of Environmental-Economic Accounts' Central Framework (developed by the U.N. and other international statistical organizations) focuses on tangible environmental assets such as water, timber, and fish, ecosystems create a wide variety of additional products and processes that benefit people. Incorporating ecosystem services into natural capital accounting allows information about their provision and use, as well as the extent and condition of individual ecosystems, to be tracked in a standardized way, helping governments, businesses, and other entities to make better-informed decisions about actions that will affect our ecosystems and economy. As part of a working group led by the USGS, we used the SEEA - Experimental Ecosystem Accounts (EEA) as the foundation for an ecosystem accounting structure. To test the framework, we developed pilot accounts for a ten-state region in the southeastern U.S. for 2001 through 2011. Natural capital accounts track contributions of ecosystems in physical and monetary terms; we focused on physical contributions.

The three basic ecosystem account types are ecosystem extent, condition, and supply and use of ecosystem goods and services. Ecosystem extent accounts quantify the area of each ecosystem type. We used land cover as an initial classification for ecosystem type, but did not create extent accounts for the Southeast pending ongoing work to create national land accounts (also presented in this session). Condition accounts can contain information on any aspect of ecosystem condition. We used condition accounts to track information relevant to ecosystem functions and characteristics of interest to people that could not be included in supply-use tables because they are not directly used by people or information about their use was not available. Our condition accounts for the Southeast include metrics related to the availability of wild pollinators, the removal of pollutants from runoff water and air, and bird biodiversity. Supply-use accounts track the amount of ecosystem products supplied by ecosystems and directly used by households, industries, or government. The supply-use accounts for the Southeast include information on two ecosystem services: recreational birdwatching and breathing cleaner air.

Attributing ecosystem services and processes to particular ecosystem types highlights the importance of certain ecosystems for individual services and related processes, including low-density developed areas for recreational birdwatching and woody wetlands near agricultural lands for the availability of wild pollinators. Tracking trends in service provision and ecosystem condition over time illustrates where human actions may threaten the long-term ability of ecosystems to provide services valuable to people, such as water purification in rapidly-developing counties around major metropolitan areas. The process of compiling data for the ecosystem accounts illuminated gaps in data availability and understanding of ecosystem service provision, as well as the relationship between ecosystem condition and the provision of ecosystem services, all of which can help to guide future research and data collection efforts to develop more information-rich accounts.

## INDIGENOUS SCIENCE AND ECOSYSTEMS SERVICES AND THE FUTURE OF THE PLANET

*Jon Waterhouse*<sup>1</sup>, *Angela Spotted Wolf*<sup>2</sup>, *Amchat Edwards*<sup>3</sup>, *Aaron Dana*<sup>4</sup>, *Todd Woodward*<sup>5</sup>, *Mary Marshall*<sup>6</sup>

<sup>1</sup>S'Klallam – Chippewa-Cree Tribes, Oregon Health & Science University – Portland State University – School of Public Health,

<sup>2</sup>Navajo – Arapaho – Cheyenne Tribes

<sup>3</sup>Haiti -U.S. Fish and Wildlife Service

<sup>4</sup>Passamaquoddy

<sup>5</sup>Samish Tribe Department of Natural Resources

<sup>6</sup>Co-Founder of the Living Indigenous Network of Knowledge

Our intent is to bring forth the narrative that Indigenous Science is real and the Indigenous Science and Contemporary Science should not be in conflict. Rather, that they are complimentary and bringing the two together with equal weight and importance to the general body of scientific knowledge on a global scale will better serve the interests of ecosystems services and humankind.

There are roughly 370 million Indigenous People on the planet that measure their scientific knowledge base in terms of “since time immemorial”. This wealth of knowledge has existed much longer than contemporary science, whether you measure it against the fathers of modern science, Galileo or Newton, or chose to go further back in time to Aristotle or Archimedes.

Indigenous Science allowed for these people to thrive in regions of the world that even today are considered forbidding. The Arctic knowledge possessed by people such as the Inuit, Sami, or Dolgan allowed them to live and traverse and without which Robert Peary, among others, would have never been able to explore the poles. Consider that modern science has synthesized many traditional Indigenous medicines including aspirin and is now looking to the Indigenous past to find cures for the future in long known, by the Native People, cures in sage, chokecherries, and cannabis. Traditional navigation practiced by the Pacific Islanders is truly the mathematics of navigation that led to them populating the entire Pacific and beyond when most of western culture was still confined to hugging the coastlines of the world. In the context of ecosystem services we need to look no further than the Samish Tribal efforts at eel grass bed and kelp forest restoration. Utilizing traditional institutional memory and the latest NASA earth observation equipment combined time honored traditional practices and the most modern plant restoration techniques they are successfully rebuilding ecosystems that were destroyed by development years ago. In the true spirit of scientific collaboration between the Samish and contemporary scientists we find the truth that the “two ways of knowing”, Indigenous and Contemporary, are complimentary and actually make for better scientific and human results for the planet.

These are but a few examples of a rich new field of scientific exploration that should be pursued with vigor for the betterment of understanding our place within ecosystems services.

## **INDUSTRIAL PROCESS POND/IMPOUNDMENT CLOSURES: BUSINESS-CASE OPPORTUNITIES TO CREATE ECOSYSTEM SERVICES**

***Jonathon A. Weier***

Jacobs, Atlanta, GA, USA

For industrial infrastructure, end-of-life commonly represents a financial challenge for site owners. However, for process ponds and impoundments, there are opportunities to create ecosystem service value as part of the closure. Options for non-traditional closures range from no action to subaqueous covers to terrestrial covers focused on a specific type of habitat or an ecological theme. These non-traditional methods are often significantly less expensive, require less maintenance, and provide many more co-benefits than traditional methods in the form of human use and ecological service value. There are opportunities to capture benefits with even small investments, so ecosystem service generation, cost reduction and the generation of stewardship examples are not confined just to the largest projects. Process pond and impoundment closures also represent an opportunity to use natural resource by-products from other activities (e.g., cut trees and rock) to control erosion, accelerate plant colonization, and create habitat for predators that will control nuisance species. In certain cases, the waste itself may be effectively harnessed for productive uses. The scope of the presentation will include examples of non-traditional, valuing-nature closures that span a range of contexts, the business case, challenges and lessons learned, and methods for identifying opportunities and building support for acceptance. The objective is to facilitate awareness and understanding of these opportunities so that both industry and agencies can work together to mainstream approval of non-traditional methods when they are protective of human health and the environment.

## **IMPACT OF HURRICANES IRMA AND MARIA ON PUERTO RICO MATERNAL AND CHILD HEALTH RESEARCH PROGRAMS AND STRATEGIES FOR FUTURE**

***Michael Welton***

University of Georgia, Athens, GA, USA

Prior to September 2017 when hurricanes Irma and Maria passed through the Caribbean, Puerto Rico had marked disparities in reproductive health. Compared to the mainland U.S. in recent years, Puerto Ricans had a 23% higher rate of preterm birth, a 35% higher rate of low birth weight, 38% higher infant mortality rate, 67% higher teen birth rate, and 75% higher rate of unintended pregnancy. The Puerto Rico Testsite for Exploring Contamination Threats (PROTECT) and Center for Research on Early Childhood Exposure and Development in Puerto Rico (CRECE) Centers are National Institute for Environmental Health Science (NIEHS) funded Superfund Research Programs that have been investigating exposures and health outcomes among Puerto Rican mothers and infants since 2010. PROTECT/CRECE have been very active in the hurricane recovery efforts in order to ensure the safety and welfare of team members, study participants, community health center partners, and members of the surrounding communities. These efforts have given our team first-hand experience with the impact difficulties of long-term recovery and preparedness. In this presentation, we identify access to care, maternal stress, access to potable water, access to nutrition, and climate change as major challenges to maternal and child health following Hurricanes Irma and Maria. Furthermore, we will illustrate the steps we are taking to include disaster preparedness into our programs' future strategies. The PROTECT/CRECE team's close proximity to the storms' impact and recovery allow us to reflect and to prepare for future disasters, using our experiences to improve Puerto Rico's maternal and child health.

## FROM PRACTICE TO PAYMENT: PARTNERING WITH LANDOWNERS TO DEVELOP CREDITS FOR ENVIRONMENTAL MARKETS

*Lindsay White<sup>1</sup>, Dennis Carman<sup>2</sup>, Max Dubuisson<sup>3</sup>, Jessica Fox<sup>4</sup>, Robert Veldman<sup>5</sup>*

<sup>1</sup>USDA Natural Resources Conservation Service

<sup>2</sup>White River Regional Irrigation Water Distribution District

<sup>3</sup>Climate Action Reserve

<sup>4</sup>Electric Power Research Institute

<sup>5</sup>K-Coe Isom

The USDA Natural Resources Conservation Service (NRCS) provides technical and financial assistance to landowners and agricultural producers on millions of acres of agricultural and forestland every year. Nevertheless, a gap exists between NRCS's available resources and the total conservation need on America's private lands. Environmental markets can help fill that gap by attracting non-Federal funding to private lands conservation and generating new sources of economic support for rural communities. Environmental markets extend NRCS's mission of Helping People Help the Land.

At NRCS, programs like Conservation Innovation Grants (CIG) provide financial support for projects developing environmental markets throughout the United States. CIG funding provides backing to test new approaches and metrics, fostering innovations and partnerships that help landowners receive support for conservation practices and payments for ecosystem services.

This panel discussion will address the process of working with landowners to develop and market credits for participation in greenhouse gas reduction, wildlife habitat and water quality markets. The panelists—four CIG recipients—will cover the landowner outreach, evaluations, and agreements that go into developing credits on working lands. Challenges and key lessons learned in working with landowners will be discussed. Projects covered will include:

- Sage Grouse Habitat Credits on Ranchland (Robert Veldman, K-Coe Isom)
- Grassland Greenhouse Gas Credits (Max DuBuisson, Climate Action Reserve)
- Methane Reductions in Rice Production (Dennis Carman, White River Regional Irrigation Water Distribution District)
- "Stacked" Ecosystem Credits (Jessica Fox, EPRI)

## CONTINENTAL SCALE VALIDATION OF ECOSYSTEM SERVICE MODELS

*Simon Willcock<sup>1,2</sup>, Danny A.P. Hooftman<sup>\*3,4</sup>, Stefano Balbi<sup>5</sup>, Ryan Blanchard<sup>6</sup>, Terence P. Dawson<sup>7</sup>, Patrick J. O'Farrell<sup>6,8</sup>, Thomas Hickler<sup>9,10</sup>, Malcolm D. Hudson<sup>11</sup>, Mats Lindeskog<sup>12</sup>, Javier Martinez-Lopez<sup>5</sup>, Mark Mulligan<sup>7</sup>, Belinda Reyers<sup>13</sup>, Kate Schreckenberg<sup>11</sup>, Charlie Shackleton<sup>14</sup>, Nadia Sitas<sup>6</sup>, Ferdinando Villa<sup>5,15</sup>, Sophie M. Watts<sup>2</sup>, Felix Eigenbrod<sup>2,16</sup> & James M. Bullock<sup>†4</sup>.*

<sup>1</sup>School of Environment, Natural Resources and Geography, Bangor University, United Kingdom

<sup>2</sup>Biological Sciences, University of Southampton, United Kingdom

<sup>3</sup>Lactuca: Environmental Data Analyses and Modelling, The Netherlands

<sup>4</sup>NERC Centre for Ecology and Hydrology, Wallingford, OX10 8BB, United Kingdom

<sup>5</sup>Basque Centre of Climate Change, Spain

<sup>6</sup>Council for Scientific and Industrial Research, South Africa

<sup>7</sup>Department of Geography, King's College London, United Kingdom

<sup>8</sup>Percy FitzPatrick Institute of African Ornithology, University of Cape Town, South Africa

<sup>9</sup>Senckenberg Biodiversity and Climate Research Centre (SBIK-F), Germany

<sup>10</sup>Department of Physical Geography, Goethe University, Frankfurt, Germany

<sup>11</sup>Engineering and the Environment, University of Southampton, United Kingdom

<sup>12</sup>Department of Physical Geography and Ecosystem Science, Lund University, Sweden

<sup>13</sup>Department of Conservation Ecology and Entomology, Stellenbosch University, South Africa

<sup>14</sup>Department of Environmental Science, Rhodes University, South Africa

<sup>15</sup>IKERBASQUE, Basque Foundation for Science. Bilbao, Bizkaia, Spain

<sup>17</sup>Geography and Environment, University of Southampton, United Kingdom

Faced with environmental degradation, governments world-wide are developing policies to safeguard ecosystem services (ES). Many ES models exist to support these policies, but they are generally poorly validated, especially at large scales. We describe a study of multiple models of five ES, which we validate against 1,675 data points across sub-Saharan Africa. We find that potential ES (biophysical supply) are reasonably well predicted and can be used as inputs to new standardised models for realised ES (use). However, if realised ES estimates do not take ES flows into account, then model accuracy declines in more urban landscape contexts – an effect of at least equivalent importance to that resulting from model identity. We find that increasing model complexity can improve estimates of both potential and realised ES. While ensembles of models are generally not better predictors of ES than the best-fit individual models, ensembles can provide estimates of confidence in data-deficient areas. Finally, we show that machine learning model outputs (64-91% accuracy) can be of comparable accuracy as conventional modelling techniques (54-77% accuracy). Model validation and consequent improvement should become standard practice by those building and applying models, providing a stronger base to support policies which seek to achieve sustainable development in support of human well-being.

## **BUILDING AND APPLYING A FRAMEWORK TO UNCOVER RELATIONAL VALUES OF ECOSYSTEM SERVICES**

*Kathleen Williams, David Bolgrien, and Joel Hoffman*

Mid-Continent Ecology Division, Office of Research and Development, United States Environmental Protection Agency,  
Duluth, MN, USA

Many of the Midwestern US “Rust Belt” cities contain Areas of Concern (AOC) where extensive efforts to remediate aquatic sediments, restore riparian habitat and ecosystem services, and realize community revitalization are unfolding. USEPA has coined the term “Remediation to Restoration to Revitalization,” or R2R2R, a place-based practice that requires ongoing communication among agencies, local governments, and citizens about the ecosystem services and benefits they value. One of the challenges is that each of these entities has a different relationship with and responsibility to places where R2R2R plays out. The array of activities involved in R2R2R, such as changes to the biophysical environment, community planning, and personal connections diverge in scale, focus, and interaction depending on the agency or individual. The divergence can manifest itself as conflict, but in reality, reflects how different individuals and organizations recognize and value ecosystem services. Scholars who study relational values of ecosystem services recognize that different types of value of an ecosystem resource is based on relationships in both the social and biophysical environments, in addition to the supply of resource. This required us to develop a tool, in this case a framework we call the Neighborhood Model, to identify and characterize these relational values of ecosystem services.

We used R2R2R a representative case to develop the Neighborhood Model using Distinctions-Systems-Relationships-Perspectives (DSRP) and grounded theory as analytical approaches to distinguish ecosystem services in context. Because R2R2R consists of state and federal agency environmental management, local development decisions, and citizen activities, it functions as a complex system where the biophysical environment, economic development, and community values intersect in a place where ecosystem services are embedded. As a result, the Neighborhood Model includes neighborhood or community components that individuals, agencies, organizations, and local governments may discuss in the context of a place. The characteristics in the framework are a mix of built environment types, structural dimensions, personal experiences, and human-environment relationships and include: parks/open spaces, trails or connections, housing, schools, infrastructure, local businesses, macro-economy, natural features, governmental rules or regulations, demographics/crime statistics/health care facilities, safety, self-determination or participation, identity, social cohesion, sustainability, and aesthetics. The Neighborhood Model empowers researchers identify the ecosystem in context, because they might be valued because of proximity to the built environment (e.g., a scenic view) or access to a resource (e.g., a fishing pier). We intend this framework to be utilized as a “decoder ring” to interpret distinct values and facilitate communication or comparison. This presentation will include both an overview of the framework development, as well an example of application.

## GREEN INFRASTRUCTURE PLANNING & DESIGN FOR HUMAN HEALTH CO-BENEFITS

**Kathleen L. Wolf**

University of Washington, Seattle, WA, USA  
USDA Forest Service, Pacific Northwest Research Station

The multiple benefits of ecosystem services are being used to inform decision-making, at all locations within the wildland to peri-urban to urban landscape gradient. This presentation will focus on ecosystem services provided within urban contexts. Green infrastructure systems within cities are increasingly promoted in urban planning and design. Elements can include all ecological, cultural, and engineered green spaces, such as (but not limited to) parks, open spaces, community gardens, and the urban forest. Building design innovations increasingly incorporate nature in structures, such as green roofs and living walls. Green infrastructure performance goals usually focus on environmental or sustainability services, such as reduced energy use, flooding, or heat island effects.

Yet nearly 40 years of research across social and health disciplines (such as psychology, sociology, urban planning, and epidemiology) demonstrates a broad array of health and well-being benefits associated with the human experiences of metro nature. The web site [\*Green Cities: Good Health\*](#) at the University of Washington (Seattle USA) presents concise summaries representing more than 4,500 peer reviewed science publications about social and health benefits. This knowledge is profoundly important as human well-being benefits include stress reduction, healing and therapy, better learning and work productivity, and improved social dynamics in communities. These findings have broad implications, from support of individuals, to community cohesion, to economic costs and benefits.

This presentation will merge topics of green infrastructure and public health that are typically separated by professional and departmental traditions within local governments. The presentation will start with an introduction to the extensive evidence of human health and well-being benefits derived from metro nature. It will then turn to translating health and well-being evidence into a framework of co-benefits that are possible if green infrastructure installations incorporate multi-function designs. Finally, the talk will explore how a co-benefits emphasis can promote expanded collaborations with diverse partners, such as urban planners, social services providers, and public health professionals.

Two recent reports will provide case studies and examples. Each offers practical guidelines for ways to optimize human health ecosystem services, while addressing environmental performance. The booklet titled [\*Cascading Benefits: Designing Green Stormwater Infrastructure for Human Wellness\*](#) is a collaborative effort of the USDA Forest Service and The Nature Conservancy. It combines principles of green stormwater infrastructure and public health research to provide co-design ideas (based on research and theory) that generate co-benefits of better water management and more livable environments for people in cities. The second example, *Green Infrastructure and Health Guidelines* has been created for the Green Infrastructure Leadership Exchange (based in the U.S.) by the Willamette Partnership and Oregon Public Health Institute. This publication encourages engineering and infrastructure professionals to pursue hyperfunctional landscapes in ways that achieve primary infrastructure objectives, but also provide positive externalities of human health and well-being.

## PROJECTING THE IMPACTS OF LAND COVER CHANGE ON DRINKING WATER TREATMENT

*Sean A. Woznicki<sup>1</sup>, James Wickham<sup>1</sup>, and George Kraynick<sup>2</sup>*

<sup>1</sup>Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

<sup>2</sup>Minneapolis Water Works, Minneapolis, MN, USA

Source protection is a critical aspect of drinking water treatment. The benefits of source water quality protection on reducing drinking water treatment costs are clear. However, forecasting the impacts of environmental change on source water quality and its potential to influence drinking water treatment processes is rare. The Minneapolis, MN drinking water treatment plant recognized the threats of land cover change on source water quality in their drinking water watershed, the Upper Mississippi River Basin (UMRB). Consistent losses of forests, wetlands, and grasslands in the watershed, coupled with a projected population increase of one million people by 2030, is of great concern to the drinking water treatment plant with respect to meeting water quality standards in the future.

The objective of this study was to relate forecasted land cover change (forest and wetland loss, agricultural expansion, urbanization) to changes in source water quality and drinking water treatment for Minneapolis. The Soil and Water Assessment Tool (SWAT) watershed model was driven with historical land cover change using all eras (2001, 2006, 2011) of the National Land Cover Database (NLCD) to understand the impact of recent change on water quality and drinking water treatment. Then, mid-century projections of land cover change from the the FOREcasting SCEnarios of Land-use Change (FORE-SCE) model were used in SWAT to characterize potential future water quality conditions. The spatially-explicit land cover change projections are based on the A1B, A2, B1, and B2 emissions scenarios from the Special Report on Emissions Scenarios (SRES). In-stream water quality (sediment, nitrogen, and phosphorus) was linked to chemical treatment data at the treatment plant (e.g. alum and powder activated carbon).

The land cover change scenarios demonstrate uncertainty in projecting the magnitude of change, although all capture the trend of forest and wetland loss. The “A” scenarios translate these losses to urbanization and agricultural expansion, while the “B” scenarios also lose agricultural lands to urbanization. Forest loss projections range from 390 to 1,370 km<sup>2</sup>, while urban growth ranges from 330 to 860 km<sup>2</sup> and agricultural change from 220 km<sup>2</sup> of loss to 610 km<sup>2</sup> of expansion. This translates to an additional 22,000 to 216,000 metric tons of sediment erosion to rivers in the watershed annually, up to 940 metric tons of total nitrogen, and 60 metric tons of total phosphorus, highlighting the potential increases in drinking water treatment chemical input requirements. These analyses will contribute to determining the value of natural landscapes in protecting drinking water quality, while providing the Minneapolis drinking water utility with information critical to their planning process.

## **ECOSYSTEM SERVICES, SOCIOECONOMICS, AND ADDRESSING STAKEHOLDER CONCERNS**

***Barbara Wyse***

Highland Economics LLC, Portland, OR, USA

As currently practiced, socioeconomic impact analyses conducted to comply with the National Environmental Policy Act (NEPA) and other other state and federal requirements typically analyze economic and social impacts separately from environmental impacts. In these traditional analyses, the biological and physical science sections usually identify potentially adverse project impacts while the socioeconomics section usually identify potentially beneficial economic impacts on jobs, income, and taxes. Rather than silos of information on biological, physical, and social effects, using an ecosystem services approach integrates information, and translates environmental impacts into social and economic terms that the public can relate to and more readily understand. Such an approach provides stakeholders and decision-makers with more useful and meaningful information, and avoids the dichotomy of many traditional NEPA and other documents that identify positive economic effects and adverse environmental effects.

We present several example cases applying an integrated ecosystem services approach in which the diverse social and economic implications of environmental impacts are identified and communicated with key stakeholders, and describe how we implemented such an approach. These disparate case studies include 1) a NEPA Environmental Impact Statement of a Habitat Conservation Plan affecting instream flows and agricultural withdrawals in the Deschutes Basin of Oregon, 2) a regional economic development strategy that connects investments in natural areas and associated ecosystem services with increased business attraction and retention in Northeast Arizona, and 3) an educational tool to encourage cities to use green infrastructure as part of voluntary mitigation of adverse environmental impacts from transportation projects in the Dallas-Fort Worth region of Texas.

These case studies highlight the importance of early engagement with affected stakeholders to identify key issues of concern, careful definition of impact measures that speak to stakeholders' concerns, and clearly connecting the dots between biophysical resource and environmental changes and impacts to key values held by stakeholders.

## ENCOURAGING GREEN INFRASTRUCTURE TO MITIGATION TRANSPORTATION IMPACTS

*Amanda Long Rodriguez<sup>1</sup>, Kate Zielke<sup>1</sup>, Barbara Wyse<sup>2</sup>*

<sup>1</sup>North Central Texas Council of Governments

<sup>2</sup>Highland Economics LLC, Portland, OR, USA

The North Central Texas population is expected to grow by over 45 percent by 2040, and as infrastructure develops to meet the needs of this population growth, there will be increased use and development of environmental resources. This is expected to lead to less provision of many ecosystem services. In a proactive move to identify and prioritize non-regulatory (i.e., voluntary) activities to mitigate environmental impacts of transportation projects, the North Central Texas Council of Governments is developing a decision-making tool. The tool can be used by political subdivisions to evaluate the adverse environmental impacts of proposed transportation-related infrastructure, and then understand the associated environmental and economic benefits of implementing green infrastructure mitigation strategies.

Currently, mitigation of environmental impacts of transportation is seen by many jurisdictions as a cost, with few jurisdictions recognizing the economic and social benefits. Demonstrating the economic value of green infrastructure mitigation strategies is critical to encouraging adoption of these measures. To do so, this project includes developing a tool that requires minimal information from users on characteristics of their transportation project. The tool then estimates the change in ecosystem services with and without green infrastructure mitigation, and the associated economic value of the green infrastructure based on changes in 1) direct transportation infrastructure and maintenance costs, 2) stormwater and water quality management costs, and 3) value to the public associated with reduced flooding, improved aesthetics, air quality, water quality, recreation, and open space.

The project includes defining a list of green infrastructure measures to mitigate transportation impacts, quantifying ecosystem service effects of mitigation measures, estimating the social and economic benefits of preserving/creating ecosystem services through non-regulatory mitigation, and combining these data into the tool that draws from area GIS data to estimate project-level environmental impacts and the economic benefits of mitigation.

## INCENTIVIZING CONSERVATION PRACTICES IN AGRICULTURE: DECISION SUPPORT TOOLS AND PAYMENTS FOR IN-LIEU RECHARGE

*Sacha Lozano<sup>1</sup>, Lisa Lurie<sup>1</sup>, Barbara Wyse<sup>2</sup>, and Travis Greenwalt*

<sup>1</sup>Resource Conservation District of Santa Cruz County, California

<sup>2</sup>Highland Economics, Portland, Oregon

The Pajaro Valley in Santa Cruz, California produces many high valued agricultural crops, but the long-term viability of agricultural irrigation and other water uses is jeopardized by overdraft of groundwater resources. A public-private partnership, the Community Water Dialogue (CWD), led by the Resource Conservation District of Santa Cruz County in collaboration with local agribusiness stakeholders, is working to find sustainable water management solutions to incentive and cost-share conservation practices. Rotational fallowing with cover cropping (a form of in-lieu groundwater recharge) can help to bring water use into balance with supply while also generating other positive environmental benefits. As such, a voluntary rotational cover crop program is being collaboratively designed by the CWD. The CWD identified that fallowing with cover cropping is a promising strategy for conserving water and building soil health, thus preserving the long-term viability and value of agricultural resources in the valley. As part of this effort, Highland Economics conducted an analysis of public benefits and private costs of several cover crop fallow scenarios, as well as an assessment of potential incentive program structures that would encourage voluntary cover cropping in the valley.

We developed a decision-making tool that summarizes the private (to agricultural businesses) and public costs and benefits of cover cropping of ten crop rotation scenarios. The tool includes economic values related to reduced agricultural profit (i.e., private costs from foregone cash crop production on cover cropped lands) as well as increased public benefits related to increased ecosystem service values from effects on soil fertility, carbon sequestration and carbon emissions, groundwater supply, and surface water quality (related to reduced nitrogen loading and sedimentation in local waterways). The study also estimates the level of public funding required to incentive agricultural interests to reduce crop profit benefits and increase environmental benefits through cover cropping.

The analysis drew from numerous ecological studies focused on impacts of cover cropping, and applied these data using information specific to the Pajaro Valley. To account for uncertainty, ranges of costs and benefits were used in an @Risk model to project the 90<sup>th</sup> percentile range and 'most likely' net benefit values for each of the ten crop rotation scenarios. Findings identified the most cost effective scenarios for water conservation as well as the scenarios with the greatest net benefits, considering all benefit categories. Results indicate that public benefits of cover crop fallowing in the Pajaro Valley can exceed private costs (including foregone revenue of cash crops) for certain rotations. The CWD is currently in discussions with the local water management district and other potential funders to structure funding and pilot programs for cover cropping that use study findings to maximize return on investment.

## LINKING ECOSYSTEM SERVICES TO HUMAN HEALTH TO INFORM ESTUARY MANAGEMENT IN PUERTO RICO

*Susan H. Yee<sup>1</sup>, R. de Jesus Crespo<sup>1</sup>, D. Betancourt<sup>2</sup>, T. Dean<sup>2</sup>*

<sup>1</sup>U.S. Environmental Protection Agency, Gulf Ecology Division, Gulf Breeze, FL, USA

<sup>2</sup>U.S. Environmental Protection Agency, Air and Energy Management Division, Research Triangle Park, NC, USA

Estuary management programs are increasingly framing management issues within the context of ecosystem services benefits to the well-being of stakeholders. However, assessments and monitoring are still often limited to measures of ecological condition. When benefits assessments are conducted, they overwhelmingly focus on monetary valuation of economic resources such as fisheries, while under-representing potential social benefits to human health and well-being. A key challenge is that the methods, data, and models needed to quantify health impacts are generally less developed than monetary valuation approaches.

For example, the San Juan Bay estuary, Puerto Rico, comprises a connected system of bays, lagoons, and canals in a highly urbanized watershed. Habitat alterations and land-use development have disrupted the natural flow of water throughout the estuary system, subjecting some neighborhoods to frequent flooding events and exacerbating the effects of wastewater discharges, including untreated sewage, and stormwater runoff into areas of the bay. In addition to restoring habitat and water quality of the estuary, objectives of the San Juan Bay estuary management program include many social elements of human well-being, including cultural opportunities, education, public safety, a social connection to nature, good governance, and human health. However, the degree to which estuarine management actions to improve wetland condition and restore natural hydrology could improve human health and well-being is largely unknown.

Here, we overview several research studies aimed at assessing how restoration of estuarine ecosystem services could benefit human health and well-being. First, we developed a holistic index of human well-being to assess inequalities among neighborhoods in human health and well-being. Second, we developed a conceptual model to identify how ecosystem services might convey potential benefits to human health. Third we conducted a number of field and modeling studies to evaluate whether changes in ecological condition could be quantitatively linked to human health impacts. In particular, we evaluated i) the potential impacts of flood regulation on indoor mold and bacterial populations that might be associated to asthma and other respiratory illnesses, ii) the potential impacts of water quality regulation, temperature regulation and flood regulation on vector-borne illnesses, and iii) the potential impacts of floodwater retention on waterborne gastro-intestinal diseases. Taken together, results indicate health disparities in communities that border the estuary could in part be mitigated by estuary management actions largely aimed at improving water quality and restoring habitat. As data and models linking ecosystem services to human health continue to grow, environmental management programs will be increasingly empowered to communicate benefits to stakeholders.

## **ERIE P MARKET: MULTI-JURISDICTIONAL WATER QUALITY CREDITS AND STEWARDSHIP IN THE WESTERN LAKE ERIE BASIN**

*Nicole Zacharda, Victoria Pebbles, and Daniel Gold*

Great Lakes Commission, Ann Arbor, MI USA

The Erie P Market project is a Conservation Innovation Grant funded by NRCS to see whether water quality trading may be an additional tool to help address the nutrient pollution problem in the Western Lake Erie Basin. The project developed a Framework that provides a common approach that the three states surrounding Western Lake Erie (Michigan, Ohio and Indiana) can use to certify phosphorus reductions and credit generation and support all phases of the transaction of buying and selling water quality (specifically phosphorus reduction) credits. The Framework describes who is eligible, where and when trading can occur, and the process for verifying that conservation practices are working to improve water quality. Water quality and agriculture agency directors from those three states signed an MOU in December 2017 agreeing to consult the Framework when pursuing phosphorus trading/crediting in the Western Lake Erie Basin. Throughout 2018, the Framework was tested through several pilot trades. This discussion will highlight the key elements of the Framework, lessons learned from the project, and conclude with feedback from the audience on the potential for future credit generating programs around the Great Lakes.





# Thank You to our Sponsors and Supporting Organizations

